Creation of ecological sustainability of the main riverbeds in the coastal territories of the Southern Aral Sea region

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Abstract. The article provides an analysis of materials concerning the use of transboundary rivers in Central Asia related to the creation of artificial reservoirs in mountainous areas. An assessment of the prevention of possible breakthroughs of dams and earthen dams formed in mountain riverbeds is given, and the possibility of using water from artificial small local reservoirs for energy and irrigation needs is assessed. The climatic, geographical and demographic conditions of Uzbekistan require the development of a water management system.

1 Introduction

One of the most important problems of the modern stage of human development is the rational and efficient use of water resources, as well as protection from their harmful effects, which involves regulating river flow, including the creation of reservoirs, ponds, storage tanks, etc.

Instead, with the increasing demand for water resources in many parts of the world, particularly in our region, water scarcity is also increasing every year. The climatic, geographical and demographic conditions of Uzbekistan require the development of water management networks. Therefore, these issues are of particular importance when conducting targeted research aimed at improving the methods of their effective management and integrated use of water resources. The article also discusses the issue of automatic water volume control for a reservoir.

As a result of intensive changes in the modulus of soil deformation and the observed failure of groundwater dams, roads and canals entered the coastal area. Collectors, municipal and household equipment and hydraulic structures – dams, dams, reservoirs, as well as systems of small local reservoirs.

According to the current regulations, all these structures must be protected from the harmful effects of the environmental consequences of the coastal territories of the Aral Sea. To ensure reliable operation of structures, it is necessary to know the permissible values of

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the deformation parameters of the base and, if the permissible deformations are exceeded, apply certain measures to eliminate a possible accident of the structure.

Accidents of underground dams, as shown by extensive experience in the operation of these structures in hydraulic engineering, are associated with significant material damage, due to the emptying of reservoirs and flooding of nearby territories, with human casualties, and dam failures can lead to environmental pollution.

The study of fracturing in groundwater dams in coastal areas is of great scientific importance. It has been established that one of the main causes of transverse cracks, as the most dangerous for structures [11]. Currently, quite a lot of studies of soil tension have been conducted both in our country and abroad, which makes it possible to assess the degree of danger of deformation phenomena. According to observations, the destruction of the structure began with the formation of a crack and the release of a turbid stream along the crack from the ridge to the base of the lower slope. The crack at the bottom began to expand rapidly and the flow exited through it, causing soil suffusion, where progressive erosion led to the formation of gullies in the body of the dam (the dam collapsed).

The problem related to the use of water resources, the reduction of environmental and social roles under the influence of natural and anthropogenic factors on the human environment are common to the entire region and involve the development of a unified strategy for the rational use of natural resources. According to the above, the research objectives of this scientific work are formulated.

2 Materials and methods

Tension of water situation in the Central Asian region, including the lower reaches of the Amudarya River, has caused enormous damage to the national economy and nature due to water shortage. At present, there is a need to develop measures for rational use and improvement of water resources management.

3 Results and Discussion

The main theoretical and practical foundations are reflected in the works (Douglas Webeter, Ti Le Hu, M. Falkenmark, Margaret Catlay - Carlson, Dukhovny V.A., Sokolov V.I., P.A. Polad - Zadeh, V.I. Sokolov, A.I. Tuchin, E. Kurbanbaev and others).

Conditions of water masses movement in river beds and reservoirs are characterized by unsteady water movement, influence of complex natural conditions. During the operation of hydraulic structures, channel deformation continuously occurs, which leads to changes in hydrometric indicators that form the hydraulic characteristics of the river bed. The mentioned factors should be taken into account in the methods of calculation of prediction of channel processes, which are used different engineering methods of calculation. Empirical methods based on the processing of experimental data in the form of regression controls are also used.

In the work of [1] Prof. A.E. Asarin notes the role of the transboundary rivers of the Amu Darya basin, where an extremely complex picture of integration between independent states has developed.

The Amu Darya River and its main component, the Panj River, form a natural water boundary for a considerable length between Afghanistan on the one hand and successively Tajikistan, Uzbekistan and Turkmenistan on the other. Further, the Amu Darya flows through the territory of Turkmenistan, then along the border between Turkmenistan and Uzbekistan, and finally, after entering the territory of Uzbekistan, it reaches the Aral Sea.

The predominant part of the hydropower potential of the Amu Darya River basin is concentrated on its two main components – the Vakhsh and Panj rivers, which cross the mountainous regions of Tajikistan and Afghanistan with high slopes and thus possess enormous energy of soaring (high pressure). The main water withdrawals for agriculture are confined to the flat area of the Amu Darya River for irrigation of the lands of Afghanistan, Uzbekistan and Turkmenistan. It is solved on the basis of international treaties [1]. Water users of the Amu Darya River basin include: energy, irrigated agriculture, municipal water supply, as well as the Aral Sea system, considered as an independent object of water consumption.

Under conditions of water resources deficit, water as a factor determining the level of socio-economic development of the region and satisfaction of ecological requirements of the society has no alternative, that is why at present the most expedient operation mode of reservoirs remains irrigation mode.

For all Central Asian countries, water resources are the basis for two major economic sectors: hydropower and irrigated agriculture, which, in the arid climate of the region, is based on irrigation.

The solution to the problems of the relationship between hydropower and irrigation in Central Asia can only be achieved through development and integration within the framework of cooperation between the countries of the region [1-2, 9].

In the article [2] Professor G.N.Petrov analyzing many years of materials on the integrated use of water and energy resources of transboundary rivers in Central Asia came to the conclusion that the solution of problems can be achieved only on the way of development and integration, within the framework of cooperation between the countries of the region.

In work [9] prof. E. Kurbanbaev, exploring the role of the principles of integrated water resource management of the Amudarya River delta, notes the tense water management situation in the lower reaches of the Amudarya River due to water shortage.

Throughout the history of the Amu Darya River several independent deltas have been formed and the Priaral delta is a new one. The Priaral delta is an alluvial plain composed of river sediments, which starts from the Takhiatash cape, along the rest of the contour the border is clearly expressed between the alluvial plain and the sandy desert Kyzylkum on the right bank and the Ustyurt plateau on the left bank. The territory covers the northern part of the Priaralie delta of the Amu Darya. The position of the river delta is intensively irrigated land starting from the town of Kungrad and westward to the Ustyurt Chink. In the right-bank border can be the channel of the Kazakhdarya, which is bordered on the eastern side by the Gulf of Zhiltirbas (Figure 1).

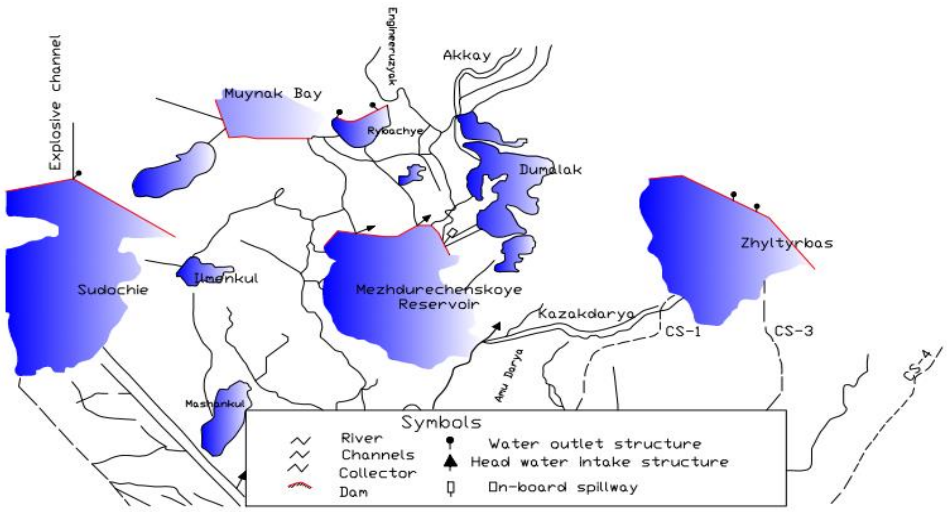

Fig. 1. Map of the location of hydraulic structures in the delta of the Amu Darya River.

Due to the lowering of the Aral Sea level and draining of sea bays, huge changes took place in the Amudarya River delta. Starting from 1968 - 1970, the Adjibay, Muynak, Rybachiy, Mezhdurechenskoye, Zhiltirbas, Sudochie and a number of other small water bodies were drained (Figure 2).

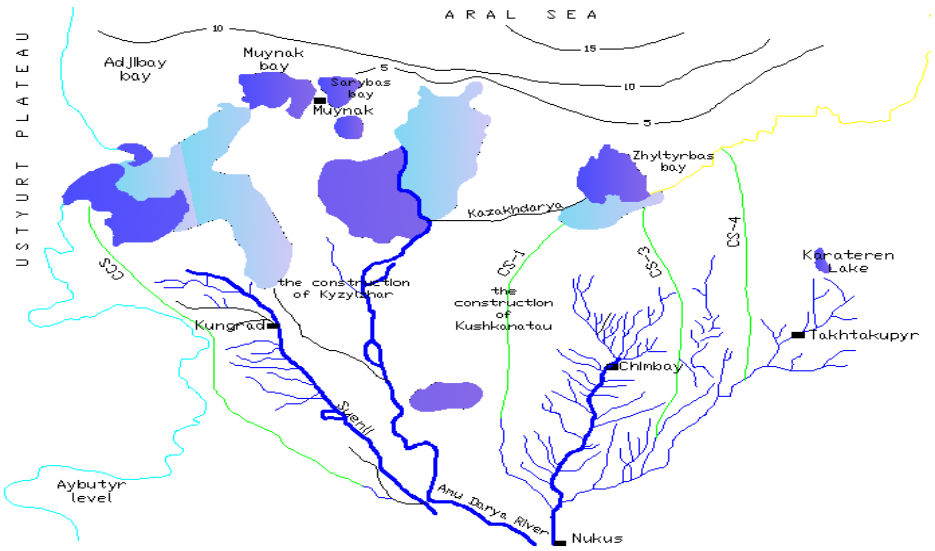

Fig. 2. Schematic map of the Amu Darya River delta.

Large-scale water management construction works were carried out in the area of the Mezhdurechensk reservoir. Due to this, water management and distribution capabilities have now been created in the delta, which have been achieved through safe water management.

To improve the environmental situation in the Southern Aral Sea region, the staff of the SANIIRI [3] developed a proposal to enclose it under the sea in the southern part and create an avalanche at the 53 m mark. By now, facilities are being designed and built for the

normal functioning of the Mezhdurechensk reservoir. According to the project [12], it was proposed to create a system of local lakes in the Southern Aral Sea region (Figure 3).

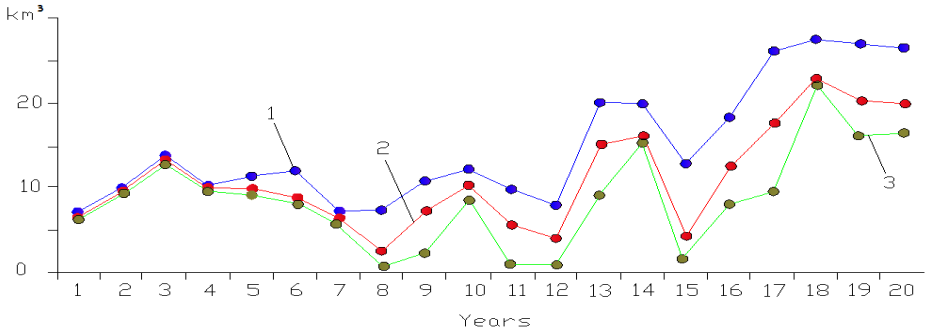

Fig. 3. Forecast of the Amu Darya river flow for 20 years in the Samanbai formation under various scenarios for the development of states in Central Asia: 1 – optimistic; 2 – intermediate; 3 – while maintaining the existing trends in the development of this region.

Analysis of the results of existing [4, 12] and engineering-geological studies [12] showed that sandy loam and dusty sands are found in the construction area of the Mezhdurechenskoye reservoir. When filling the reservoir, water filtration will occur through the soils. The results of studies of domestic and foreign scientists have shown that water filtration through sandy and dusty sands causes volumetric deformations in time, which will have an unfavorable effect on the serviceability of structures.

In 2017 - 2022, together with the Karakalpak Branch of the Academy of Sciences of the Republic of Uzbekistan, we conducted scientific research to determine the stress-strain states in the body and base of the dam of the Mezhdurechenskoye reservoir. Hydrological, mechanical and hydrodynamic characteristics were determined to assess the stability of the considered objects. Geomorphologically, the site is located within the Amudarya River delta floodplain. In these conditions, channel forms caused by channel processes are developed.

The Mezhdurechenskaya reservoir is a reservoir for regulating and managing water supply to the Muynak and Rybachye reservoirs, as well as to Lake Maypost and the Akdarya River. In order to accumulate water in the Mezhdurechensk reservoir with a volume of up to 440 million m^3 at a normal retaining level of 57.0, the crest of the Northern and Eastern Dams is located at 59.0. In this way, ground structures are being built to create the Mezhdurechensk reservoir.

In recent years, the PLAXIS computer program has been used to calculate the stress-strain state of the dam body and foundation. In the calculations, the soil medium is divided into finite elements of a discrete medium and stress and strain components are calculated at the nodal points.

The article [6] outlines the economic significance and effectiveness of the Rogun hydroelectric complex; the role of the hydroelectric complex in providing consumers with water is shown. A description of the design of the main structures and design features of a complex hydraulic system with a stone–earth dam is given.

4 Conclusion

- The analysis of the results of theoretical, experimental and field studies, design studies, as well as observations on the operation of hydraulic structures made it possible to

develop a hydraulic method for calculating the stability and deformability of earth structures built on the coastal territories of the Southern Aral Sea region.

- In recent years, there have been significant violations of the ecological state in the lower reaches of the Amu Darya River; Studies on anthropogenic changes in the channel process in the Aral Sea region, flow reduction, redistribution in time and regulation can have various impacts on the channel forms developing and existing in river channels. The nature and degree of such impact depends on changes in kinematic and dynamic factors of urbanisation.
- In the delta of the Amu Darya River there is a global problem of the world requiring the development of measures to improve the current state of the Aral Sea. After 1990 by regulation of river flow by reservoirs and low water, i.e. due to sharp reduction of water flow and drop of sea level below 33 m abs. the Aral Sea dried up. Recently in our work we have studied hydrological and hydraulic conditions of the Amu Darya delta and the functioning of shallow lakes in the Aral Sea region and given appropriate recommendations on further ecological life of the Aral Sea.
- The results of the study proposed a method for calculating the deformation indicators of soil structures, allowing to assess the operational hazard being a source of scour and settlement for different conditions of non-bonded soils under the influence of under-pressure hydraulic structures of the Mezhdurechenskoye reservoir.
- The results of hydrogeological studies in the coastal areas of the Aral Sea region have shown that the floating state of soils appears due to the increase in pore pressure, which leads to a decrease in the pressure of soil cohesion. Local alluvial soils can be used for reliable construction of dams and dikes in this region.
- The Amu Darya River, as it emerges from the mountains onto the plain, does not receive any tributaries for almost 1200 kilometres before flowing into the Aral Sea. In the delta part, the river branches into several branches, the flow becomes slow and suspended sediments fall out intensively. Thus, in the mountainous part, the river intensively erodes its channel, deepens it, and transports sediment.

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