Influence of geographical location on reservoir vegetation formation

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Abstract. The paper provides information on the vegetation cover area on the reservoir bottom. In the growing shortage of water resources, one of the important tasks is to improve methods for estimating reservoir volume. The vegetation cover of reservoirs influences the quality of the water supply. While the bottom of some reservoirs is drained, this bottom is covered with vegetation, but this trend is not observed in all reservoirs. The Talimarjan and Charvak reservoirs were selected as study sites. As a method, spatial data were selected that were collected using GIS. The results have shown that when the Talimarjan Reservoir is impounded, a considerable part of the reservoir is covered by vegetation of different species, while the bottom of the Charvak Reservoir remains without vegetation. The intensity of eutrophication processes in the reservoir may cause excess nutrients and change the reservoir's water quality in the near future. To prevent such a situation, reducing the number of plants in the reservoir and increasing water exchange is necessary.

1 Introduction

Rational use of water resources in the world, improvement of methods for increasing the hydraulic efficiency of reservoirs, and development of methods for predicting hydraulic processes in them are urgent issues. In this connection, the increase in the operational reliability of water reservoirs and the improvement of methods for calculating their useful volume and the water exchange process are of particular importance [1]. Efficient use of water resources is carried out through constructing reservoirs of different shapes and purposes, designed to collect water during flood periods in river and irrigation systems. In this regard, special attention is paid to constructing reservoirs, preventing siltation, water overuse, and reliable operation [2].

Special attention is paid worldwide to targeted scientific research aimed at developing reliable and efficient methods for predicting the usable volume of reservoirs. In this regard, one of the important tasks is to improve methods for estimating reservoir volume and to develop recommendations taking into account changes in the usable volume of reservoirs as a result of operation [3].

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Insufficient attention to hydrological and environmental factors during the operation of reservoirs, anthropogenic impact on rivers regarded as water sources, and a slowdown in water exchange processes in reservoirs cause deterioration of water quality, resulting in water resource shortages, reduction of water supply reliability by water supply method, as well as an increase in its salinity [4].

2 Research object

The Talimarjan Reservoir is a pumped storage reservoir near Talimarjan in the Nishan district of Kashkadarya province (Figure 1). Seven pumping stations supply Water to the Talimarjan reservoir from the Amudarya. The distance from the reservoir to the river is 90 km. The reservoir is designed to provide irrigation and drinking water for the farms of the Karshi steppe and technical water for the Talimarjon TPP and the Shurtan gas and chemical complex [5].

The construction of the Talimarjon Reservoir started in 1974, and the filling of the reservoir started in 1986. According to the design data of the reservoir, the relative height of the reservoir in a full state is 400.5 m abs; the total volume is 1525.03 million m3, the water surface area in a full state is 77.35 km^2, the relative height of dead volume is 373.0 m abs, water surface area in a dead volume is 22.38 km2, dead volume is 125 million m3, the greatest depth is 40 m. The useful water volume of the reservoir is 1400 mln m3, the maximum water discharge is 155 m3/s, the capacity is up to 360 m3/s, and the total water discharge is 47.7 days [6, 7].

When a reservoir is used for irrigation, changes occur at the bottom of the reservoir, resulting in the useful volume of sediment shifting towards the dead volume, and it becomes difficult for moisture-loving plants to grow [8, 9, 10].

Fig. 1. Talimarjan reservoir

The Charvak reservoir is a hydro-technical structure built in the upper Chirchik River (1963-1970). It was built for water supply agriculture, flood prevention, and other purposes. Charvak reservoir seasonally regulates river water consumption (Fig.2.). The reservoir is constructed between Chatkal and Ugam mountain ranges. The rockfill dam is 768 m long, 168 m high, and 12 m wide at its apex. The dam has two tunnels length of 800 m, and a diameter of 11 m for water supply to Charvak HPP. The total capacity of Charvak reservoir is 2006 million m3, of which the useful water volume is 1580 million m3, the water surface level is 40,1 km2, width in some places 10 km, length 19 km, maximum depth 131 m, average depth 55 m. The Piskem, Koksuv, and Chatkal rivers flow into the reservoir. The reservoir is equipped with a mine (1200 m^3/s) and two-stage (450 m3 /s and 500 m3 /s) outlets which release water when the discharge reaches a dangerous level (19). The Charvak reservoir provides a stable water supply to the Chirchik, Bozsuv basin. The construction of the reservoir ensured stable water supply to more than 355,000 ha of land in the Tashkent oasis and South Kazakhstan province of the Republic of Kazakhstan during low-water years (including 150,000 ha of newly developed lands), as well as flood elimination in the upper Chirchik river. When a reservoir is used for hydropower purposes, it is strictly necessary to maintain the water level at the NPI for normal hydropower plant (HPP) operation, resulting in the possibility of an increase in moisture-loving plants [11, 12].

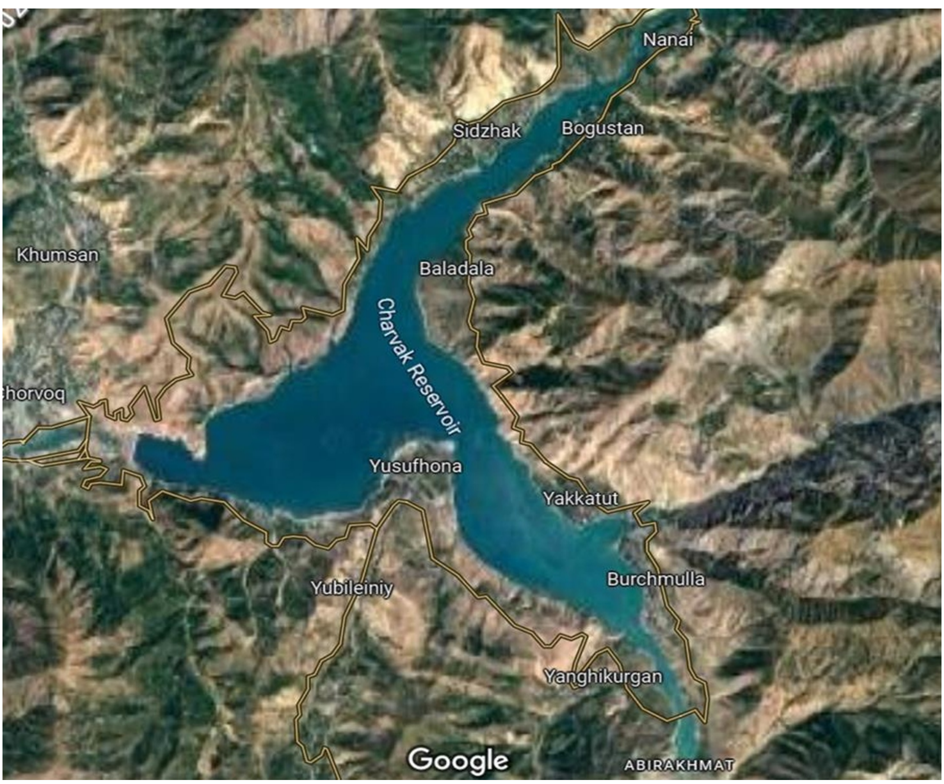

Fig. 2. Charvak reservoir

3 Methods

This area of vegetation was determined remotely using satellites. Landsat OLI satellite images were used for this purpose. This high-resolution satellite captures objects at a resolution of 30 m/pixel and has 11 spectral layers. These layers and resolutions allow for high-resolution analysis of large objects [1]. This satellite was launched by NASA in 2013. The satellite images were downloaded from the agency's website https://earthexplorer.usgs.gov/. The downloaded images were classified in ArcMap 10.1 and divided into water, vegetation, and soil regions. The fields of each region are defined and displayed in the ArcMap attribute table [13, 14].

The NDWI model of ArcMap was used to delineate the reservoir area. The water surface was delineated from the reservoir banks. The normalized difference water index (NDWI) is derived from the near-infrared (NIR) and green (G) channels. This formula highlights the amount of water in the reservoirs. The following calculation formula was used:

$$\text{NDWI} = \frac{(\text{Band 3} - \text{Band 5})}{(\text{Band 3} + \text{Band 5})} = \frac{\text{NIR} - \text{SWIR}}{\text{NIR} + \text{SWIR}}$$

here near infrared (NIR) is wavelengths are slightly longer than red, and they are outside of the range visible to the human eye. Blue wavelengths, a part of natural color film, are filtered out of CIR.

Short-wave Infrared imaging (SWIR) is an advanced method of producing images based on radiation in the region of the electromagnetic spectrum invisible to the naked eye.

4 Results and Discussion

Since it is impossible to fill the reservoir completely with water under water shortage conditions, a certain area of the reservoir remains open, and over the years, various plants have grown in this area, and the area is covered with plants of various sizes. Due to the moisture in the reservoir, these plants proliferate, forming a large area of plants. The banks of the reservoir and the bottom of the banks are covered with different plants. While the banks of the reservoir are mainly covered with reed and partly with cattail (Typha spp.), the coastal areas of the reservoir basin are heavily covered with algae such as Chara (Chara spp.), a perennial aquatic plant of the family Rhodonium (Potamogeton). This process should be considered when determining evaporation and the process of water exchange from the reservoir.

Table 1. Results of calculation of evaporation from the reservoir

Months	Total area (km^2)	Water surface area (km^2)	Area covered by plants (km^2)	Reservoir area covered by plants and soil (km^2)
January	78.18	42.69	7.48	35.49
March	78.18	46.94	4.11	31.24
June	78.18	43.61	9.25	34.57
July	78.18	31.61	10.15	46.57
August	78.18	16.5	13.4	61.68
September	78.18	23.37	13.47	54.81
October	78.18	29.04	8.82	49.14

The change in the area covered by plants in the reservoir can be seen in the following diagram (Figure 3) [15].

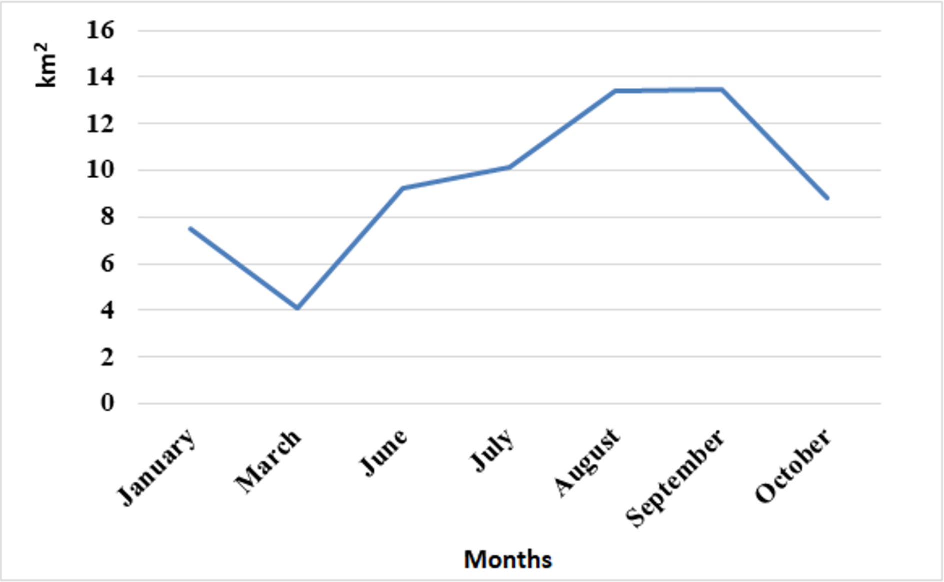

Fig. 3. Change in area covered by plants in bowl Talimarjan Reservoir

The change in plant coverage by month can be seen in the following maps.

Fig. 4.1. Map of water volume changes in reservoir (March 2019)

Fig. 4.2. Map of water volume changes in reservoir (June 2019)

Fig. 4.3. Map of water volume changes in reservoir (September)

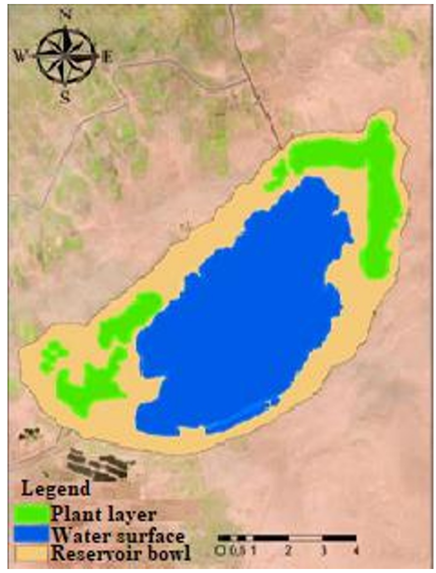

Fig. 4.4. Map of water volume changes in reservoir (October)

The ratio of evaporation from the dried part of the reservoir to the evaporation from the water surface in summer is estimated as the following indicative figures: meadow, various plants 0.5-0.7, forest and shrub 0.9-1.1, reeds and rushes 1.1-1.3. [16]. During the vegetation period (April-May month), a part of the Charvak reservoir bowl remains open, and over the years, various plants do not grow in this area, and the area remains empty. The data are given in Fig. 5.1, 5.2, taken from Landsat OLI satellite images.

Fig. 5.1. Charvak Reservoir at full volume

Fig. 5.2. Charvak Reservoir during growing season

5 Discussion

The shallow waters of many shallow reservoirs are covered by aquatic vegetation for most of the year. With the emergence of aquatic plants, evaporation becomes not only a physical but also a biological process. Other things being equal, plants receive different amounts of moisture during different life stages. Aquatic plants' presence increases evaporation [10, 13]. During the ice-free period, it increases up to 1.3 times in forest and forest-desert areas and up to 1.5 times in desert and semi-desert areas. The course of evaporation during the year from reservoir areas overgrown with aquatic plants is characterized by the following figures (in the period May-October as a percentage of the total).

Months	V	VI	VII	VIII	IX	X	V-X
%	8	22	27	24	14	5	100

As described above, two processes must be considered when determining the amount of water loss by evaporation from the reservoir. The first is evaporation from the total water level, and the second is evaporation from the plants in the reservoir.

6 Conclusions

X The study results show that the Talimarjan reservoir has increased the overgrowth of different plant species, affecting both the reservoir exchange and the usable volume. The study results in Charvak reservoir show that overgrowing by different plant species is not observed; the reason for this may be the lack of sediment load in the mountain rivers and water temperature. In addition, the intensity of the eutrophication processes in the reservoir can cause an excess of nutrients and change the reservoir's water quality in the near future. To prevent such a situation, reducing the number of plants in the reservoir and increasing the water exchange is necessary.

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