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Evaluation of sedimentation of water reservoirs with modern technologies

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Abstract. When dams are built, sedimentation accumulation starts in high-fuzzy; after filling of dead volume happens, blurring of useful volume, and the efficiency of the reservoir decreases. In this research, the Chartak reservoir in the Namangan region. In this study, the ArcGIS application was used with the ArcMap program. Originally Sentinel 2 Satellite images were downloaded free of charge from Glo Vis US official website. The unstable reservoirs were selected for the length of the reservoir. For each reservoir, the dependence of the water level on the flow rate was calculated, thus analyzing the sediment movement. The research results showed that 10 control points were taken, where Q was the same. In the first control point, in which all value was a bit lower than others, Q was 5, followed by 310 in B, 3.4 in H, omega had 1081.3, and 4.6 in ϑ.

1 Introduction

Currently, the country does not pay sufficient attention to improving the working regime of reservoirs and the development of theoretical bases to reduce reservoir capacity and inefficient water loss due to blurring, application of numerical methods based on water balance, and modern information technologies. Therefore, the development of an improved working regime of reservoirs, taking into account the watery year and changes in the water level in the reservoir, plays an important role in the effective use of reservoirs [1,3]. To date, analyzing the number of sediments that accumulated in the cup of the reservoir, the amount of water lost to evaporation and filtration, and the improvement of methods for calculating them by taking into account the watery year of the water objects are insufficiently studied, given the water level of the year [1-3]. Scientifically based, cost-effective, and environmentally sound solutions for these tasks gives direct sediment management, quantitative and qualitative estimation, development of new technologies for use, and, ultimately, provision of the national economy with natural, ecologically safe, and inexpensive raw materials [4-6]. It should be noted that the regime of river sediments, its annual and perennial variability, sediment size, and fractional and chemical composition are important to design, constructing, and maintaining large and small reservoirs, main canals,

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drainage structures, and other river sediment structures. It is used for efficient operation and prediction of river deformation [7-9].

Several studies were conducted in this field, where the different stages of the sedimentation process and changes in the sedimentation process in reservoirs were investigated using modern technologies. Simpson et al. (1999) stated that sediment suspended in suspension by flow turbulence forms a two-phase mixture with water whose density is higher than that of ambient water, producing turbidity products. They are stable and occur at short time scales; turbidity currents are considered the main factor influencing the sedimentation process in the reservoirs (Oehy, 2003). Moreover, modeling approaches are very helpful in investigating the sedimentation process, where initial mechanisms and interaction between the current and the bed can be simulated using models (Meiburg & Kneller, 2010). The modeling can research the water depth during the plunging process. In this case, a plunge can be defined as a shift between a homogeneous open channel flow and a stratified underflow (Wang, Zhang, & Deng, 2016). Return flow after the arrival of turbidity current in the reservoir can be different due to the length to depths ratio of the reservoir. According to Theiler & Franca (2016), an oscillatory movement can occur when the supply is long enough. Noteworthy, economic analysis of new dams and reservoirs should be done where the effect of the sedimentation process in the reservoirs is to be monitored and researched. Furthermore, it is vitally important to consider the impact of climate change on the sedimentation process in the reservoir (Anton J. Schleiss, Mário J. Franca, Carmelo Juez & Giovanni De Cesare 2016).

2 Materials and Methods

The Chartak reservoir in the Namangan region was selected as an example of the study area. Chartak reservoir is located 14 km north of Chartak town, north of Karabakh village, on the Chortaksay river, constructed by Uzgiprovodkhoz to irrigate 5100 hectares of area and protect human and agricultural objects during floods. Full size 45 million m^3. The water source is the Podshootasoy river through Chartaksay and Begabadsoy. The dam is made of corrugated soil reinforced with rocky soil; the screen is 1447 meters long, 41.5 meters high, 350 feet wide, 6.0 meters wide, 3.0 feet wide; 3.5; 2.5. Water intake facility - a tunnel with a maximum water capacity of 30 m^3 / sec with 4 flat-repair and 2 cone-working gates. The tunnel consists of 2 eyes and is 180 meters long. The emergency water discharge is an open trapezoidal channel with a concrete length of 435 meters and a maximum water capacity of 168 m^3/sec.

Flow sediments and bottom sediments continuously flow into the river's bank reservoirs. Because the width and depth of the reservoir are larger than the River, the flow speed will decrease than the river bed. This influences the movement of sediment into the river. Low speed brings in sediment deposition in a reservoir and reduces the amount of useful volume. The two-phase flow movement will constantly change the reservoir's hydraulic and hydrological parameters. These changes can be seen in the cross-sectional surface, the longitudinal section, and the project cross-section. One of the important issues is the rapid identification of these changes in the reservoir bowl and the accurate assessment of the situation [10-11]. New theories are now being developed to accurately evaluate these processes.

The most widely used GIS is currently available as a solution to the issue above. The ability to easily analyze remote sensing data in GIS has increased the level of its use in various fields. These images also explore areas that are difficult to navigate and explore [12-14]. However, initially, they were of low resolution and were not available in the water sector. Therefore, in recent days, existing very little research about using remote sensing in the water sector. GIS is a ground-breaking analysis of ground changes based on satellite data [15-17]. Now there are more than 300 satellites in space, each of which has its mission area. Existing satellites differ in their applications, such as scope, accuracy, quality, and data speed. Sentinel 2 satellites were selected to study and analyze the above changes. The purpose of the Sentinel 2 satellite selection is given below.

2.1 Spectral Bands and Resolution

The MSI measures reflected radiance through the atmosphere within 13 spectral bands. The spatial resolution is dependent on the particular spectral band:

- 4 bands at 10 m.: blue (490 nm), green (560 nm), red (665 nm), and near-infrared (842 nm).
- 6 bands at 20 m.: 4 narrow bands for vegetation characterization (705 nm, 740 nm, 783 nm, and 865 nm) and 2 larger SWIR bands (1,610 nm and 2,190 nm) for applications such as snow/ice/cloud detection or vegetation moisture stress assessment.
- 3 bands at 60 m.: mainly for cloud screening and atmospheric corrections (443 nm for aerosols, 945 nm for water vapor, and 1375 nm for cirrus detection).

In this study, the ArcGIS application was used with the ArcMap program. Originally Sentinel 2 Satellite images were downloaded free of charge from Glo Vis US official website. Although there are several sites where satellite images can be downloaded, their usage status is different [18,19,20]. Each site has its requirements for its use. The Global Visualization Viewer (Glo Vis) is an Internet application launched by USGS, with the ability to easily download all US satellite images. The United States Geological Survey (USGS) was founded on March 3, 1879. USGS is an organization that provides RS data, which is important for monitoring ecosystems and natural health, natural factors, natural resources, climate, and climate change. USGS collects, monitors, analyzes, and conducts scientific analyzes of changes and problems in the state of natural resources. The ArcGIS software was downloaded and processed using the ArcMap application to create a study area map. The unstable reservoirs were selected for the length of the reservoir, and for each reservoir, the dependence of the water level on the flow rate was calculated, thus analyzing the sediment movement [21].

3 Results and Discussion

In chosen points were measured the width of the flow and flow level with using ArcMap software (Fig. 1).

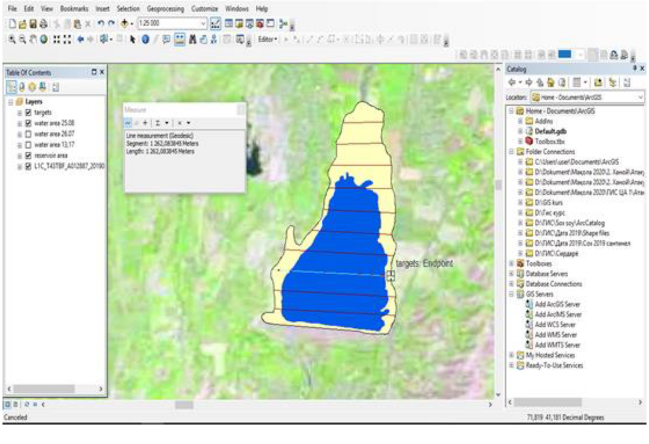

Fig. 1. Measuring width of control points

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The average flow depth was calculated by the flow rate and the free surface widths. In this case, the equations proposed by scientists were used using equations, which were calculated considering morphometric connections. Through the flow of water flow and the free step widths, the average depth of the flow was determined. The formula created using V.S. Altunin's flow morphometric relationships was used [15].

$$H = 0.05 * B^{0.74} \qquad (1)$$

The morphometric parameters for each station were calculated using the computational formulas present in the hydraulics. The calculations were made in the table.

Table 1. Flow Morphometric parameters

Points of control	Q	B	H	ω	ϑ
1	5	310	3.4	1081.3	4.6
2	5	410	4.2	1758.8	2.8
3	5	558	5.3	3006.9	1.6
4	5	648	6.0	3900.4	1.2
5	5	780	6.9	5385.4	0.9
6	5	990	8.2	8154.1	0.6
7	5	1090	8.8	9640.3	0.5
8	5	1190	9.4	11231	0.4
9	5	1160	9.2	10743	0.4
10	5	1199	9.4	11379	0.4

During the experiments, 10 control points were taken, where Q was the same. In the first control point, Q was 5, followed by 310 in B, 3.4 in H, omega had 1081.3, and 4.6 in ϑ. Whereas this indicator was quite high in the 10th control point, where it was 1199 in B, 9.4 in H, and it was 11379 and 0.4 in ω and ϑ. Created graph of the mean velocity dependence of the free-field width ϑ=f(B) based on the table.

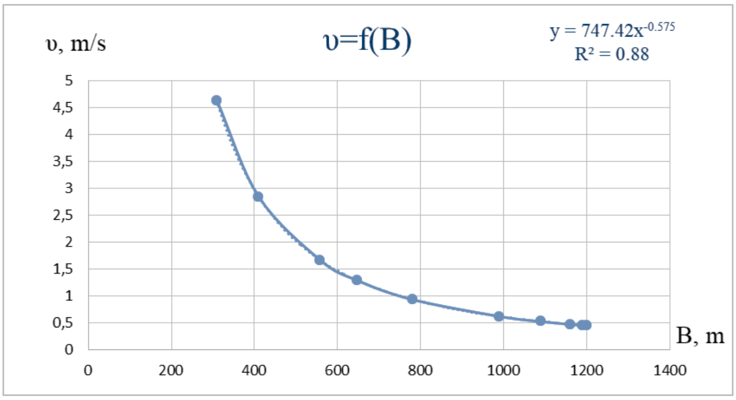
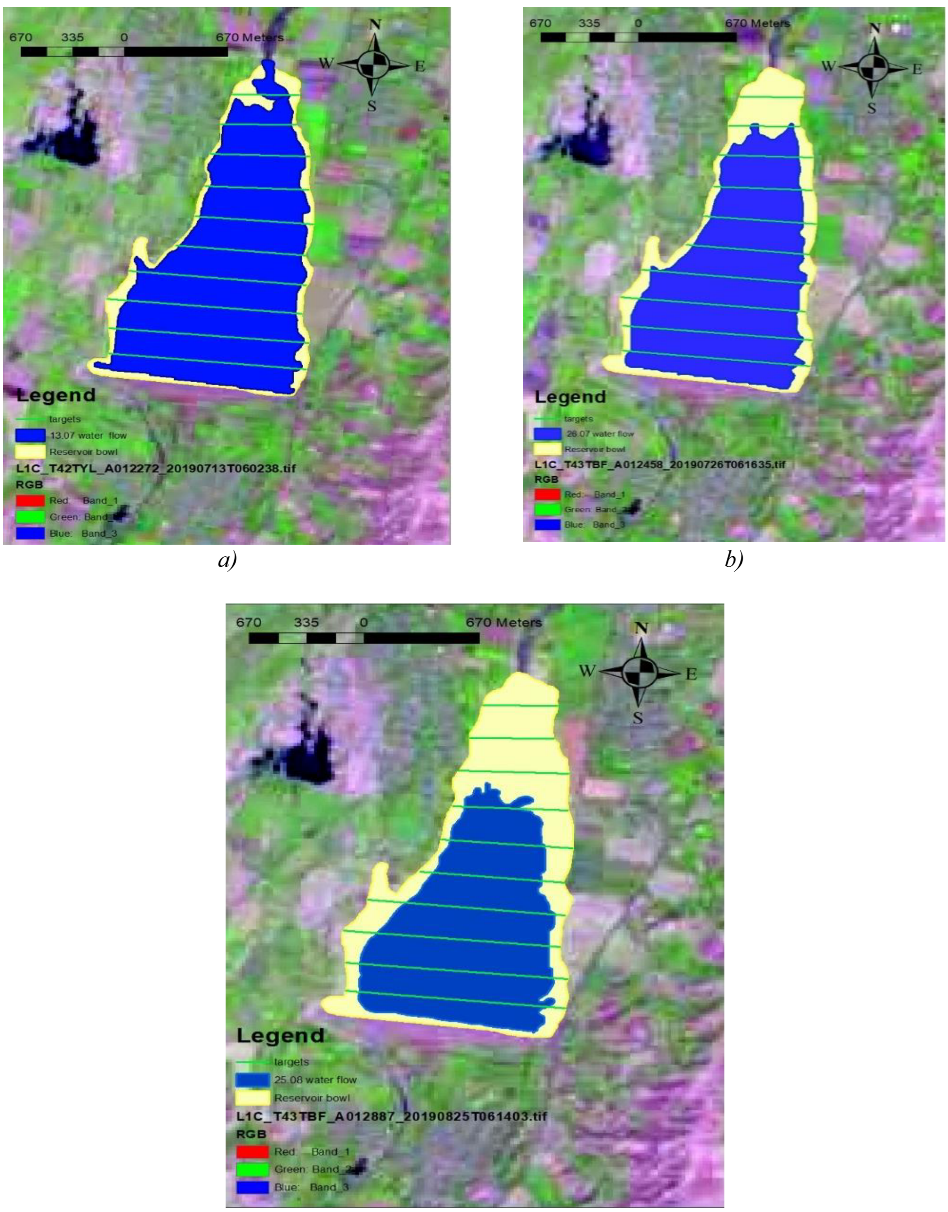


Fig. 2. The graph of $\vartheta = f(B)$

As seen from the table above, the changes in the free surface of the reservoir affected the flow rate. Decreasing average flow velocity brings the deposition of sediments in the flow to the bottom of the water reservoir. The deposition process is accelerated when the hydraulic size of the sediment in the flow is bigger than the average flow rate (W>ϑ). The relationship between ϑ and B was 0.88, and when ϑ was 0.5 m/s, B was 1200 m.

The reservoir maps were created in ArcMap software based on the downloaded data. The change in the surface area of the aquifer is influenced by the changes in flow rate and the movement of the sediment within the flow. For each date, were created a graph of water level dependence on average flow speed (ϑ=f(B)). It can be seen that with the increase of water discharge to a certain extent, the width of the water level increases. Based on the interdependence of flow and water levels, it is possible to estimate mudflow or dewatering processes in the rivers (Fig.3).



a) *b)*

c)

Fig. 3. GIS-based maps (a -13 July, b-26 July, c-25 August)

4 Conclusions

It was found that when the hydraulic size of the sediment in the flow is bigger than the average flow rate (W>ϑ), the deposition process is accelerated. The relationship between ϑ and B was 0.88, and when ϑ was 0.5 m/s, B was 1200 m.

Besides, 10 control points were taken during the experiments, where Q was the same. In the first control point, Q was 5, followed by 310 in B, 3.4 in H, omega had 1081.3, and 4.6 in ϑ. Whereas this indicator was quite high in the 10^{th} control point, where it was 1199 in B, 9.4 in H, and it was 11379 and 0.4 in ω and ϑ. The change in the surface area of the aquifer was influenced by the changes in flow rate and the movement of the sediment within the flow.

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