ENGINEER

international scientific journal

SPECIAL ISSUE

E-ISSN
3030-3893

ISSN
3060-5172

A bridge between science and innovation

TOSHKENT DAVLAT TRANSPORT UNIVERSITETI
Tashkent state transport university

ENGINEER

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E-ISSN: 3030-3893

ISSN: 3060-5172

SPECIAL ISSUE

16-iyun, 2025

engineer.tstu.uz

“QURILISHDA YASHIL IQTISODIYOT, SUV VA ATROF-MUHITNI ASRASH TENDENSIYALARI, EKOLOGIK MUAMMOLAR VA INNOVATSION YECHIMLAR” MAVZUSIDAGI RESPUBLIKA MIQYOSIDAGI ILMIY-AMALIY KONFERENSIYA TASHKILIY QO‘MITASI

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I-SHO'BA: SUV TA'MINOTI VA EKOLOGIK MUAMMOLAR, SUVNI TOZALASH VA SAQLASH TIZIMLARINI YARATISHNING INNOVATSION YECHIMLARI

Study of siltation intensity of water reservoir

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Abstract: Reservoirs play an important role in providing water for agriculture and generating energy. After the reservoirs are filled, morphometric changes occur in the reservoir area during operation. As the reservoir fills, the flow rate decreases, resulting in accumulation of suspended sediments and bottom sediments in the stream. Large sediments are concentrated in the upper part, while fine sediments are distributed in the middle and lower parts as the flow velocity decreases, and the size of the mud fractions gradually decreases towards the dam. The article analyses the dynamics of turbidity during the operation of the reservoir using the example of the TMGU O'zan reservoir. The volume of turbidity in 1981-2001 was approximately 1145 million tons, and by 2021 it reached 1744 million tons. Considering the average density of the settling turbidity, today 790 million m3 of the volume is filled with turbidity, which means that 35% of the volume of the O'zan reservoir is filled with turbidity.

Keywords: reservoir, O'zan reservoir, efficiency, sediment, operational regime, useful volume

1. Introduction

One of the main ways to regulate river flow in the world is to build reservoirs and large water intake structures. Reservoirs are used worldwide to provide reliable water supply, hydroelectric power, and flood control services [1]. China, the USA, Canada, Germany, Australia and other developed countries pay special attention in this regard (Fig.1).

Fig. 1. Top 10 countries studying reservoir problems

Scientists are looking for ways to increase the service life of reservoirs, prevent a decrease in their capacity, reduce water losses, and constantly monitor changes in reservoirs due to hydrodynamic processes. Currently, the economic sectors of the Republic of Uzbekistan use an average of 50-55 km3 of water per year, of which 20-22 km^3 are under the control of 55 large and several small reservoirs [2]. Reservoirs play an important role in providing water for agriculture and energy in our republic [3], [4]. After the reservoirs are filled, morphometric changes occur in the reservoir bed during operation. As a result of siltation of the upper part of reservoirs, its useful volume decreases and affects economic efficiency [5], [6], [7]. Such phenomena are mainly observed in the upper reaches of reservoirs, in water accumulation areas and in flooded river beds, and especially in the area of hydroelectric power plant pipelines, canal intakes and downstream water discharge facilities [8], [9]. Despite the development of the theory of flow formation, there are still many unresolved problems in the mechanisms of occurrence of many phenomena and the laws of flow distribution. Scientists are constantly conducting research to find solutions to these problems. Scientists such as I.I. Levi, S.T. Altunin, G.I. Shamov, M.A. Velikanov, A.V. Karaushev, A.N. Gostunsky, K.I. Rossinsky, I.A. Kuzmin, M.A. Mostkov, I.A. Moldovanov, I.A. Shneer, V.G. Sanoyan, V.S. Lapshenkov worked on the study of the process of silt deposition in the upper reaches, on the calculation of the silt volume using methods based on the data of field research, on the determination of the silt volume based on the movement of the flow between the weirs and on improving the balance method [10].

As a result of blocking the river flow with the help of a dam and the creation of a reservoir, the flow rate decreases, so suspended sediments and bottom sediments in the stream accumulate in the reservoir [11]. Large sediments are concentrated in the upper part, and fine sediments are distributed in the middle and lower parts with a decrease in flow velocity, and the size of the silt fractions gradually decreases towards the dam. As a result, continuous turbidity of the reservoir occurs. This leads to a decrease in the reservoir capacity and flow control potential, and, as a result, to a decrease in the ability to provide consumers with water in a timely manner and in the required amount.

The lifespan of a reservoir can be calculated in years, decades, and hundreds of years, depending on the reservoir volumes and the annual turbidity rate. When calculating the turbidity of reservoirs, data on the turbidity of the stream, mechanical composition, water flow, reservoir parameters, and sediment mass density are used. There are two cases when calculating the turbidity of a reservoir: 1) data are obtained from the results of discharge and sediment monitoring; 2) the case when no observations have been made and the results are not available (in this case, the main data on the turbidity of the stream are hydrological records) [2], [11], [12].

2. Materials and methods

The Tuyamuyun Reservoir is a large hydraulic structure located in the Khazorasp district of the Khorezm region of the Republic of Uzbekistan, built in the Tuyamuyun Gorge, downstream of the Amu Darya River, and serves to seasonally adjust the water of the Amu Darya River for irrigation and energy purposes (Figure 2).

The reservoir belongs to the 1st class of hydraulic structures, with a total volume of 7.800 billion m³. The Tuyamuyun hydro-electric complex includes 4 reservoirs, in particular, the O'zan (channel) (2340 million m³), Kaparas (960 million m³), Sultansanjar (2690 million m³) and Kushbulak (1810 million m³) reservoirs.

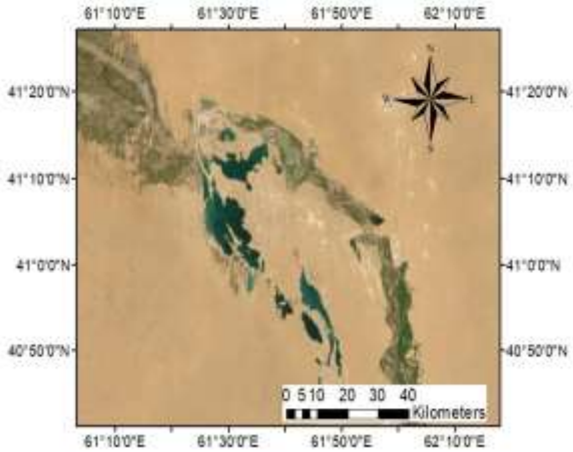

Fig. 2. Space image of Tuyamuyun hydrocomplex

The reservoirs are interconnected, and the O'zan reservoir performs the main control function, i.e., the function of collecting the water, raising its level, and directing the flow to other reservoirs. The maximum difference in the upper and lower reaches reaches 18-24 m. The full characteristics of the O'zan reservoir are given in Table 1.

Table 1

Full characteristics of the O'zan reservoir

Parameters		O'zan Reservoir
Total volume, mln. m3		2340
Useful volume, mln. m3		2070
Water surface area at NPWL, km²		303
NPWL, m		130
DL, m		120
Length, km		102
Width, km	maximum	11
	average	4
Depth at NPWL, m	maximum	20
	average	7,7
Depth at DL, m	maximum	10
	average	2,8

The studies on the speed of silting and effective working mode of the Tuyamuyun Hydroponic O'zan Reservoir used generally accepted methods in hydraulics and hydrology, and mathematical statistical methods were used to process the data of the monitoring results on flow and sediments.

The watery part of the reservoir was measured using an acoustic doppler profile SonTek S5 and HD-MAX echo sounder, and the non-water area was measured using a LEICA 250M digital leveling device. All measurement data is stored in a database.

3. Results and discussion

Field measurements of siltation of the O'zan reservoir were carried out annually by the Tashkent Central Asian Research Institute of Irrigation (CARII) expedition until 2002, and in recent years, measurements of the reservoir capacity have been carried out by the Bathymetric Center (in 2008) and Scientific-Research Institute of Irrigation and Water Problems (SRIIWP) (in 2021). The siltation volume in 1981-2001 was approximately 950-1000 million m3 (Fig. 3).

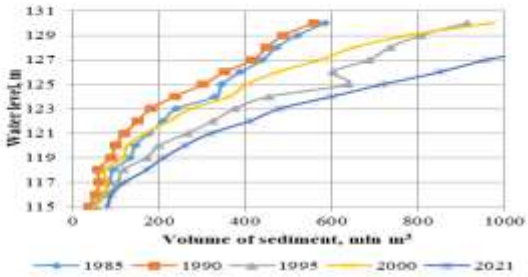

Fig. 3. Dynamics of reservoir silting

According to the collected research materials, the intensity of silting of the O'zan reservoir is observed in July-August, when the water level is above 125 m. The lowest process is observed in February-March [1].

After the Tuyamuyun hydrocomplex was put into operation, monitoring of the siltation process of the reservoir was organized. In this regard, 36 measuring stations were established in the reservoir basin 73.5 km long from the dam and systematic measurements were carried out. In the first years of operation, the flow turbidity at the outlet of the reservoir was very high (> 95%) and the volume density of sediments was approximately 1.12 tons/m3. By 1996, the dead volume of the reservoir was completely covered with silt. Part of the effluent and sediments began to flow downstream, that is, the second period of silting of the reservoir began.

Only after this period did the effects of sediment transport and the washing of previously deposited silt downstream in the reservoir begin to be felt (Fig. 4). Over the past 2-3 years, erosion processes in the basin have accelerated, which has a significant positive effect on the useful volume of the reservoir.

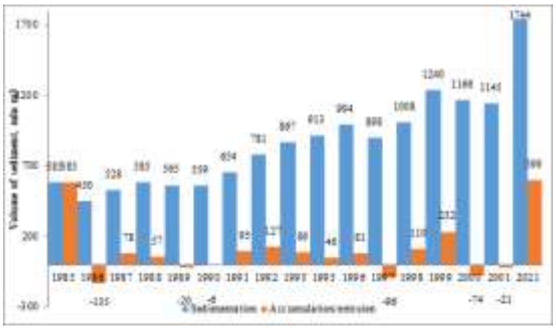

Fig. 4. Dynamics of siltation of the O'zan reservoir

The average long-term discharge of the Amu Darya at the entrance to the O'zan reservoir was 61.8 million m3 in 1982-91. According to the 1987 report, the total volume of turbidity in the reservoir was 528 million m3, and by 1988 it was 608 million m3, of which 117 million m3 was dead volume. As a result of compaction of sediments accumulated in the low-water years of 2000 and 2001, as well as very low water levels, sediment washing and a decrease in the volume of turbidity by 51 million m3 occurred (Fig. 4).

The efficiency of the reservoir regime of the Tuyamuyun hydrocomplex depends on the operating regime of the O'zan reservoir. The main task of the reservoir operational regime in years of low water is to collect the required volume of water, maximize the use of available capacity, and rationally distribute water resources for irrigation purposes in conditions of water deficit.

The main reservoirs in the region were built and commissioned in 1956-80. However, regular monitoring of the turbidity of these reservoirs is not carried out, since measuring the capacity of reservoirs is a complex process and requires a lot of money. In the O'zan reservoir of the Tuyamuyun hydrocomplex, sedimentation of silt in the river flow, as well as other solid particles settling to the bottom of the basin (sand brought by the wind from the coastal zone, coastal erosion, etc.) leads to a steady decrease in the reservoir's ability to control the flow. Among the rivers of Central Asia, the Amu Darya River ranks fifth in terms of turbidity, and as it approaches Tuyamuyun, the characteristics of turbid sediments change: in years of low water, 30...40 million tons, in years of average water, 70...90 million tons, and in years of high water, up to 150...170 million tons. In years of average water, the total volume of suspended sediments in the Darganata River basin is 81.5 million tons, in years of high water, the turbid sediment flow is 129.7 million tons, and during the flood period - 122 million tons).

4. Conclusion

The decrease in the water capacity of the O'zan reservoir as a result of siltation of the useful volume has led to a deterioration in the water supply for Uzbekistan and Turkmenistan. It can be seen from the above data that, if the filling of the reservoir with water began in 1981, then the process of siltation and a decrease in the accumulation capacity also began. As a result of more than 40 years of operation of the reservoir, its project characteristics have undergone significant changes. The volume of siltation in 1981-2001 was approximately 1145 million tons. The sediment entering the O'zan reservoir reached its highest level in 1999 (232 million tons), while in the following two years, as a result of the flushing process, 95 million tons of siltation fell into the lower reaches. Over the past 20 years, the amount of siltation accumulating in the O'zan reservoir has continued to increase, and by 2021 this figure reached 1744 million tons. If the average density of the settling turbidity is considered to be 2.2 t/m3, then today 790 million m3 of the volume is filled with turbidity, which means that 35% of the volume of the O'zan reservoir is filled with turbidity. As a result, the efficiency of the dam has decreased, the supply of water to the irrigation canals, as well as to the three reservoirs located downstream, is insufficient, and the hydroelectric power station in the complex has partially failed.

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