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Satbayev University

Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ
НАУК РЕСПУБЛИКИ
КАЗАХСТАН
Satbayev University

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N.A. Abdimutalip[1], A.K. Kurbaniyazov[1], G. Toychibekova[1*], G. Koishieva[1], G. Shalabaeva[1], N. Zholmagambetov[2]

[1]A.Yasavi International Kazakh-Turkish University, Turkestan, Kazakhstan;
[2]Karaganda State Technical University, Karaganda, Kazakhstan.
E-mail: gaziza.toychibekova@ayu.edu.kz

INFLUENCE OF CHANGES IN THE LEVEL OF SALINITY OF THE ARAL SEA ON THE DEVELOPMENT OF ECOSYSTEMS

Abstract. The article presents the results of research on the current state of the Aral Sea. An estimate of the area of the residual reservoir is given, since the remaining area of the Aral Sea already belongs to the drying zone. The paper describes the processes of modern sedimentation in the residual reservoir of the Aral Sea, meaning only the Western deep-water part of the sea, the area of which is 1/10 of the full-water Aral Sea, and the salinity of the water as shown by chemical analyses has increased more than 10 times (110-120 g/ l). The purpose of the study is to observe changes in the state of physical, chemical and biological ecosystems of the water masses of the residual reservoirs of the Aral Sea in the conditions of the current ecological crisis, as well as to study the mechanism of their adaptation to the conditions of a shortage of desalination runoff and the dryness of the regional climate. The species composition and the number of inhabitants of the reservoir depend on the properties and level of salinity of the water. The main idea of environmental monitoring is that hydrobionts reflect the prevailing environmental conditions in the reservoir. Those species, for which these conditions are unfavorable fall out, being replaced by new species with different needs.

Key words: ecosystem, salinity, drainage, hydrobionts, mineralization, microepiphytes, algae.

Н.Ә. Әбдімүтәліп[1], А.К. Құрбаниязов[1], Г. Тойчибекова[1], Г. Койшиева[1], Г. Шалабаева[1], Н. Жолмагамбетов[2]

[1]А. Ясауи атындағы Халықаралық қазақ-түрік университеті, Түркістан, Қазақстан;
[2]Қарағанды мемлекеттік техникалық университеті, Қарағанды, Қазақстан.
E-mail: gaziza.toychibekova@ayu.edu.kz

АРАЛ ТЕҢІЗІНІҢ ТҰЗДАНУ ДЕҢГЕЙІ ӨЗГЕРУІНІҢ ЭКОЖҮЙЕЛЕРДІҢ ДАМУЫНА ӘСЕРІ

Аннотация. Мақалада Арал теңізінің қазіргі жағдайын зерттеудің нәтижелері келтірілген. Осы уақытқа дейін құрғаған Аралдың қалған бөлігі тұзды кепкен аймағына жататындықтан, қалдық су айдынының ауданына баға берілді. Ғылыми жұмыста Аралдың қалдық су қоймасында қазіргі заманғы шөгінділердің пайда болу үдерістері сипатталған, анықталғандай теңіздің тек батыс терең сулы бөлігі ғана қалған, оның ауданы толық сулы Аралдың 1/10 бөлігін құрайды, ал жүргізілген химиялық талдаулар көрсеткендей судың тұздылығы 10 еседен астам өсті (110-120 г/л). Зерттеудің мақсаты – қазіргі экологиялық дағдарыс жағдайында Арал теңізінің қалдық су қоймаларындағы су массаларының физикалық, химиялық және биолологиялық экожүйелерінің жай-күйінің өзгеруін бақылау, сондай-ақ олардың тұщыландыру ағынының тапшылығы және өңірлік климаттың құрғақ жағдайларына бейімделу үдерістерін зерделеу. Теңіз суындағы тіршілік түрлерінің құрамы мен саны судың қасиеттері мен тұздану деңгейіне байланысты екендігі анықталды. Экологиялық мониторингтің басты идеясы гидробионттардың су қоймасында қалыптасқан қоршаған орта жағдайларына бейімделгіштігін көрсетеді. Бұл қолайсыз жағдайда кейбір түрлер жоғалып, орнына басқа жаңа түрлермен алмастырылатыны айқындалды.

Түйін сөздер: экожүйе, тұздану, құрғау, гидробионттар, минералдану, микроэпифиттер, балдырлар.

Н.А. Абдимуталип[1], А.К. Курбаниязов[1], Г. Тойчибекова[1], Г. Койшиева[1], Г. Шалабаева[1], Н. Жолмагамбетов[2]

[1]Международный казахско-турецкий университет имени А. Ясави, Туркестан, Казахстан;
[2]Карагандинский государственный технический университет, Караганда, Казахстан.
E-mail: gaziza.toychibekova@ayu.edu.kz

ВЛИЯНИЕ ИЗМЕНЕНИЙ УРОВНЯ ЗАСОЛЕННОСТИ АРАЛЬСКОГО МОРЯ НА РАЗВИТИЕ ЭКОСИСТЕМ

Аннотация. В статье приведены результаты исследований современного состояния Аральского моря. Дана оценка площади остаточного водоема, так как остальная площадь Арала уже относится к зоне осушки. В работе описываются процессы современного осадкообразования в остаточном водоеме Арала, имеется ввиду лишь Западная глубоководная часть моря, площадь которого составляет 1/10 части полноводного Арала, а соленость воды, как показали проведенные химические анализы, увеличилась более чем в 10 раз (110-120 г/л). Цель исследования – наблюдение за изменением состояния физических, химических и биоллогических экосистем водных масс остаточных водоемов Аральского моря в условиях современного экологического кризиса, а также изучение механизма их адаптации к условиям дефицита опреснительного стока и сухости регионального климата. Видовой состав и численность обитателей водоема зависят от свойств и уровня засоленности воды. Главная идея экологического мониторинга состоит в том, что гидробионты отражают сложившиеся в водоеме условия среды. Те виды, для которых эти условия неблагоприятны, выпадают, заменяясь новыми видами с иными потребностями.

Ключевые слова: экосистема, засоленность, осушение, гидробионты, минерализация, микроэпифиты, водоросли.

Introduction. Observations of the state of the natural environment have been conducted by human for a long time. They are necessary for determining living conditions, farming, taking measures to prevent adverse impacts on people's lives, etc. The data on the quality of the environment includes both information about the current state and forecasts of changes in natural conditions. The problem under consideration in the article concerns the Aral Sea. Once the world's fourth largest lake has practically disappeared, and in its place a real desert has formed – Aralkum with an area of over 5.5 million hectares, from which winds annually lift up to one hundred million tons of sand and salt, carrying them for many hundreds of kilometers.

But this is not just a catastrophe, the scale of which has gone far beyond the region, but a real tragedy for people living in the Aral Sea region in more than harsh conditions and in need of special support and assistance, primarily from the state. The Aral Sea is a drainless salt lake in the western part of Central Asia on the border between the republics of Uzbekistan and Kazakhstan. The Aral Sea was a unique water natural object, providing ecological and climatic balance of the vast territory of the Eurasian continent. Unfortunately, this is already in the past, and today it is divided into 2 parts of reservoirs – Northern (Small) and Southern (Large). In 2014, the eastern part of the Southern (Large) The Aral Sea has completely dried up. Within the framework of the project "Regulation of the Syrdarya Riverbed and the Northern part of the Aral Sea" (RSRNAS) in 2003-2005, Kazakhstan built the Kokaral Dam, which fenced off the Small Aral from the rest of the Large Aral. A number of hydraulic structures, dams, main channels were also built and reconstructed, which made it possible to bring the water level to 42 m. abs. mark, volume up to 27 cubic square kilometers, and reduce salinity from 21 to 11 mg / liter, restore the habitat of 23 species of fish. Annually, the catch of fish in the Small Aral Sea is 8-10 thousand. tons and several types of fish are exported to European countries. According to the second stage of the RSRNAS, it is planned to bring the water level in the Small Aral to 46 m. abs. mark, which will practically bring the seashore to the city of Aralsk and restore the lake ecosystems of the lower reaches of the Syrdarya River. In the 60s of the last century, intensive development of virgin lands began in all the republics of Central Asia and Kazakhstan. 70-80 thousand hectares were developed annually. And in order to introduce one hectare of land into agricultural circulation and grow crops there, it takes at least ten or more thousand cubic meters of water. Thus, 600-700 million, and sometimes up to a billion cubic meters of water per year were spent on development. Every year the water intake from the Syr Darya and Amudarya increased, and over time the rivers no longer reached the Aral Sea and did not feed the sea, as it has been in recent years. The reasons, first of all, are the annual population growth in the republics of Central Asia by 2-2.5 percent. And here a few questions arise. For example, Kazakhstan with the current population of 19 million and Uzbekistan would be able to feed more than 33 million people if at one time the area of irrigated land was not brought from 1.8 million to 4.3 million hectares. The second reason why, knowing about the negative consequences for the Aral Sea, they nevertheless went to large-scale land development and huge expenditures of water resources of the Syr Darya and Amu Darya, was the need for the development of the Central Asian republics. It was during that period, along with the accelerated growth of agricultural production, large enterprises were built that not only provided products, but also provided jobs for the population. Together with the complex development of land, there was a complex construction of settlements in which millions of people live today. That is, without the development of new lands, we would not have achieved the level of economic development that became the basis for its further growth during the years of independence (Pokrovsky et.al, 2017; Zav'yalov et.al, 2006 a:892; Zav'yalov et.al, 2006 b:604; Zav'yalov et.al, 2005).

To better understand what led to the disaster, let's just turn to the facts, leaving emotions aside. Take a look at the map. Let's take the Syr Darya. It flows through Tajikistan, Uzbekistan and Kazakhstan. But almost three-quarters of its flow is formed in Kyrgyzstan, where the Karadarya and Naryn rivers originate from glaciers, at the confluence of which the Syr Darya is formed. And 80 percent of the Amudarya stream is formed in the mountains of Tajikistan and Afghanistan. Then the river flows along the border of Uzbekistan and Afghanistan, crosses the north-eastern part of Turkmenistan and then flows through the territory of Uzbekistan again. Probably, even with the current global warming and the recorded melting of glaciers, the water of these two rivers that fed the Aral Sea would be enough to preserve it (Ni et.al, 2003; Zavialov et.al, 2003; Sapozhnikov, 2012; Sapozhnikov et.al, 2009).

Currently, it is easier to estimate the area of the residual reservoir, since the remaining area of the Aral Sea already belongs to the drying zone. Consequently, when the processes of modern sedimentation in the residual reservoir of the Aral Sea are described, only the Western deep-water part of the sea will be taken into account, the area of which is 1/10 of the full-water Aral, and the salinity of the water has increased more than 10 times (110-120 g/l). In this small reservoir, the dynamics of wave movement is greatly weakened. Terrigenous sedimentation here currently occurs due to wave washing and re-deposition of previously accumulated bottom sediments (Abdimutalip, 2017).

According to his data, the salinity of the Aral Sea water ranged from 10.65 to 12.13 g/l. According to the data of 1901, the Aral Sea belonged to the sulfate formation, to the sulfate-chloride-magnesium-sodium facies. With an increase in the mineralization of water, the salts change from hardly soluble to easily soluble. According to the observations of 1961, the level of the absolute level of the sea mirror was 53 m, the salinity of the water reached a value of 11.38 g/l. In 1985, the Aral Sea level dropped to 42 m, while salinity increased to 20 g/l, and in 1990 the sea level fell to 39 m, while salinity reached 43.5 g/l (Aimbetova et.al, 2020).

In October 2003, in April and August 2004, the expedition work was repeated, and the research area covered the Chernyshev Bay and the strait between the

Eastern and Western parts of the Aral Sea. The results of hydrochemical studies for this period are shown in Table 1. For the convenience of comparing the results, the data of hydrochemical studies (Table 1) are given according to the works (Zhou et.al, 2021; Mamyrbekova et.al, 2017). From Table 1 and Figure 1, the first conclusion should be drawn that mineralization continues to grow.

In table 1, samples No. 2 and No. 15 refer to Chernyshev Bay, and samples No. 13 and No. 14 were separated for control. Chemical analysis of water samples was performed at the Institute of Geology and Geophysics of Uzbekistan and at the A. Wegener Institute of Marine and Polar Research in Germany.

As can be seen from table 1, the salinity of the water of the residual reservoir of the Aral Sea increases from year to year, and within a year - seasonally. Thus, from 2002 to 2004, the salinity of water (brine) increased from 81.67 to 114.4 g/l (on average by 10 g/l per year) (Plotnikov, 2013; Mordukhai-Boltovskoi, 1974).

Table 1 - Chemical composition of the Aral Sea water and determination of salinity

Sample No. (1-6, 2002; 7-12, 2003; 13-18, 2004)	pH	SO_4^{-2}	HCO_3^-	Na^+	K^+	Ca^+	Mg^{+2}	Σ salts, g/l	dry residue, g/l
		mg*eq/l							
1	8,2	420	8,23	486	7,6	40	364	72,1	
2	8,2	505	6,83	839	27	37	425	82,21	
3	7,9	126	10,03	956	22	25	416	80,82	81,67
4	7,9	618	7,47	406		60	358	90,24	
5	7,9	462	7,5	374	28	35	1102	84,3	85,37
6	7,9	477	7,5	388	27	35	1108	85,23	85,23
7	7,8	460	7,5	367	25	37	1091	83,27	83,55
8	7,8	460	7,5	363	25	32	1119	84,04	84,24
9	8	460	7,5	374	25	35	1102	84,12	84,28
10	8	464	7,5	380	25	35	1102	84,42	84,19
11	7,3	386	6,98	361	26	31	402	81,2	
12	7,5	346	6,98	352	98	31	398	79,2	
13	8,2	477	7,37	919	29	30	450	84,92	90,89
14	8,3	469	7,58	968	35	33	425	84,97	
15	8,2	614	6,5	1149	31	29	511	103,3	114,4
16	8,4	596	5,75	1165	31	29	516	103,9	110,5
17	8,2	618	6,5	1164	31	29	516	104,3	114,2
18	8,4	496	6	970	31	29	451	88,5	97

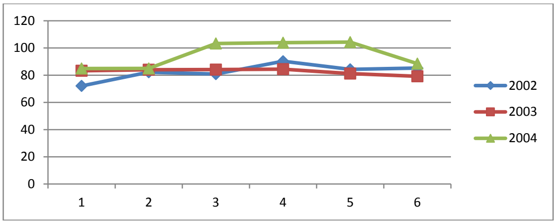

Figure 1 - Dynamics of increasing salinity for the period 2002-2004yy.

This indicates that intensive hypson accumulation is currently taking place in the waters of the Aral Sea, so the calcium content in the water is negligible. Recalculation of the results of chemical analyses for salt composition (table 2) confirms the above. In the brine of the residual reservoir, Na, K, Mg, SO4, C1 accumulate in the form of NaCl, KC1, Nacl, $MgSO_4$, Na_2SO_4 salts.

Table 2 - Probable salt composition of the waters of the Aral Sea for the period 2014-2016yy

№ проб	Probabilistic salt composition in %								Σ ions, g/l
	$Ca(HCO_3)$	Mg(HCO3)	$CaSO_4$	$MgSO_4$	$NaSO_4$	MgCl	NaCl	KC1	
1	0,24	0,59	3,53	16,83	17,31	9,88	50,88	0,48	72,1
2	0,15	0,48	2,96	17,82	17,53	9,87	48,71	2,48	82,21
3	0,27	0,65	1,87	5,2	2,97	19,7	67,29	2,08	80,82
11	0,2	0,44	2,41	13,05	15,87	12,73	54,16	1,14	81,2
12	0,2	0,44	2,45	13,71	14,85	12,53	54,53	1,29	79,2
13	0,1	0,61	2,38	20,79	13,16	8,06	52,53	2,37	84,92
14	0,18	0,49	2,48	18,9	16,93	8,3	49,65	3,07	84,97
15	0,12	0,35	1,8	18,91	18,13	8,06	50,38	2,25	103,3
16	0,12	0,35	1,77	18,32	17,39	8,54	51,38	2,21	103,9
18	0,16	0,44	2,11	18,8	15,43	8,81	51,64	2,61	88,5

In many cases, climatic conditions do not allow brine of salt lakes to concentrate to such an extent that other salts begin to settle (except halite), therefore, the onset of NaCl cages allows for a long time to exist in equilibrium in sulfate lakes with a sufficiently high content of SO_4 in salts. Under conditions conducive to an increase in the concentration of salts in the sea and if there is a sufficient amount of C1 in the inflow waters, accumulation of the latter may occur, leading to the predominance of C1 over SO_4 in sea salts. The banding of salt-bearing deposits in the drying zone (gypsum, rock salt) serves as an example of the reflection of climate changes in the sedimentation process. Salt-bearing strata are formed in the conditions of a warm arid climate, the changes of which are associated not so much with temperature fluctuations as with the humidification regime. By the manifestation of neogene gypsum in the drying zone of the Aral Sea, it is possible to determine the rhythmicity of climatic processes in the past and assess climate changes in the present.

In connection with the above-mentioned salinization process, it remains relevant to study the state of ecosystems of living communities inhabiting the coastal areas of the Avandelta of the Syr Darya, to assess biodiversity and identify the main species of hydrobionts.

The purpose of the study is to observe changes in the state of physical, chemical and biological ecosystems of the water masses of the residual reservoirs of the Aral Sea in the conditions of the current ecological crisis, as well as to study the mechanism of their adaptation to the conditions of a shortage of desalination runoff and the dryness of the regional climate.

Materials and methods. The practical application of observations was the use of plants from ancient times as indicators for finding fresh water in arid areas – a method of observation, now called bioindication. During the work, methods of chemical and physico-chemical analysis are widely used to determine the quantitative and qualitative composition of pollutants in the natural environment. A comprehensive study of the components of the Aral Sea (hydrochemical composition, temperature, microphytobenthos, etc.) was carried out using the latest methods and modern equipment, as well as GIS. The materials of marine research were selected at the site of the coastal zone near the mouth of the Syrdarya River. Here samples were taken in three biotopes: 1) by diving at a depth of 2 m (from the surface of a dense sandy bottom covered with a large rowan wavy shadow); 2) from the bottom, covered with plant remains of reed beds bordering the shore with a wide strip – at a depth of 5, 10, 15 and 20 cm; 3) from the branches of rhinoceroses and dest, covering the bottom with massive thickets at a depth of 15-20 cm (from the border of the reed) and at a depth of 0.5 cm-0.7 m from underwater slopes of aquatic vegetation. A dense growth was noted, indicating the presence of microepiphytic communities in all vegetative organs of plants. The hydrochemical composition of water was determined by the following methods: hydrogen index (pH) – potentiometric method of measurement, total mineralization – weight (arbitration) method of measurement, dry residue - weight (arbitration) method of measurement, carbonates, bicarbonates, – titrimetric method of measurement, hardness, calcium, magnesium – complexometric method of analysis, chlorides – argentometric method of analysis, sulfates – weight (arbitration) method of analysis, silicon – colorimetric method of analysis, sodium, potassium – potentiometric the method of analysis.

Results. When studying the changes in the salt composition of the object under study, hydrochemical analyses of water were carried out on selected samples for 2020 and 2021. The results of the chemical analysis of the water of the coastal zone of the Aral Sea for 2020 are shown in Table 3. The delivered samples of water, salt and soil were analyzed in the Laboratory of Hydrochemistry and Environmental Toxicology of the Institute of Geography. The analysis of the ion-salt composition of the waters was determined by the titrimetric method. Samples of soil and crystal salt were also delivered to the laboratory. According to the results of water extraction in soil samples, mineralization was at the sampling point No. 1 to 86 g/kg, No. 2 to 39 g/kg and No. 3 to 62 g/kg, in crystalline salt – 646 g/kg.

Table 3 - Ion-salt composition of the Aral Sea water for 2020y

Place of selection	мг/дм^3						Total ions, mg/dm3	Salinity, ‰	Water composition class according to O.A. Alekin
	Ca^{2+}	Mg^{2+}	Na^{+}+K^{+}	Cl^{-}	SO_4^{2-}	HCO_3^{-}			
No. 2 Chernyshov Bay (point B)	521,0	17194,2	60112,5	105316,2	40921,6	1373,0	225438,5	225,4	S^{Na}_{II}
No. 5 Aral Small Sea	881,8	1021,4	3062,5	4113,4	6243,9	274,6	15597,6	15,6	$ClSC^{Na}_{I}$
No. 12 Large Aral Chernyshov Bay point D	721,4	17559,0	57850,0	108153,0	34581,6	1464,5	220329,6	220,3	ClS^{Na}_{II}
No. 13 Large Aral -13	881,8	13692,2	45162,5	84040,2	28145,6	1250,9	173173,1	173,2	SCl^{Na}_{II}
No. 15 Large Aral Sea western part point B	641,3	802,6	2762,5	2659,5	6147,8	335,6	13349,3	13,3	Cl^{Na}_{II}
No. 15 Aral Small Sea	1042,1	14202,9	46950,0	87586,2	29202,2	1220,4	180203,8	180,2	Cl^{Na}_{II}
No. 26 Large Aral Sea point D	861,7	14263,7	45575,0	87586,2	26416,5	1159,4	175862,5	175,9	Cl^{Na}_{II}
No. 31 Tushchybas Bay point E	961,9	3964,2	16412,5	24112,8	16426,3	518,7	62396,3	62,4	Cl^{Na}_{II}

The species composition and the number of inhabitants of the reservoir depend on the properties of the water (Table 4), the volume of which is shown in Figure 2. The main idea of biomonitoring is that hydrobionts reflect the prevailing environmental conditions in the reservoir. Those species for which these conditions are unfavorable fall out, being replaced by new species with different needs.

Table 4 - Chemical composition of the Aral Sea water sample for 2021y

№	Place of selection	Physical and chemical indicators											
		pH	Total mineralization, mg/dm^3	Dry residue, mg/dm^3	CO_3^{2-}, mg/dm^3	HCO_3^{-}, mg/dm^3	Hardness, mg-eq/dm3	Ca, mg/dm^3	Mg, mg/dm^3	Cl, mg/dm^3	SO_4^{2-} mg/dm^3	Si, mg/dm^3	Na,K, mg/dm^3
1	near the shore	8,71	171082	202720	348	573	1218	800	14308	87207	21790	7,5	46049
2	the mid-dle of the sea	8,71	185868	203608	330	488	1238	800	14550	87916	30735	7,5	51042

Regulatory requirements	6,0-9,0	1000	1000-1500	not standardized	not standardized	not standardized	not standardized	not standardized	350,0	500,0	10,0	not standardized

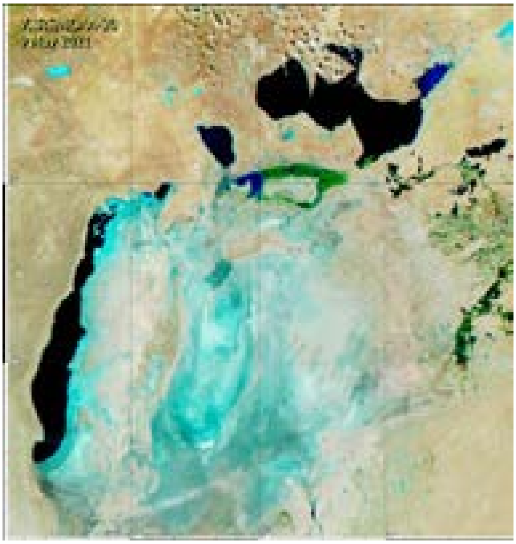

Figure 2 - Survey of the current state of the waters of the Aral Sea, 2021y.

On Lake Tshebas, the salinity of the waters of which on the day of sampling was slightly more than 70%, the material was selected on a wet salt crust 5 m from the water's edge, as well as from the surface layer of bottom sediments at depths of 5, 10, 20 cm and 1 m. In addition, for the analysis of microepiphyton, a sample was taken from an algae mat that completely covered the shore with a wide strip separating the salt crust and the mirror of open water. These algae - filaments from the genus Cladophora - grow on the surface of the bottom, anchored by rhizoids on the shells of bivalves. With strong surging winds, the waves are churning, they are torn off the ground and knocked down by clusters lying on the shore. Thus, communities of microepiphytes living on filaments were formed not at all in the surf band – but already here, in conditions of higher insolation, greater salinization due to evaporation of water and dramatic temperature changes during the day, inevitably underwent a number of structural changes, thanks to which they transformed into microphytic cenoses of the filamentous mat at the lower boundary of the drying band.

By its origin, the indigenous fauna of the Aral Sea before its salinization in the middle of the twentieth century was heterogeneous (Aladin et.al, 1995). Initially, more than 150 species of free-living invertebrates lived in the Aral Sea (Boomer et.al, 2000). 78% of free-living invertebrate species were inhabitants of freshwater and brackish-water continental reservoirs, 17% were Caspian species (representatives of the Caspian fauna), and only 5% were Mediterranean-Atlantic species (Junhong et.al, 2020). Unlike the Caspian, the Aral fauna was characterized by poverty and a low percentage of endemic species (Xiaoxiao et.al, 2022; Lisana et.al, 2022). Freshwater and Caspian species predominated in the native bottom fauna of the Aral Sea. In the 1950s-60s, 8 species of free-living invertebrates were introduced into the Aral Sea, including eurybiont benthic species Hediste diversicolor, Abra segmentum, as well as planktonic Misida: Paramysis (Mesomysis) intermedia and Paramysis (Serrapalpisis) lacustris (Aladdin et.al, 2008).

In 1989, the Small Aral Sea completely separated from the Big One and only euryhaline species remained in the Small Aral Sea at a salinity of about 30%. The total number of benthic invertebrates excluding Protozoa, small Metazoa and rare species was 11 species in the Small Sea in 1988. The regional project of the neighboring territories of GIZ “Ecologically oriented regional development of the Aral Sea region” is aimed at the production potential of environmentally friendly production of Artemia saltwater shrimp in the Aral Sea region. The project is characterized by a limited future potential for the extraction of artemia from the West Aral Sea, but the potential for the development of a new industry for the cultivation of artemia on salt-affected soils south of the Aral Sea basin in Karakalpakstan. In the plan, there is an opportunity to lead to new industrial activities with the use of artemia breeding and aquaculture: the creation of new jobs and a new sustainable development for Karakalpakstan. The possibility can be considered subject to positive results of tests for the viability of shrimp and short-term cultivation in nurseries using typical water samples from drainage channels and wells.

Discussion. In addition, a number of reclamation works are being carried out to restore the ecosystems of the Aral zone. To this end, since 2018, large-scale forest reclamation works have been carried out using special technology to sow about 3.2 million hectares of the dried-up seabed with protective forest plantations. Moreover, if over the previous 42 years saxaul plantations with an area of 400 thousand hectares were created here, then only during the winter-spring period of 2018-2019, 461 thousand hectares were covered with protective forest plantations. Based on the experience already accumulated in the winter-spring period of 2019-2020, another 706 thousand hectares are covered by the green cover. Saplings of saxaul are pre-grown in nurseries of more than 80 forestry enterprises throughout the country, a territory is assigned to each on the drained bottom of the sea, a large number of special equipment and aviation are involved. The final result of the work carried out is to bring the area of forest plantations on the part of the dried-up bottom of the Aral Sea to 60% by 2030y.

According to the estimates of the academician, Doctor of Agricultural Sciences

Z. The roots of the saxaul grow parallel to the soil and are fixed in a mixture of sand, earth and salt. Shoots that rise above the surface prevent erosion and act as a protective forest belt, reducing the wind speed on the surface by 60-70%. At the age of ten, one plant will retain ten cubic meters of sand. After that, fodder plants will be planted between the grown rows of the saxaul. Consequently, animal husbandry will be intensively developed in the region.

The retreating sea left behind 54 thousand square kilometers of dry bottom, covered with salt, and in some places also with deposits of agricultural pesticides, washed away once by runoff from the fields. Currently, during hurricanes, a mixture of salt, dust and pesticides rises into the atmosphere and spreads over a radius of 500 kilometers or more, polluting the air and salting fertile lands. The ecological balance of the region was disrupted, which led to the disappearance of a number of representatives of flora and fauna, the death of all living things for hundreds of kilometers around the sea. Tugai were cut down or died from lack of water, more than 60 percent of reed beds in the lower reaches of the Amu Darya dried up. The local population began to suffer from respiratory diseases, anemia, cancer of the throat and esophagus, as well as digestive disorders, liver and kidney diseases. The main purpose of creating reservoirs in the Amudarya delta, as experts explain, is to improve the ecological situation, partially restore disturbed and create new ecosystems, ensure the regularity of the regime of water bodies in the project zone, preserve and sustainably develop biodiversity, increase the natural productivity of bioresources of the Aral Sea region. One of the important components of improving the ecological situation in the region is also the creation of forest zones using drought-resistant and salt-resistant local shrubs.

Now the salinity of the Small Aral Sea is ideal for the habitat of various fish. The lake has also become a home for waterfowl. Many fish breeds returned here, and this was the impetus for the opening of new jobs, an increase in income. The implementation of the second part of the RSRNAS project, which takes place in the Aral Sea region, will serve to increase fish farming and fishing. The implementation of the RSRNAS-2 project will have a positive impact on the socio-economic situation in the Aral Sea region. Namely: to ensure sustainable water supply of irrigated lands with an area of more than sixty thousand hectares, irrigation of pastures and hayfields, will protect a number of settlements from flooding. As a result, the level of mineralization of the water of the Northern Aral Sea was reduced from 23 to 17 grams per liter, the volume of water increased from 15 to 27 cubic kilometers. The capacity of the Syr Darya increased in winter to 650-700 cubic meters of water per second. The provision of water to irrigated lands has improved. This, in turn, made it possible to restore large lakes and develop fisheries.

Conclusion. The crisis situation caused by the drying up of the Aral Sea has developed as a result of the economic and agricultural policy of irrational use of water resources, the growth of irretrievable water consumption for irrigation. As a result, the sea level dropped by 29 meters, the area of the water area decreased by more than half, the coastline retreated by 120 kilometers, and the volume of the sea decreased by 90 percent. It cannot be said that they had not been engaged in solving the problem of the Aral Sea before. Various measures were taken, both in Uzbekistan itself and at the international level, for example, by the International Fund for Saving the Aral Sea. Assistance and support from other countries in overcoming the negative consequences of the Aral disaster are important and necessary. But Uzbekistan itself should set the tone for large-scale work. And a number of major projects in this direction are being actively implemented in the republic. For example, much attention is paid to forest plantations on the dried-up bottom of the Aral Sea. During the years of independence, according to some data, their area in the Aral Sea region exceeded 400 thousand hectares. However, not all plants started, as the technology was often violated. Back in the 1990s, the sea became so shallow that fish disappeared in the salty waters. Time has passed, the project “Regulation of the Syrdarya Riverbed and preservation of the northern part of the Aral Sea” (RSRNAS) began to be implemented in the region. Thanks to the restoration of the fishing industry in the Aral Sea region, it is now better, as fishing has begun to generate income and has become the center of fishing in the Small Aral Sea. Scientists of the Institute of Fisheries, located in Aralsk, closely monitor the fishery. This is done so that there is no overfishing, in order to collect biological data on marine fish.

Clearly, the blame is human intervention, which led to the death of the Aral Sea. So, we will not see the former Aral Sea even on a smaller scale anymore. The three lakes that are now in its place will remain. They are fed by groundwater and other sources, but not by the Syr Darya and Amu Darya. The resulting Aralcum should be planted with saxaul and other plants resistant to salt and drought. These lessons are relevant, because in a number of regions of the world there is also a situation when, due to uncontrolled intake of water for various economic needs from rivers feeding seas and lakes, they are gradually decreasing in size. According to experts, over the past 40 years, the area of the famous Dead Sea has decreased by a third, which is already divided into two parts and continues to be shallow, and skeptics claim that in half a century the sea may disappear altogether. Since the 1960s, Lake Chad, the largest reservoir in Africa, began to shrink. The Great Salt Lake in the USA is decreasing. Work is underway to save Lake Urmia in the northwestern part of Iran, which is considered one of the largest drainless salt lakes in the world. If it dries up, billions of tons of salt will remain in its place, and millions of people living near the reservoir will find themselves in conditions similar to those in which the residents of the Aral Sea region found themselves. At the same time, it is increasingly difficult to control water intake, especially from transboundary rivers feeding lakes and seas. And given the growing shortage of fresh water and food in a number of regions of the world, experts predict even the possibility of conflict situations between some countries.

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Information about authors:

Abdimutalip Nurlibek – Doctor of Sciences (Environmental), Acting Associate Professor of the Department of Ecology and Chemistry of the Faculty of Natural Sciences, A. Yasavi International Kazakh-Turkish University, Turkestan, Kazakhstan, nurlibek.abdimutalip@ayu.edu.kz, ORCID ID: https://orcid.org/0000-0003-1173-4344;

Kurbaniyazov Abilgazy – Candidate of Geographical Sciences, Professor, Department of Ecology and Chemistry, Faculty of Natural Sciences, A. Yasavi International Kazakh-Turkish University, Turkestan, Kazakhstan, abylgazy.kurbanyazov@ayu.edu.kz, ORCID ID: https://orcid.org/0000-0002-2983-6763;

Toychibekova Gaziza – Doctor of Sciences (Environmental), Acting Associate Professor of the Department of Ecology and Chemistry of the Faculty of Natural Sciences, A. Yasavi International Kazakh-Turkish University, Turkestan, Kazakhstan, gaziza.toychibekova@ayu.edu.kz, ORCID ID: https://orcid.org/0000-0003-3575-3021;

Koishieva Gulnar – Candidate of Chemical Sciences, Senior Lecturer, Department of Ecology and Chemistry, Faculty of Natural Sciences, A. Yasavi International Kazakh-Turkish University, Turkestan, Kazakhstan, gulnar.koishiyeva@ayu.edu.kz, ORCID ID: https://orcid.org/my-orcid?orcid=0000-0002-1892-0521;

Shalabaeva Gulshat – Candidate of Technical Sciences, Acting Associate Professor, Department of Ecology and Chemistry, Faculty of Natural Sciences, A. Yasavi International Kazakh-Turkish University, Turkestan, Kazakhstan, gulshat.shalabaeva@ayu.edu.kz, ORCID ID: https://orcid.org/0000-0003-3605-4708;

Zholmagambetov Nurbek – Candidate of Technical Sciences, Associate Professor, Head of the Department of Mine Aerology and Labor Protection, Karaganda State Technical University, Karaganda, nurbekz@mail.ru, ORCID ID: https://orcid.org/0000-0002-3337-9833.

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