ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 11, Issue 3, March 2024

The Tuyamuyun Hydro Complex O'zan Reservoir Siltation Dynamics

Ikramova M., Khodjiev A., Akhmedkhodjaeva I., Allayorova D.

Doctor of technical sciences, professor, Scientific Research Institute of Irrigation and Water Problems
PhD, Environment and Nature Protection Technologies Research Institute
Professor of Hydraulics and Hydro informatics, TIIAME National Research University
PhD student, Scientific Research Institute of Irrigation and Water Problems

ABSTRACT: The dams alter the natural balance of river flow and sediment, and sedimentation process takes place during its operation life. Effective management of reservoirs can benefit from study and monitoring which predict future state, including capacity loss. This paper focuses on study of reservoir hydrodynamics and sedimentation including inputs such as bathymetry, hydrology and sedimentation. Described the reservoir sedimentation, including the issues of sediment delivery to reservoir, deposition patterns in the O'zan reservoir, which is the part of the Tuyamuyun Hydro Complex in the Khorezm region of Uzbekistan. Due to high turbidity of the Amu Darya water the reservoir volume has been decreased over 40 years operation, and as a result, its original capacity has been significantly lost. In the paper an analyze of the reservoir siltation dynamics, the measured results and GIS data presented.

KEY WORDS: water reservoir, sedimentation, silt volume, capacity loss

I. INTRODUCTION

One of the main methods of river flood control in the world is river flow management through reservoirs and large water intake facilities. Reservoirs are used worldwide to provide reliable water supply, hydropower and flood management services [0]. Special attention is paid in Germany, China, Egypt, Russia, Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan and other developed countries. Sedimentation deposits quickly reduce and diminish storage capacity and greatly shorten the useful life of a reservoir [0]. Scientists are looking for the ways to improve the reservoirs' operation terms, prevent their capacity reduction, extend the life period, reduce water losses and continuously monitor changes in reservoirs due to hydrodynamic processes [0].

It is known that after filling the reservoirs, morphometric changes occur in the reservoir area during operation. Such events have a negative impact on the working mode of the water reservoir and the technical condition of the facilities [0, 0, 0]. As a result of siltation of the upper part of water reservoirs, its useful volume decreases and affects the economic efficiency. Sediment monitoring for sustainable management requires more detailed data collection and analysis than the approach traditionally used to merely document storage loss [0]. The reservoir's elevation-storage relationship is normally replotted using data from bathymetric survey, producing a family of curves that illustrates the change in volume over time [0]. The cross and longitudinal profiles are useful for analyzing the sedimentation processes in a reservoir, because the deposits extending upstream from the dam provide evidence on sediment accumulation and transporting [0, 0].

At present in the Uzbekistan a great attention is being paid to water demand, determining the factors affecting the effective use of available water resources, preventing water losses, reducing a silting process in reservoirs, as well as modernizing the flow management structures and increasing its efficiency. Therefore, accurate data related to water is required depending on the reservoir operation. Taking into account the above, conducted research using modern technologies in the THC [0]. The main purpose of the research devoted to study of the O'zan reservoir siltation process during its operation period and silt distribution along the reservoir.

II. THE STUDY AREA AND METHODOLOGY

The research object is the O'zan reservoir, which is the part of the THC in the Khorezm region of Uzbekistan (Fig. 1). The THC is located in the lower reaches of the Amudarya River in the area of 41°25.34 and 61°18.13 north latitude,

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 11, Issue 3, March 2024

40°10.13 and 62°21.50 east longitude, and was commissioned in 1981. The O'zan reservoir with total of 2340 Mio m3 capacity aimed to irrigate 270 thousand agricultural lands. In the system operates Hydroelectrical Station with 150 MW. Turbidity of the Amu Darya River water is high, depending on season variates from 0.04 to 0.15 kg/m3. Over 40 years of reservoir operation the O'zan reservoir has significantly lost its original capacity due to sediment accumulation.

Figure 1. The THC O'zan reservoir location

The reservoir measurements were carried out in June 2021 at water level of 126 m (Turkmenistan) and in August at water level of 125 m (Uzbekistan). The watery part of the reservoir was measured using an acoustic doppler-profiler SonTek S5 and HD-MAX model echo sounder, and the water-free area was carried out with an electronic digital leveling device LEICA 250M. All measurement data is stored in a database. The total number of cross sections along the reservoir is 37 covering of 82.5 km length. Taking into account the non-parallelness of some sections in a plan, as well as the shape and local location of the reservoir, a correlation coefficient k = 1.07 was identified.

III. RESULTS AND DISCUSSION

The analysis of the research results showed the following: according the measurements, the total volume of the O'zan reservoir decreased from 2340 Mio m^3 to 863 Mio m^3, the surface area has been changed, and it is equal to 247.8 km^2 at operational level of 130 m elevation. Thus, the useful volume of the O'zan reservoir has been decreased by 1477 Mio m^3 [0]. The processed data of the measurement introducing the reservoir capacity change dynamics is presented in Table 1.

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 11, Issue 3, March 2024

Table 1. The reservoir capacity change dynamics, Mio m^3

Elevation m	Design capacity (1981)	BMC, 2008 capacity	SRIIWP, 2021			2023 ArcGIS	
			Reservoir capacity	Sediment volume	Surface area, km^2	Volume (GIS)	Surface area (GIS), km2
130	2340	1287	863	1477	247,8	907	238
129	1950	994	539	1411	211,0	571	201
128	1640	746	302	1338	175,2	238	170
127	1380	539	133	1247	134,9	115	110
126	1130	372	64	1066	69,7	43	52
125	930	263	25	905	8,2	12	8,2
124	740	188	4	736	1,7	10	1,7
123	570	129	0	570	0	6	0
122	450	87	0	450	0	0	0
121	340	58	0	340	0	0	0
120	250	36	0	250	0	0	0
119	190	20	0	190	0	0	0
118	140	9	0	140	0	0	0
117	110	3	0	110	0	0	0
116	80	1,6	0	80	0	0	0
115	50	0,5	0	50	0	0	0
114	30	0,1	0	30	0	0	0
113	10	0	0	10	0	0	0
112	5	0	0	5	0	0	0

Changes in the volume and surface area of the O'zan reservoir depending on the water level elevations are shown in Fig. 2. The data for 2023 was obtained using GIS technologies. It can be observed that the water reservoir capacity at 129-130m elevations has been increased, which can be reasoned by flushing of deposited silts due to low flow rates of water in the river during the last two years.

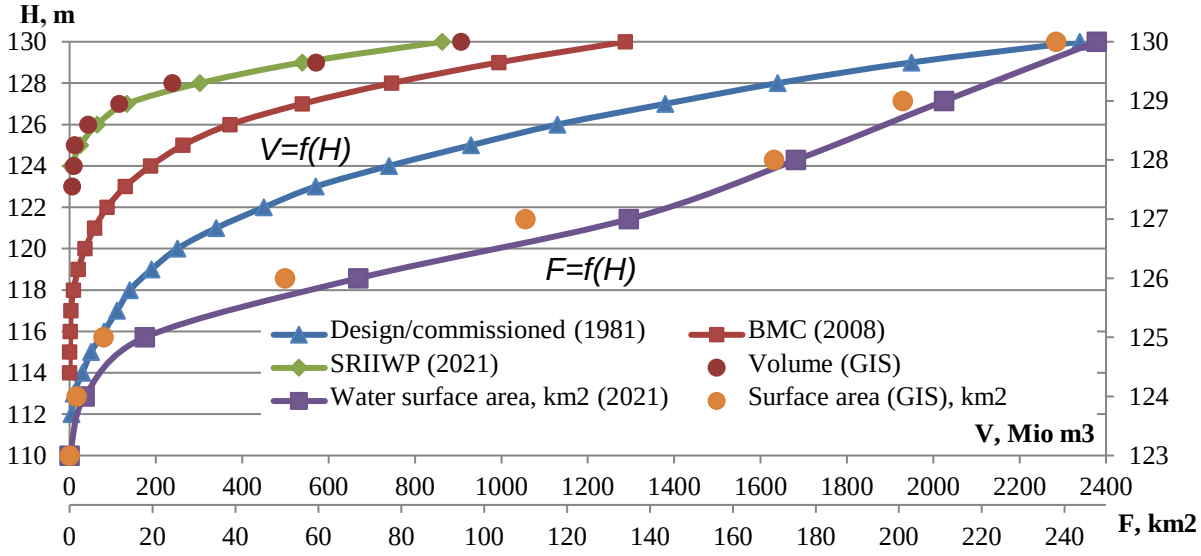
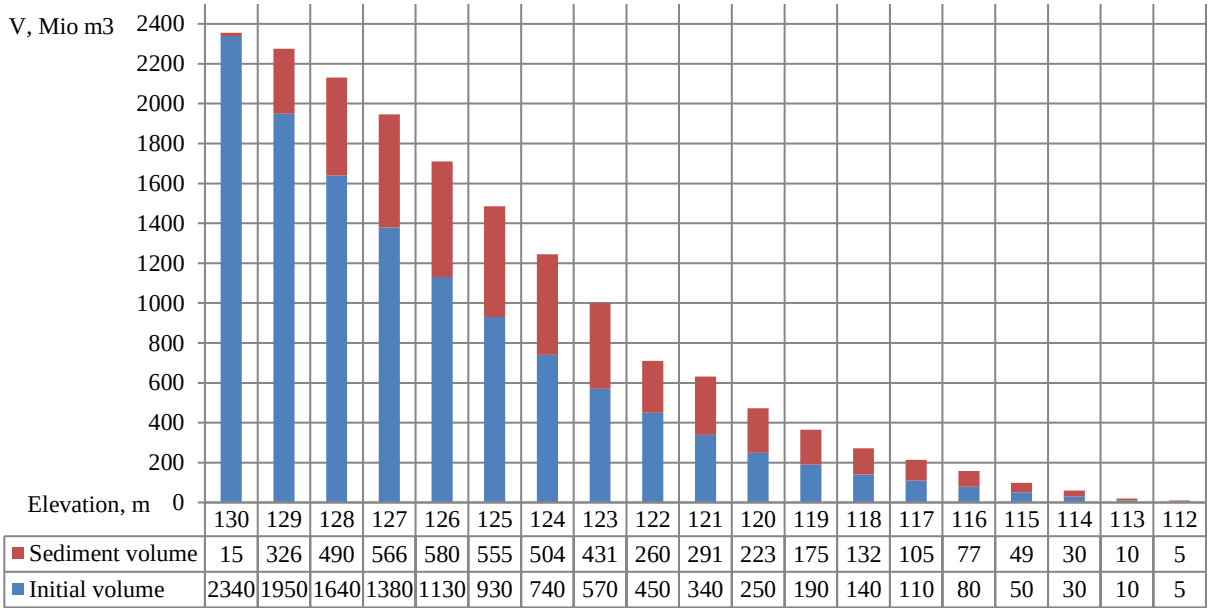


Figure 2. Changes in the volume of the reservoir

The sedimentation analysis in the reservoir showed that to the elevation of 125 m is completely covered with sediments, volume of which is 905 Mio m^3, i.e. 38.7% of the total volume of accumulated sediments (Fig. 3). The rest of the parts are located above in the following order: between 125-126 m - 161 Mio m^3 (7%); between 126-127 m - 314 Mio m^3 (13.4%); between 127-128 m - 260 Mio m^3 (11%); between 128-129 m - 310 Mio m^3 (12.2%); 390 Mio m^3 (17%) between 129-130 m.

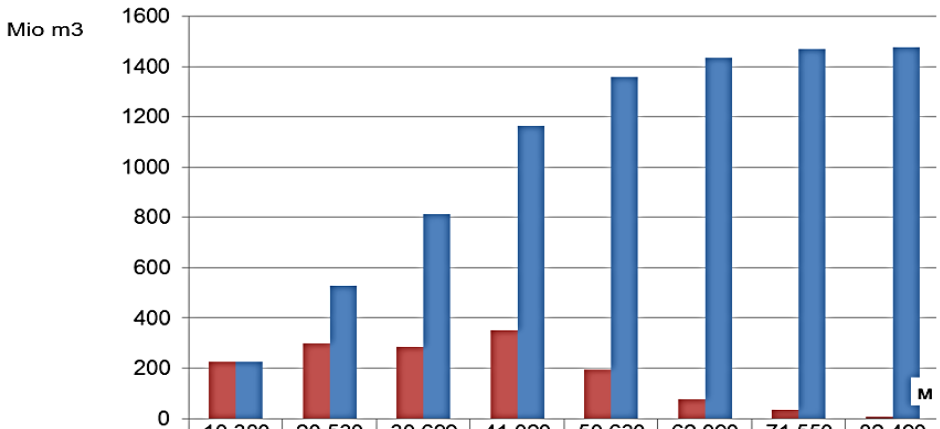
ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 11, Issue 3, March 2024



Elevation, m	130	129	128	127	126	125	124	123	122	121	120	119	118	117	116	115	114	113	112
Sediment volume	15	326	490	566	580	555	504	431	260	291	223	175	132	105	77	49	30	10	5
Initial volume	2340	1950	1640	1380	1130	930	740	570	450	340	250	190	140	110	80	50	30	10	5

Figure 3. Sediment distribution in the reservoir by elevations

According to the data of the sediment location in the reservoir by depth, the intensity of sedimentation of solid particles from 112 to 118 m is equal to 180 million m^3. The main part of sediment equal to 1.05 billion m^3 is deposited at depths from 120 m to 128 m. Sediment deposition along the length of the reservoir was studied in 8 sections, and the data presented in ascending order (Fig. 4). The results are as following: Section 1 - from the dam 10.4 km long, contains 226.4 Mio m^3 of sediment; the Section 2 is 10.2 km, deposited 301 Mio m^3, the Section 3 is 10.2 km - 285 Mio m^3, the Section 4 is 10.3km - 352 Mio m^3, the Section 5 is 9.6 km - 193 Mio m^3, the Section 6 is 11.5 km - 77 Mio m^3, Section 7 is 11 km - 35 Mio m^3, the Section 8 is 11 km where deposited 7 Mio m^3. The main part of sediments 1164 Mio m3 (79%) is in the area to 40 km from the dam, and the remaining part of 312 Mio m^3 (21%) is deposited in the next 40 km.



	10 380	20 530	30 699	41 020	50 630	62 090	71 550	82 490
Sedimentation volume by sections	226,289	300,638	285,366	352,115	193,337	77,082	35,108	7,208
Sum of silt volumes along length	226,289	526,926	812,292	1164,407	1357,745	1434,827	1469,935	1477,143

Figure 4. Sediment deposition along the reservoir

The average slope of the reservoir is I=0.00004 compared to the design I=0.0002, that means, the sediments deposited at the initial stage of the reservoir operation (first 10 years) gradually moved to the dam. The bottom elevations in front of

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 11, Issue 3, March 2024

the dam are raised, which means that although the water flows into the lower basin, sediment erosion and transporting by the current do not takes place. The maximum depth in this area is around 12 m. In the area where the stream flows towards Kaparas and Sultansanjar reservoirs, the average depth is 10 m. This means that the density of deposited sediments in these areas is very high and hydraulic flashing does not occur.

Below, the dynamics of the reservoir capacity decrease by elevations is presented (Fig. 5). In the last 5-6 years the reduction of the reservoir capacity is mainly in the range of 130-126 m. The reservoir silting at the lower elevations is in the process of completing. A satellite image of the reservoir area near the dam in June 2006 and 2023 is presented, where it is clear, that the area is completely covered with sediments during this period and the water flow is forced to create a channel.

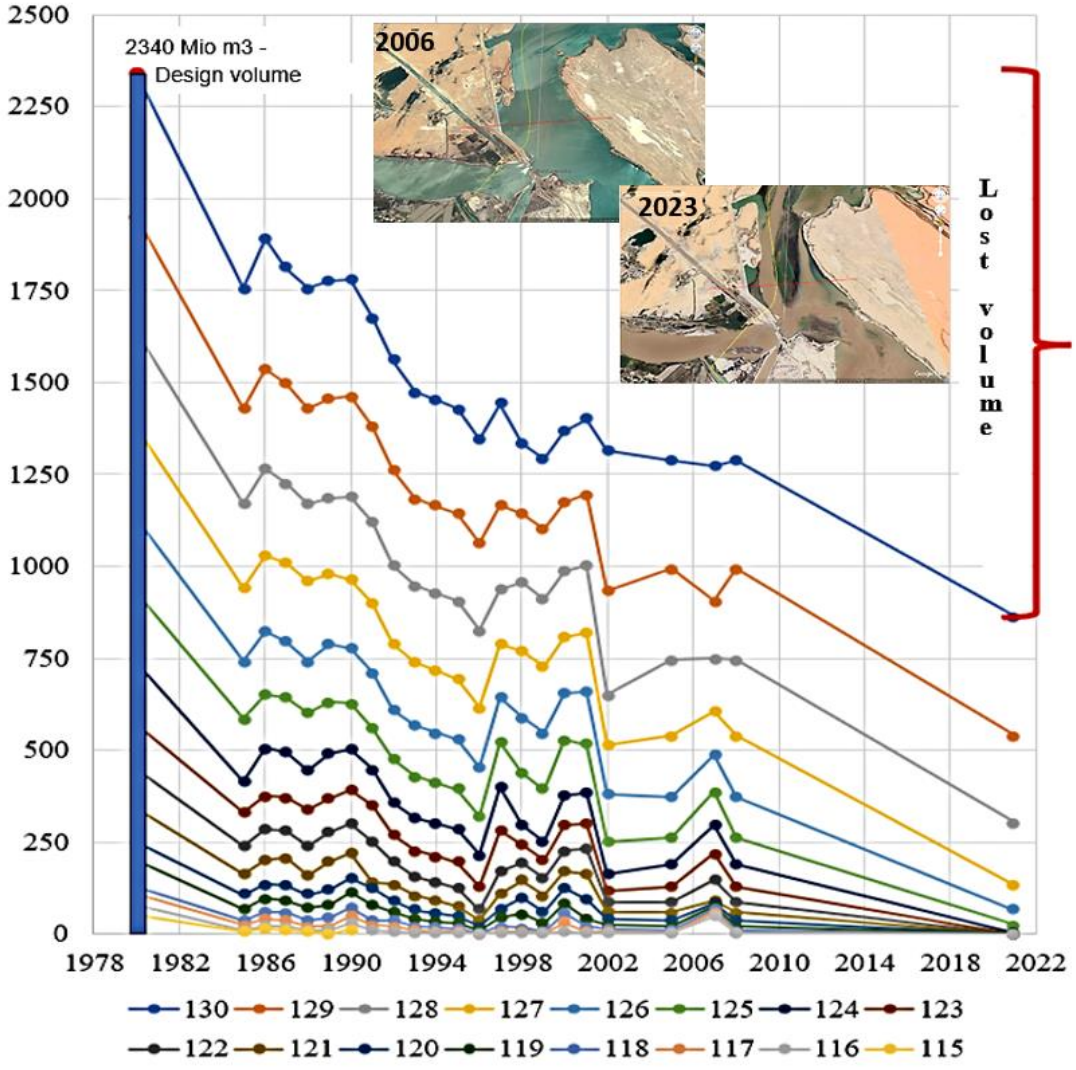


Figure 5. Changes in reservoir capacity over the years

IV. CONCLUSION

The research aimed to determining the O'zan reservoir capacity and sediment deposition. The measured data of the reservoir at the pre-dam water level (130 m) is 863 Mio m^3 in 2021 against the design volume of the reservoir equal to 2340 Mio m^3. The total volume of deposited sediments equal to 1477 Mio m^3. The surface area at 130 m water level is decreased to 248 km^2 comparing to the design area of 300 km^2. It was identified that the water flow has moved deposited

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 11, Issue 3, March 2024

sediments from upper streams to the dam area. As a result, the efficiency of the dam decreased, water delivery to the irrigation canals as well to the three off-stream water reservoirs is not enough satisfactory, the Hydroelectric Power Plant in the complex is partly disabled.

REFERENCES

[1] Antonov V., Davydov R., Maslikov V., Molodtsov D. and Chusov A. Mathematical models of operating regimes of flood control facility's system. ITNT (2019) IOP Publishing. Journal of Physics: Conference Series, 1368 (2019) 042076. doi:10.1088/1742-6596/1368/4/042076.
[2] Annandale G., Morris G., and Karki P. (2016) Extending the Life of Reservoirs. Sustainable Sediment Management for Dams and Run-of-River Hydropower. The World Bank Group, ISBN 978-1-4648-0838-8 DOI: 10.1596/978-1-4648-0838-8. P.193.[3] Wilcock, P. R., and J. C. Crowe. 2003. "Surface-Based Transport Model for Mixed-Size Sediment." Journal of Hydraulic Engineering 129 (2): 120–28.
[4] Oladipo E. Managing the Flow of Water from Reservoirs. Germany, GRIN Verlag, 2016. P.14.
[5] Hotchkiss, R., and X. Huang. 1995. "Hydrosuction Sediment-Removal Systems (HSRS): Principles and Field Test." Journal of Hydraulic Engineering 121 (6): 479–89.
[6] Sumi, Tetsuya, and Sameh Ahmed Kantoush. 2010. "Integrated Management of Reservoir Sediment Routing by Flushing, Replenishing, and Bypassing Sediments in Japanese River Basins." International Symposium on Ecohydrology, Kyoto, 831–38.
[7] Kantoush, S. A., and T. Sumi. 2010. "River Morphology and Sediment Management Strategies for Sustainable Reservoir in Japan and European Alps." No. 53B, Annuals of Disaster Prevention Research Institute, Kyoto University, Japan.
[8] Lane, E. W., and V. A. Koelzer. 1943. "Density of Sediments Deposited in Reservoirs: A Study of Methods Used in Measurement and Analysis of Sediment Loads in Streams." Report 9. Interagency Committee on Water Resources.
[9] Walling D. E. The Sediment Delivery Problem. 1983. Journal of Hydrology 65:209-37.
[10] Ikramova M. The Amudarya flow management by the Tuyamuyun Hydro Complex. Warsaw: RS Global Sp.z O.O.,2021. 78p., ISBN978-83-960097-9-1. DOI: 10.31435/rsglobal/032.
[11] Ikramova M., Akhmedkhodjaeva I., Khodjiev A. The reservoirs capacity assessment: the Tuyamuyun hydro complex in Khorezm region of Uzbekistan. IOP Conference Series Earth and Environmental Science 614, December 2020, P.8, DOI:10.1088/1755-1315/614/1/012100.
[12] Glysson, G. D. (1987) Sediment Transport Curves. USGS Open-file Report 87–218, U.S. Geological Survey.