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Reduce the intensity of siltation of bulk reservoirs for irrigation and hydropower purposes

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Abstract. The results of field studies to study the siltation of a reservoir and the dynamics of their siltation are presented. The article presents designs that allow reducing the amount of sediment entering the reservoir bowl. The structure will contain spillways located perpendicular to the bed of the supply channel, elements of connecting structures, a sediment storage facility, and a lateral water outlet to the sediment storage facility. The reservoir sediment has a mark below the bottom of the supply channel and above the maximum water level in the reservoir and a wall of large pebbles that act as a filter for residual turbid water in the channel. In the basin of the deposit storage, a road is provided for trucks and equipment to carry out its seasonal cleaning.

1 Introduction

When water enters the reservoir, there is a sharp change in the hydrological and hydraulic flow regimes. Since the characteristic of the reservoirs of our republic is the redistribution of river flow over time - the accumulated part of the flow during the off-growing period, some undesirable processes from the point of view of operation take place to supply this volume at the required time. For example, in the basin of a reservoir, water flows enter with a significant amount of sediment (12-17 kg / m3 and more); due to a sharp decrease in the average flow rate, the main amount of these sediments is deposited in the reservoirs. Since the reservoirs accumulate only 0.3-10% of the annual river flow and the degree of annual siltation of the capacity of such reservoirs averages 0.5-2.0%. In 25-50 years, they can lose half of their useful capacity, which means they are out of their systems, and in 40-80 years.

To study and analyze the ongoing channel processes, materials of field studies were used to determine the decrease in the useful volume of reservoirs [1-4] for irrigation and hydropower purposes and the results of studies carried out at a specific object [5, 6] in the supply channel of the Aktepa reservoir. The territory of the Aktepa reservoir is located on the left bank of the Surkhandarya River, 30 km north of the city of Termez, and is a

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depression stretching from north to south, 7-7.5 km long, 3-4 km wide. From the west, it is bounded by the Amu-Zang and Kokayty canals, from the north and east - by the foothills of the Ak-Tau ridge. Administratively, the reservoir is located in the Jarkurgan fog of the Surkhandarya region of the Republic of Uzbekistan.

Initially, the Aktepa reservoir was designed for a capacity of 379 million m3, but due to lack of funding, construction was stopped at the first stage of construction. The Aktepa reservoir is a water-level reservoir, with seasonal regulation, with a capacity of 120 million m3, intended to increase the water supply of irrigated lands in the zone of the Amu-Zang canal. The reservoir is filled from the Amu Darya River with the help of the Amuzang pumping stations of the first and second ascent and the Amu-Zang canal of the same name, from which water is supplied through the supply channel to the reservoir bowl. The filling is carried out during the non-growing season, from February to June, and during the growing season, the reservoir is emptied. From the reservoir, water is supplied through the outlet canal to the downstream by the Amu-Zang pumping station of the II-nd rise.

2 Methods

Study of the results of field studies at the Aktepa reservoir, assessment of the state of the reservoir, based on hydraulic calculations, develop structures to prevent the flow of sediments into the thicket of the reservoir and propose a methodology for calculating the justification of this structure.

3 Results and Discussion

Due to the high saturation of the flow, the dynamics of siltation of reservoirs entering the thicket of the reservoir is intense. It should be noted that only suspended sediments, transported by the water flow coming from the river, enter the bulk reservoirs, and they can often flow through the reservoir together with the flow, and also taking into account the fact that during the filling of the bulk reservoirs (in the winter months and before the growing season) the average turbidity of the rivers of Central Asia) is the minimum value (0.5-4 kg/m3), then it can be determined that every year the reservoirs will silt by 0.002-0.004 part of the useful capacity of the reservoir for their complete siltation of the reservoir will take several hundred years [7-12]. Usually, in many rivers, measures to prevent the ingress of bottom and coarse sediment fractions are carried out at the head water intake structure on the river, and they, as a rule, do not enter the reservoirs. On the rise of the flood, when the flow carries the greatest amount of sediment, and at the same time the flow rate of the river is still low, it is possible to regulate the volume of water supply to the bulk reservoirs, thereby reducing the volume of their siltation [9-15].

As the results of studies in the reservoirs of the Amu Darya and Syr Darya river basins show, the design period of siltation of the dead volume of these reservoirs varies from 34 to 126 years, and the period of siltation of the total volume of the reservoir is more than 700 years. The average value of the annual loss of the capacity of loading reservoirs is 0.11%; therefore, siltation of such reservoirs, basically, occurs only due to mudflows. The annual solid runoff of such rivers is 0.03 - 0.7% of the reservoir capacity, i.e., their complete siltation will occur after 150–1000 years of reservoir operation [15-20].

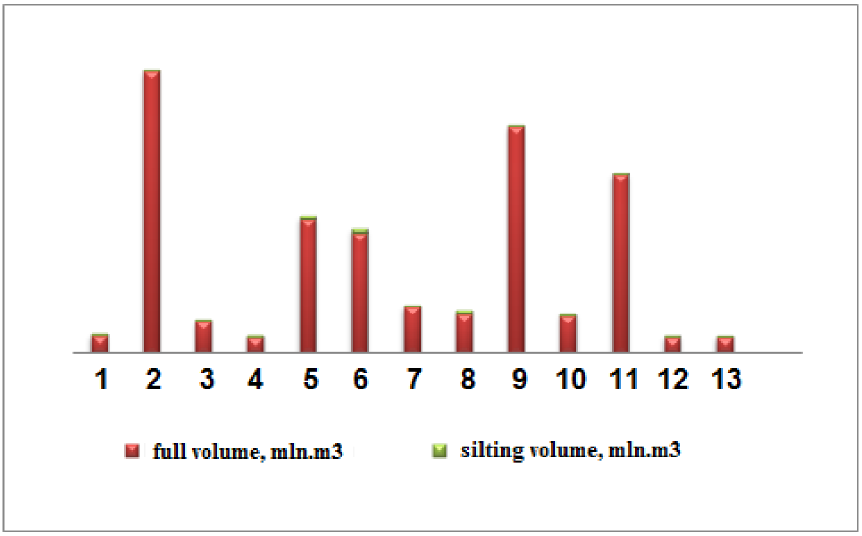

Fig.1. 1 is Akdarya, 2 is Andijan, 3 is Akhangaran, 4 is Jizzakh, 5 is Kattakurgan, 6 is South Surkhan, 7 is Kuyumazar, 8 is Pachkamar, 9 is Talimarjan, 10 is Tashkent, 11 is Tudakul, 12 is Tupalang, 13 is Aktepa

The analysis of the data of the operating services, during the course of reformation of the channel at the dams of channel reservoirs located on the territory of our state with a capacity of more than 50 million m3, from the beginning of their operation to the present, showed that the main factor in reducing the useful volume of the reservoir is the deformation (siltation) of the reservoir channel. This is due to the sedimentation of sediments entering the reservoir along with the flow. As a result of a sharp expansion of the channel at the entrance, the average speed decreases, which leads to a decrease in the transporting ability of the stream, contributing to the onset of the siltation process [21-24].

As the analysis of deformation processes has shown, the dynamics of changes in the volume of incoming sediments depends on the location of the Aktepa reservoir; if the reservoir is lower, i.e., located at a low elevation, a large amount of sediment will flow to it; otherwise, the amount of sediment entering the reservoir will be much less. In addition, a decrease in the useful volume of the reservoir contributes to a decrease in the intensity of the siltation process.

To study the operational state of the reservoir, field studies were carried out in the channel of the supply canal. As a result of the research, it was found that the earthen section of the reservoir supply channel has erosion and deformation.

The basin of the Aktepa reservoir is intensively silted up due to the incoming sediment. This contributes to an intensive decrease in its useful volume, the decrease in useful volume over 13 years of operation was 9%.

To extend the service life of the reservoir, it was proposed to introduce a structure that would reduce the amount of sediment entering the reservoir bowl.

The structure will contain the sediment storage and lateral outlets to the sediment storage and spillways located perpendicular to the channel bed. The nano-storage has a mark below the bottom of the supply channel and above the maximum water level in the reservoir and a wall of large pebbles that serve as a filter for residual turbid water in the channel bed. In the bowl of the sediment storage, a road is provided for trucks and equipment for its seasonal cleaning.

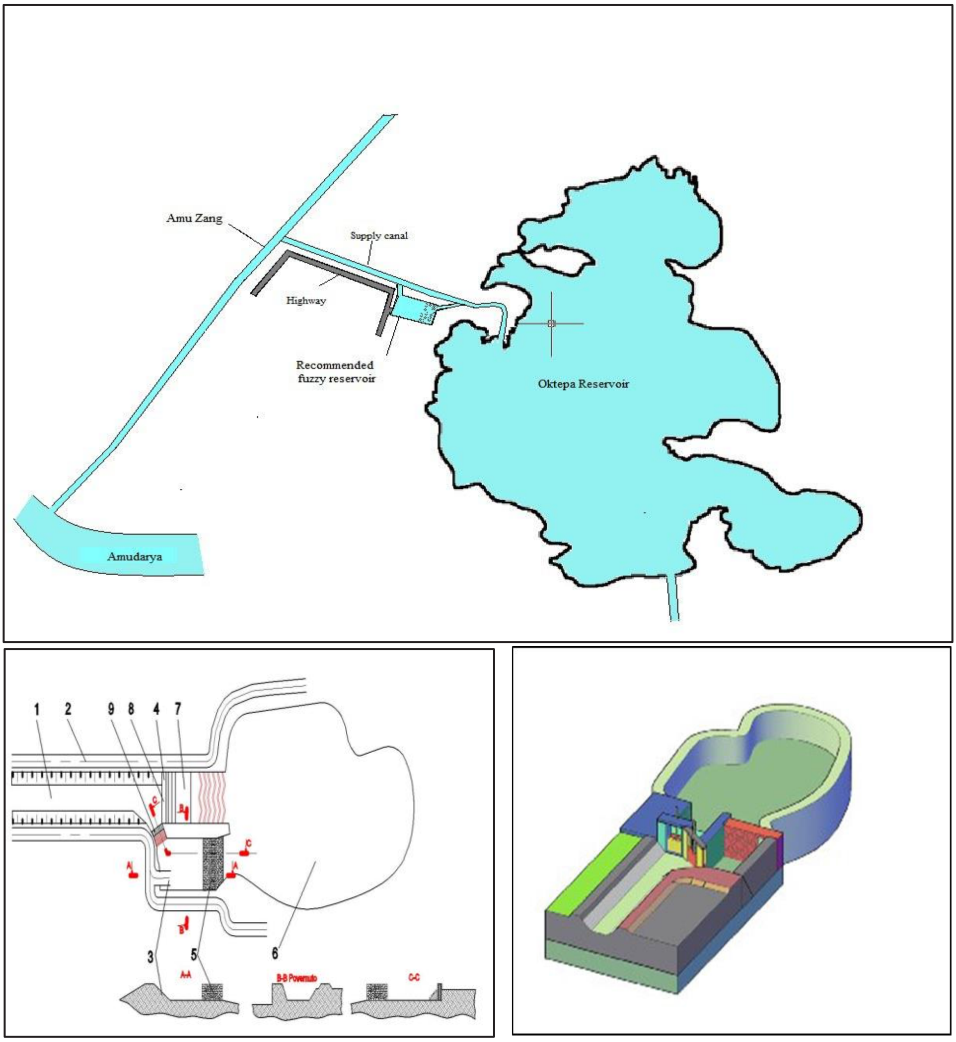

Fig. 9. The proposed scheme of the complex sediment storage: 1 is supply channel, 2 is Highway, 3 is Entrance part of the sediment storage, 4 is partitioning structure, 5 is gravel wall, 6 is reservoir, 7 is Connecting structure, 8 is Spillway shutter with a wide threshold, 9 is Shutter

In the earthen part of the supply channel, there will be a calm water regime with an average velocity less than the erosion flow rate for the soil where the supply channel is attached. This mode is achieved by changing the channel's geometric dimensions and the device of a transitional blocking structure at the end of the channel. The dividing structure is equipped with a weir, a drop, and a connecting structure. Directly in front of the partitioning structure, an entrance structure (4) to the sediment storage is installed. The elevation of the bottom of the entrance structure is taken lower than the bottom of the weir sill and at the level of the bottom of the supply channel. A shutter is installed at the entrance, which is in the closed position during the filling of the reservoir. The bottom of the reservoir has a straight slope to the filtration structure, built of stones and gravel. An access road is provided in the sediment storage - a motor road (2) for special equipment that periodically cleans the sediment storage from the sediment storage.

The device for complex regulation of sediment movement in the supply channel of small reservoirs works as follows:

During the period of filling the reservoir in the supply channel (1), the mode of water flow is achieved with a minimum permissible speed, which is less than the flow rate that does not silt. The formation of such a regime is uneven. The clarified stream passes through a dividing structure, a weir with a wide threshold, a drop, and a connecting structure. The elevation of the bottom of the supply channel is practically much lower than the height of the weir sill. The maximum level of the gate lift set in the inlet section of the sediment storage will be lower than the threshold height. The water flow passing the spillway and through the conjugate section in the downstream channel passes to a uniform mode of movement with an average velocity less than the non-eroding flow velocity.

The intensification of the erosion processes in downstream of the blocking structure is ensured by achieving a uniform regime of the water flow to the reservoir bowl.

After the end of the filling period of the reservoir, the gates installed on the dividing structure are closed, with the simultaneous opening of the gates of the sediment reservoir. In this mode, the channel will operate in an uneven suction mode. The entire volume of deposited sediment in place with the water flow will be transported to the silo. The stream leaving the sediment in the reservoir is filtered through the gravel wall (5) into the reservoir bowl. After a while, the deposited sediments can be transported to the agricultural field and to construction sites, depending on their composition, can be used for their intended purpose.

The considered type of nanoscale is used for the deposition of relatively large fractions of suspended sediment 0.20 ... 0.25 mm. and larger. The conditions for its use are the same as for the sump with periodic flushing. It can be performed single-chamber and multi-chamber and placed both as part of the water intake hydroelectric complex and at some distance from the hydroelectric complex.

4 Conclusions

Based on the results of observations and discussions, the following conclusions were made:

1. To improve the operating conditions of the supply channel, it is necessary to reconstruct it.
2. To overcome the reservoir's life, it is necessary to introduce a structure that reduces the amount of sediment entering the reservoir bowl.
3. The proposed design of the sediment storage has a mark below the bottom of the supply channel and above the maximum water level in the reservoir and a wall of large pebbles that act as a filter for residual turbid water in the channel bed. In the bowl of the sediment storage, there is a road for trucks and equipment to carry out its seasonal cleaning.
4. The optimal design of the nanoscale and the mode of its operation have been developed. 3D modeling of the operating modes of the nanoscale has been performed.

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