Assessment of Chimkurgan water reservoir sedimentation processes

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Abstract. Uzbekistan is an inland country with very dry summers and cold winters. The main course of the economy is agriculture. There are two basic kinds of agriculture in terms of irrigation: rainfed and artificial irrigation systems. Therefore, in long dry summers it is reasonable to build water reservoirs to keep enough water resources for vegetation period. Because of sedimentation transport water reservoirs sometimes quickly filled with sediment. Estimating the effects of potential sediment accumulation in reservoirs is an important element in the planning of the dam project. Sediment accumulation in a reservoir may reduce the useful storage of water in this reservoir, change the water quality near the dam, increase flooding level upstream of the dam due to sediment aggradation, influence the stability of the stream downstream of the dam, affect stream ecology in the dam region, etc. This article provides a correlation between the reservoir volume reduction from the bottom to a given level, based on the amount of water flowing into the Chimkurgan reservoir and the river basin monitoring data. Based on the results of observations and calculations, the current state of the reservoir was formed on the basis of GIS tools. In the first step we constructed a flow duration curve, which is the cumulative distribution curve of the stream runoff passing the dam.

1. Introduction
During the operation of reservoirs, it is important to exploit safe structures and facilities in the complex and efficient use of water from the reservoir. Rational use of a water reservoir requires accurate knowledge of the precise amount of water stored in the reservoir. This volume is steadily decreasing due to the annual operation of reservoirs through the sedimentation. The above problems justify the need to identify continuous changes in reservoir volumes during the operational period and develop quick methods for predicting future changes based on the data obtained. In general there are three methods to reduce sediment inflow into the reservoir. These methods are reduction of sediment inflow by soil conservation, bypassing heavy sediment-laden flows, and trapping of sediment by a vegetation screen. Before applying one of these methods it is important to know the sedimentation process in water reservoirs [6]

2. Methods
The research methodology was based on systematic, comparative analysis of the data. Using the mathematical statistics method to calculate and compare the results with the data obtained from natural observations [1]. To calculate the volume of reservoirs, the water balance components of the reservoirs during the previous years were used, which is, the total amount of inflow and outflow water volume
and the last months of the recent years. Selected years when the reservoir at or below the normal retaining level (NRL) mark and the minimum water level is close to the dead-end or inactive volume (IV). For assessments correlation curve between reservoir water level and reservoir volume was plotted. [15 – 25]

3. Results and discussion

Based on data about the amount of water coming into the Chimkurgan reservoir, it was determined that the volume of the reservoir was reduced due to fluctuation in the long-term water discharge of The Kashkadarya River during 1980-2018 [2, 3].

Reduction of the active volume

\[ \Delta V_{\text{active}} = 0.019O_c^{0.82} \]

Reduction of the total volume

\[ \Delta V_{\text{total}} = 0.033O_c^{0.79} \]

Correlation between the reservoir volume reductions from bottom to a given water level, based on sampling data, was built for the Chimkurgan reservoir. [7, 8, 9]

\[ \frac{\Delta V_H}{\Delta V_{\text{NRL}}} = 0.95 \left( \frac{H}{H_{\text{NRL}}} \right)^{1.26} \]

Table 1. Dependences of the physic mechanical and filtration properties of alluvial sands

| Surface, m | 462 | 464 | 466 | 468 | 470 | IV | 472 | 474 | 476 | 478 | 480 | 482 | 484 | 486 | 488 | NRL |
|------------|-----|-----|-----|-----|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| \( \Delta V / \Delta V_{\text{NRL}} \) | 0.04 | 0.08 | 0.14 | 0.21 | 0.27 | 0.31 | 0.37 | 0.46 | 0.58 | 0.69 | 0.85 | 0.99 | 1.00 |

Table 2. Reduction of the reservoir’s total volume relatively to the water level

| Water level, m | By the project | 1970 | 1980 | 1986 | 1990 | 2000 | 2010 | 2018 |
|----------------|---------------|-----|-----|-----|-----|-----|-----|-----|
| 462            | 0             | 0   | 0   | 0.01| 0   | 0   | 0   | 0   |
| 464            | 4             | 2.4 | 1.33| 0.67| 0.5 | 0   | 0   | 0   |
| 466            | 10            | 6.99| 4.96| 3.79| 3.38| 1.28| 0.33| 0   |
| 468            | 22            | 16.8| 13.3| 11.29| 10.6| 6.98| 4.19| 2.08|
| 470            | 40            | 32.3| 27.1| 24.11| 23.1| 17.7| 13.6| 10.47|
| 471            | 50            | 40.3| 33.8| 30  | 28.7| 22  | 16.75| 12.8|
| 472            | 62            | 52.3| 45.8| 42  | 40.7| 34  | 28.75| 24.8|
| 474            | 88            | 76.6| 68.9| 64.48| 63  | 55  | 39.09| 44.26|
| 476            | 120           | 106 | 97.3| 91.96| 90.2| 80.7| 73.42| 67.9|
| 478            | 156           | 141 | 131 | 125.39| 123 | 113 | 105.19| 99.16|
| 480            | 200           | 183 | 172 | 165.06| 163 | 151 | 141.97| 135.09|
| 482            | 256           | 235 | 221 | 212.23| 209 | 195 | 183.28| 174.65|
| 484            | 320           | 295 | 278 | 268.52| 265 | 248 | 234.57| 224.44|
| 486            | 400           | 369 | 348 | 335.98| 332 | 310 | 293.65| 281.06|
| 488            | 492           | 456 | 432 | 417.3 | 413 | 387 | 367.97| 353.26|
| 488.2          | 500           | 464 | 439 | 425  | 420 | 395 | 375.48| 360.71|
| 489.25         | 550           | 511 | 485 | 470  | 465 | 438 | 425.48| 410.71|
2. By plotting a graph from the figures of the table, we can identify the reservoir volume for a given year:

![Graph showing the relationship between Chimkurgan reservoir volume and water level for a given year.](image)

**Figure 1.** The relationship between Chimkurgan reservoir volume and water level for a given year.

Comparison of the estimated volume of the reservoir and the data obtained from sampling observations in the reservoir basin shows that the computational path yields giving better results, which is less than the difference in the active volume (+1%), it is respectively referred to

\[
\frac{55.3}{57.6} = 0.96
\]

Based on sampling observations in the reservoir and estimated reservoir volume determined by graph chart, and also to assist the practicing in planning for better regulation of the reservoir in recent years, it has been developed to apply GIS tools [4, 5].
Figure 2. GIS map of the hydrographic network of the Chimkurgan reservoir and the district borders.

This software allows you to analyze the mapped data, refer to additional databases, and frame a plan of them. Easy submission of work results through a built-in program enables the work to print a reservoir quality map or link to diagrams, tables, charts, pictures, and other files. \[10, 11, 12, 13, 14\]

Figure 3. Installation of the tools.
Figure 4. Determination tools of water level for each mark of height.

Figure 5. Filling process of the reservoir.
4. Conclusions

ArcMap 10.3 was used to create the Chimkurgan reservoir database. The Digital map of the Chimkurgan reservoir basin, designed on the basis of ArcMap, can describe the conditions associated with the sedimentation process of the reservoir storage. The tool makes it possible to map out the underwater surface, which was unimaginable some years ago. As a result, we obtained detailed information about the water level dynamics of the reservoir. This gives insight into sedimentation load and processes in the reservoir at a certain water level. The program also facilitates the identification and monitoring of water bodies and their specifications, distribution points and consumers, the status and types of water meters, and allows them to analyze the map data, add supplementary data, refer to the database and map them.

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