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THE ARAL SEA CRISIS AND ITS IMPACT ON THE CURRENT STATE OF WATER BODIES AND HIGHER AQUATIC VEGETATION

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Abstract:

The lowering of the Aral Sea level, which began in the 1960s of the last century, due to the water withdrawal from the Amu Darya river for irrigation of agricultural lands in the Aral Sea region, led to the world's largest environmental crisis. The ecological disaster affected the entire region, and first of all, the hydrographic network of the Amu Darya delta. This was especially evident in the coastal water bodies, which are located along the southern coast of the sea and sea bays of the former coast of the Aral Sea.

Due to the shortage of water resources in the Aral Sea region, the watering of natural reservoirs in the Amu Darya delta has sharply decreased, which has led to a reduction in fishing grounds. Currently, there are only about 10 lakes formed as a result of waste and collector-drainage waters, and the share of natural lakes is only about 5 thousand hectares and they are also fed by waste waters [1].

Due to the unstable hydrological regime, the state of water bodies in the delta zone of the Amu Darya River has changed significantly at the present time. First of all, the hydrological regime deterioration led to an increase in the salinity of many lakes, the disappearance of a large number of aquatic plants and a decrease in the fish species composition.

This article provides an analysis of the current state of water bodies, higher aquatic plants and recommended measures to restore ecological stability.

Keywords: Aral Sea, ecological crisis, water bodies, higher aquatic vegetation, biodiversity, fish community, fish farming.

1.INTRODUCTION

Due to the changed and unstable hydrological regime, the water bodies state in the delta zone of the Amu Darya River has been significantly disturbed. Therefore, the study of the aquatic ecosystems potential has become a priority and urgent.

The studies were carried out in 2018-2020 in the Southern Aral Sea region, on the main natural reservoirs where fish were previously caught, such as: Sudochin lake system, lake Zhaltyrbas, lake Dautkul, lake Sarbas.

Studies of higher aquatic vegetation were carried out on the basis of guidelines: "Keys to higher plants of Karakalpakstan" [3], illustrated key to higher plants of Karakalpakstan and Khorezm [10; 11], « Aquatic vegetation of the Amu Darya delta » [8].

Based on the results of the authors' research, new data were obtained on the current species composition and biodiversity of higher aquatic plants, overgrowth of water bodies and the hydrochemical composition of lakes.

2.STUDY LOCATION

A climate characteristic feature in the lower reaches of the Amu Darya and the Aral delta is a low amount of precipitation. Their annual amount is slightly lower than in the rest of Central Asia and amounts to 80-100 mm.

The climatic conditions of the Aral Sea region have undergone significant changes in the past three decades. According to experts, this is due to the coincidental change in circulation processes in the territory of Central Asia and a drop in the the Aral Sea level [7].

The studied lakes are located in the Republic of Karakalpakstan in the Amu Darya delta. The main water bodies of the study are water bodies of the delta zone of the Amu Darya River (lake Dautkul, lake Sarbas, Sudochin lake system, lake Zhaltyrbas) (Fig. 1.) [21].

Lake Sarbas (II) is located in the Muynak region. It arose on the sea site, which had dried up by 1974, as a result of its intense regression.

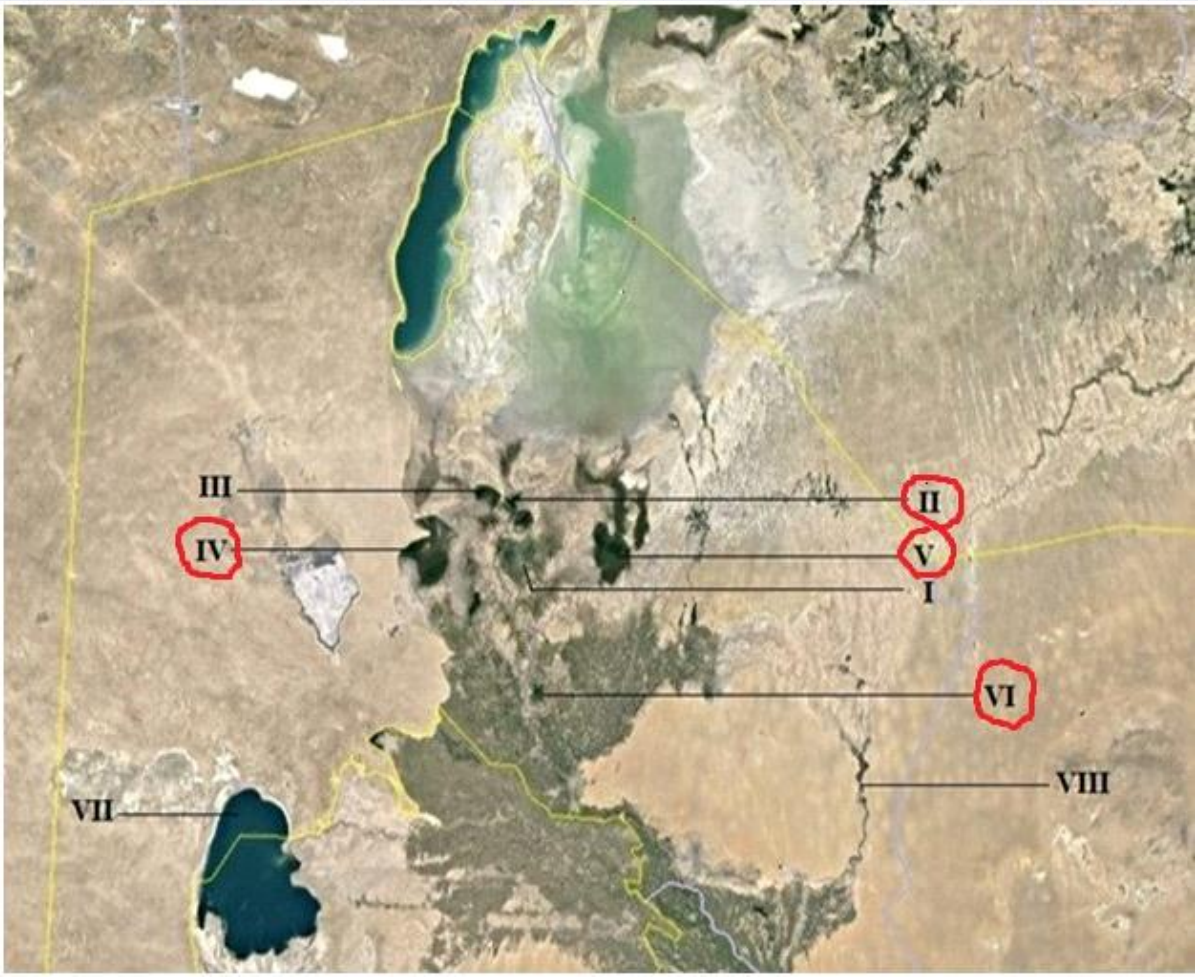

Fig. 1. A schematic map of the water bodies location of the Amu Darya delta: I – Interfluvial reservoir; II – Lake Sarbas (Fishing); III – Lake Muynak bay; IV – Lake Sudochie; V – Lake Zhaltyrbas; VI – Lake Dautkul; VII – Lake Sarikamysh; VIII – South Karakalpak main collector (SKMC);

Sudochin lake system (IV) –is one of the best-preserved ecological zones in the left-bank delta of the Amu Darya. Lake Sudochye and adjacent lake systems – small and large Sudochie, Karateren, Begdulla Aydin, Omar Salym, Karajar, Kariszagis, Akushpa is located 220 km north of Nukus [6]. Area - 19,000 hectares.

Lake Zhaltyrbas (V) – is a large reservoir with an area of 10,000 hectares. It was formed on the site of the eponymous gulf of the Aral Sea, which was completely drained in 1968.

Lake Dautkul (VI) – is one of the commercial lakes (4390 hectares), located in the south of the modern right-bank delta of the Amu Darya, 80 km north of Nukus city in the Kegeili region.

3.METHODS AND MATERIALS

As a methodological basis were used - traditional geobotanical and ecological research methods, set out in the classic manuals: "Keys to higher plants of Karakalpakstan" [3; 10; 11], "Guide to methods for hydrobiological analysis of surface water and bottom sediments» [9], «Aquatic vegetation of the Amu Darya delta » [8].

The hydrochemical composition of the reservoirs was carried out according to the "Unified methods for water analysis" [13].

When examining reservoirs, the following characteristics were taken into account: air and water temperature, organoleptic indicators of water such as: color, odor, turbidity, foaminess.

Lake Zhyltyrbas is located 30 km from the Kazakhdarya village. (N43º32′06.5″ W59^{0}55′42.2″).

Lake Dautkul – located in the south of the modern right-bank delta of the Amu Darya, 80 km north of Nukus city (N42º52′13.02′′ W059º38′10.87′′).

Location of lake **Sarbas** in the Muynak region (N43º52′03.21′′ W059º 05′ 32.51′′).

Sudochin lake system – is one of the best-preserved ecological zones in the left-bank delta of the Amu Darya (N43º25′00.97′′ W058º 29′ 59.49′′).

4.RESULTS AND ITS DISCUSSION

The reduction of the Amu Darya runoff and the lowering of the Aral Sea level led to the fact that many lakes completely dried up. The deterioration of the hydrological regime and the increase in water salinity has led to a qualitative and quantitative change in the water bodies phytocenoses. Here a change of plant communities takes place. For the same reason, there was an increase in the salinity of many lakes, which was reflected, first of all, on

the development of fisheries [22]. Changes in hydrochemical indicators led to the vegetation change and the disappearance of many species of water-submerged plants.

So, according to B. Sherbaev [23], the following species of higher aquatic plants were not found: aldrovanda vesicular (*Aldrovanda vesiculosa* L.), arrowhead three-leafed *(Sagittaria trifolia*), shield-leaved swamp flower (*Nymphoides peltatum*), water lily pure white (*Nymphaea candida),* pemphigus vulgaris (*Urticularia vulgaris*), salvinia floating (*Salvinia natans)*, stalk-embracing pondweed (*Potamogeton perfoliatus*), zannichellia big (*Zannichellia major*), hornwort immersed (*Ceratophyllum demersum*), which were mentioned in the book by O. Bondarenko in 1964 [3].

Therefore, the violation of environmental conditions necessitated research on changes in the water bodies state, the species composition of higher aquatic vegetation and the degree of overgrowth of water bodies.

Each studied lake is distinguished by the overgrowth area and the species diversity of higher aquatic plants.

The aquatic vegetation study was carried out on Lake **Dautkul**, one of the commercial lakes located in the south of the modern right-bank delta of the Amu Darya, 80 km north of Nukus city in the Kegeili region.

Water intake is carried out by gravity through the Akeden Canal and by a pump from Lake Dautkul. The soil is represented by sand and pebbles, in places of deepening in the former lakes bed place, the soil is black with the smell of hydrogen sulfide. The pollution source of the reservoir is the collector-drainage runoff. The reservoir area is 1700 hectares along the bottom, maximum depth - 5 m, average — 3, minimal — 0.7 m, average water transparency 0.5 m. The reservoir is 85% occupied by powerful thickets of reed (*Phragmites australis* Trin.), in places in the form of "caps". The reaction of the water is slightly alkaline (pH – 7,51).

In the reed thickets, the bottom is silted up and the biochemical formation of hydrogen sulfide occurs due to mineral salts and organic compounds of plant and animal origin. Due to the lack of flow and water renewal in the system, the oxygen regime was deteriorated – O_2 – 17,7.

The shores of the lake are flat, heavily indented. Water transparency up to 4-5 m.

When examining the aquatic and coastal-aquatic vegetation of the lake, a high overgrowth was noted. The growth of thickets of narrow-leaved cattail was recorded among coastal plants *(Typha angustifolia* L), from submersible –pectinate pondweed (*Potamogeton pectinatus* L.), types of water milfoil – whorled *(Myriophyllum verticillatum* L.), dominated by water milfoil spicate (*Myriophyllum spicatum*) [16; 18].

Lake Sudochye – is one of the best preserved ecological zones of the Amu Darya delta. Sudochye is located in the western part of the Amu Darya delta. Before the beginning of the drying up of the Aral Sea, it was connected with it by a narrow channel and served as a spawning ground for semi-anadromous fish species. Catches in Sudochye reached 2000 tons per year, and the maximum depth was 3 m. Intensive withdrawal of water from the Amu Darya led to a significant drying up of its delta, and soon the lake lost its national economic importance. At present, the lake includes lakes system - small and large Sudochye, Karateren, Begdulla Aydin, Omar Salym, Karadzhar, Kariszhagis, Akushpa [6].

Mineralization of Lake Sudochye differs in different sampling points. The maximum mineralization is 2.9 g/l, the minimum is 2.1 g/l by the salinity type, the water is chloride-sulphate and sulphate-chloride.

Salinity fluctuates spatially. Zones with high salt concentrations are formed in shallow water areas.

The aquatic vegetation of the lake is represented by dense reed thickets and abundant cover of the water column with water milfoil. (*Myriophyllum spicatum* L.). There is a strong overgrowth of the reservoir. On the lake, the shores and islets are covered with dense reed thickets [23].

In the warm season, the water warms up to 25-27 °C.

Lake Zh**y**ltyrbas – is a large reservoir with an area of 10,000 hectares. Maximum depth - 4 meters, minimum - 0.8-1m. It was formed on the site of the eponymous bay of the Aral Sea, which was completely drained in 1968, is shallow and consists of a large number of reaches and reed beds. The bay degradation was stopped in the early 80s, due to the supply of collector-drainage waters KS-1 and KS-3 to Kazakhdarya drain. In 1997 and 2003-2010, as a result of the implementation of the ASBP-1 (Aral Sea basin program) and ASBP-2 programs, a construction was carried out to regulate the lake's hydro-regime [14].

Due to the dam construction, the water level in it stabilized several years ago, and this reservoir was one of the most significant wetlands and fish lands against the catastrophic background drying out of the Aral lakes. However, in dry years (2000-2002), the water level in the lake dropped sharply. Silting, shallowing and a sharp reduction in the water area took place.

The bottom is silty and sandy. The coastline is indented. Reed found in areas of shallow flooding (*Phragmites australis* Trin.), reedmace (*Typha angistifolia* L.) and reeds (*Schoenoplectus litoralis* (Schrad.) Palla). The shallow water is heavily overgrown with water milfoil (*Myriophyllum spicatum* L.) and hydrohalophilic species of pondweed: pectinate (*Potamogeton pectinatus* L.) and curly (*Potamogeton crispus* L.).

The observation results show that the water of Lake Zh**y**ltyrbas is distinguished by a higher mineralization.(8,79 g\l) [17; 20].

Lake Sarbas appeared on the site of the eponymous bay of the Aral Sea, which had dried up by 1974. Since 1962, watering was started due to river runoff, but water inflows were episodic. It is currently a stable reservoir.

The soil is silty, in some places sandy. The overgrowth of the reservoir is very high (50-55 %). The predominant species are water milfoil spicata (*Myriophyllum spicatum* L.) and pondweed curly (*Potamogeton crispus* L.). During the observation period, these plants formed continuous dense thickets. The coastal southern and

southeastern parts are represented by thickets of reed, cattail and sedge. Among water-immersed plants, water milfoil spicata (*Myriophyllum spicatum* L.), pondweed curly (*Potamogeton crispus* L.), pondweed pectinate (*Potamogeton pectinatus* L.) are widespread.

Shallow floods are covered with low thickets of narrow-leaved cattail (*Typha angistifolia* L.), seaside reeds (*Schoenoplectus litoralis* (Schrad.) Palla), sea bolboschoenus (*Bolboschoenus maritimus* (L.) Palla.). The dominant associations are curly pondweed (*Potamogeton crispus* L.), water milfoil spicate (*Myriophyllum spicatum* L.), which take an active part in the overgrowing of this reservoir [2].

Mineralization of water is 3,39 g\l – 4,84 g\l. This lake is characterized by a seasonal change in water salinity, which depends on the water content. Thus, abundant overgrowth of water bodies with aquatic vegetation is an advantage for breeding phytophilous fish [19].

The water salinity in the studied water bodies varies over a wide range (2-5 g\l), but it is not critical for fish farming, moreover, when using grown fish seed material (20-25 g) for a hot climate season, you can grow marketable fish up to 1.5 kg, even with a mineralization of 11-12 g/l [5]. According to Martynova and etc. [15], and also Konstantinov and etc. [12], carp-like fish (carp, grass carp, silver carp) with water salinity 1-3 g/l show faster growth than in fresh water.

5.CONCLUSION

The investigated water bodies – Lake **Dautkul**, Lake **Sudochie**, **Zhyltyrbas** and **Sarbas** differ in the overgrowth degree and species composition of aquatic macrophytes and depend on water input. The dominant higher aquatic plants are reed (*Phragmites australis* Trin.) and cattail (*Typha angistifolia* L.), and also curly pondweed (*Potamogeton crispus* L.), spicate water milfoil (*Myriophyllum spicatum* L.), which are actively involved in the overgrowing of water bodies. Studies carried out on the reservoirs of the Amu Darya delta have shown that they are characterized by strong overgrowth, in connection with which a complex of reclamation works is required. One of these effective measures is to combat overgrowth by using herbivorous fish, in particular grass carp (*Ctenopharyngodon idella*), white Amur bream (*Parabramis pekinensis*), white (common) silver carp (*Hypophthalmichthys molitrix*) [4].

Mineralization of the studied reservoirs allows for breeding (aquaculture) of phytophilous fish such as grass carp (*Ctenopharyngodon idella*), carp (*Cyprinus carpio* Linnaeus).

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