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QUANTITATIVE EVALUATION OF SEDIMENT ACCUMULATION IN MATAGHIS RESERVOIR

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Mataghis Reservoir was built on the bed of Tartar River 58 km far from its estuary. The reservoir was operated in 1974. Monitoring is planned to be implemented at certain regulations after operating such structures during which data on hydraulic structures, filtration flows, sediments and other parameters entering the rim of the reservoir are collected. In particular, the river sediment regime has a great impact on the assessment of the amount and volume of the distribution of sediments in the reservoir which will allow to develop measures that will increase the efficiency of the operation of the reservoir. This article refers to the mentioned problems. The results of the developments based on the hydrometric measurements of the Tartar are also included in the work.

Key words: water, river, outlet, feeding ground, sediment, effective storage of the reservoir, dead storage.

Introduction

Experience of operation of large and medium-sized reservoirs shows that most of the incoming sediments is placed at the bottom of the reservoir occupying the effective storage [1]. The reservoir fills with sediments over time fully or partially and loses its ability to accumulate and distribute water. This description of sediment accumulation is very similar to the hydrodynamic phenomena currently observed in Mataghis Reservoir which is the subject of our research.

In order to assess the sediment regime of Mataghis Reservoir multifaceted studies were conducted with the participation of the authors of this article in 2012-2013 [2]. In order to clarify the conditions of the formation of liquid and sediment flows coming along Tartar River, to determine the amount of sediments accumulated in reservoir as well as to determine their distribution form within the framework of the topic 19YR-1E011 of RA SC, it was foreseen to implement the following in addition to the researches already done:

- Collecting the results of hydrometric measurements of the Tartar,
- Collecting the data of water outlet of Sarsang HPS,
- Geodesic digging of the area near the reservoir and pointing of key axises typical of studies,
- Implementing direct measurements of surface coordinates of silt accumulations in Mataghis reservoir,
- Developing the collected and field research data.

The results of the elaborations and their comparative analysis will allow to assess the geometric characteristics of sediment accumulations in Mataghis Reservoir and to make predictions about their further behavior.

The results of the developments based on the hydrometric measurements of the Tartar are given in our work.

The maximum impounded water horizon of Mataghis reservoir is 416,7 m, the dead storage horizon is 401,5 m, the total storage of the reservoir is 5,56 million m^3, the effective storage is 5,21 million m^3. The dam is earthen with a maximum height of 28 m [3].

Sarsang Reservoir was built on the bed of the Tartar above Mataghis Reservoir in 1976 with 625 million cube meter storage the catchment area of which is 2160 km^2. Since 1976 the unregulated river flow which feeds Mataghis Reservoir has been occurring on the area of 330 km^2 half of which flows to the Trghi and the rest to the tributal inflows.

In order to compile the water balance of Mataghis Reservoir it is necessary to study the inflows of the Trghi and tributal inflows and make hydrological calculations.

Hydrological observations had been made on the Trghi in the section of Maghavuz village from 1940 to 1971 [4] 31 years of which are sufficient basis for assessing the hydrological regime of the river (Table 1).

Table 1

Average month outlets of Trghi River in the section of Maghavuz village hydro observatory

Years	Months												Q, m^3/s	W, mln. m^3
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII		
1940-1971 average	1.7	1.7	2.2	4.6	5.5	5.6	4.2	3.4	3.0	2.8	1.9	3.3	3.2	102

The transfer from the data of Maghavuz observatory to reservoir river section was done through the coefficient of comparison of relevant water catchement basins $K_F = \frac{300}{175} = 1.89$:

On the basis of the studies the maximum outlets of various safety are given in Table 2 concerning river section of Maghavuz hydroobservatory of Trghi River and the reservoir [5].

Table 2

Maximum outlets of various safety

River section	Water catchement surface km^2	Maximum outlets (m^3/s according to safety					
		0.1%	1%	3%	5%	10%	25%
Trghi –Maghavuz	192	242	150	109	88	58	34
Trghi-Mataghis reservoir	330	335	208	151	122	80	47

Using the results of water flow treatment, let us estimate the sediment flow into the Mataghis Reservoir. The surface liquid flow of the Tartar which occurs during spring floods and rainfall is enriched by decayed and wind-blown materials in the river basin. The river is fed by sediments due to the washing and erosion of the riverbed and the banks. During the operation of the reservoir, the determination of the storage of the accumulated sediments is of great importance as it occupies a significant amount of the storage of the reservoir.

The outlets of suspended sediments had been measured in several sections of Tartar River by the hydrometeorological service during the period of 1949-1980. The results obtained by elaborating the measurement data are presented in Table 3.

Using the data given in Table 3, let us calculate the storage of suspended sediments brought by Tartar River in the Mataghis dam section. Taking into account that the outlet of the suspended sediments measured at Mataghis observatory is 13,86 kg/s, let us determine the average annual storage of sediments coming along the Tartar stream during a year before the construction of Sarsang dam by Wy=13.86 kg/s x 31.54x106 =437 thousand tones equation.

Table 3

The monthly distribution of outlet of dependent sediments in the Tartar R (kg/s) and liquid flow Q (m^3/s) till 1977
River/observatory 1 - Tartar – Maghavuz village, 2 – Tartar - Mataghis village

n	Rigid and fluid outlets	Months												Anuual average
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
1	Rkg/s	0,21	0,29	1,08	24,0	45,3	24,7	23,4	10,4	4,7	5,9	1,3	0,6	11,8
	Qm^3/s	8,3	7,8	10,1	28,6	49,5	42,7	23,5	14,4	13,9	12,4	10,3	8,9	19,2
2	Rkg/s	0,34	0,35	1,82	21,42	44,30	53,05	29,7	6,9	5,5	2,0	0,5	0,4	13,9
	Qm^3/s	10,0	9,5	13,7	32,1	53,7	52,2	28,3	19,5	15,5	15,8	13,8	11,1	22,9

Taking into account the density of sediments of small grains the storage of the flow will comprise about 360 thousand m^3.

Consequently during those three years before Sarsang reservoir had been operated (1974 January- 1976 December) the amount of water sediments flowing to Mataghis reservoir only along the Tartar will comprise 1,2 mln. t or 1 mln. m^3 according to the data after measurements.

For determination of the total sediment accumulation the following had been used during all the time of the operation of the reservoir (46 years (1974-2020)):

- Data of hydrometric measurements,
- The balance of sediments was calculated and accumulated storage was determined by the method of calculation.

The total storage of accumulated sediemts had been formed by three factors conditioned by sediment flows:

- The main storage had been formed by the sediments flown over the Tartar before Sarsang operation during three years (1974-1977),
- After Sarsang operation the tributaries flowing into the Tartar in Sarsang-Mataghis river section affected the formation of total storage. Their sediments were also accumulated in Mataghis reservoir (Trghi tributary brings the main part of sediments).
- The third factor are the underwashings occurred in the bed of the Tartar from water outlet of Sarsang HPS. As a result the decayed grounds of the bed section were flown into Mataghis reservoir.

Let us estimate the mentioned storages by the method of calculation.

Using the results of measurements of the outlets of sediments in hydrometric observatories, the following functional relation was suggested in the bulletin of liquid and sediment (suspended) of the Tartar [4]

$$R = 0{,}72\, Q_0^{0{,}95},$$

where R - is average annual outlet of suspended sediments, the value of Q_0 corresponds to the average annual outlet of the Tartar.

With the help of this formula let us try to calculate the storage of suspended sediments in Mataghis reservoir. Since 1977 (after the construction of Sarsang Reservoir) the sediment flow to Mataghis Reservoir has undergone significant changes. For the 3 years prior to the operation of Sarsang Reservoir, let us make the balance of sediments flown into Mataghis Reservoir. The average annual water outlet in the Tartar-Mataghis river section is 21,7 m^3/s. Consequently, the average annual calculated output of suspended sediments will be $R = 0{,}72 \cdot 21{,}7^{0{,}95} = 13{,}4$ kg/sec.

Counting the bulk density of suspended sediments as 1,200 kg/m^3 [6], the total storage of of ground received over 3 years will be W_w=(13,4 x 31,54x10^6/1200)=1,06 mln. m^3.

It is known that about 60% of suspended sediments are particles smaller than 0,05 mm which are transient and do not settle in the reservoir [7,8]. Hence, the storage of installed sediments will be W_d=0,4x1,06=0,424 mln. m^3.

The outlet of the bed sediments, according to the experience of the flow study, is half the outlet of the dependent sediments making 6,7 kg/s [4.7]. Taking the density of the bed sediments as 2400 kg/m^3 [6], the storage of bed sediments is calculated for 3 years as W_b=(6,7x3,54x10^6/2400)x3=0,264 mln. m^3.

Thus, the estimated total storage of bed and suspended sediments installed in Mataghis reservoir coming along Tartar River during three years will be 0,69 million m^3.

Let us make the balance of sediments that came along the tributaries of Sarsang-Mataghis river section using the second factor. For this purpose let us determine the flows from Sarsang dam to Mataghis reservoir covering 330 km^2 area flowing into the Mataghis reservoir which continue to bring sediments to Mataghis reservoir.

The flow module of Tartar river at Mataghis reservoir is 8,8 l / km^2 and the water outlet is Q_0=8,8x330/1000=2,9 m^3/s. According to these dimensions, the outlet of suspended sediments will be $R = 0,72 \cdot Q_0^{0,95} = 0,72 \cdot 2,9^{0,95} = 1,98$ kg/s.

Let us calculate the amount of suspended sediments entering the reservoir during the next 42 years: W_w=(1,98x31,54x10^6/1200)x42=2,21 mln. m^3. 40% of these is located in only Mataghis Reservoir. The storage of installed sediments is W_d=0,88 mln. m^3.

We accept the output of the bed sediments as half of the output of the suspended sediments - 1.0 kg/s. Let us also determine the storage of bed sediments during 42 years: W_b=(1,0x31,54x10^6/2400)42=0,55 mln. m^3.

Consequently, the total storage of water sediments brought by tributaries to the reservoir and accumulated in the reservoir during 42 years will be 1,43 million m^3.

As for the amount of ground that has been decayed and taken to the reservoir due to the bedwashing, its impact due to reasons caused by small specific weight in total storage of sediments can be ignored.

During the period from the operation of Mataghis reservoir until 2020 the total storage of sediments installed in the rim of reservoir is estimated as $W_H = 0,69 + 1,43 = 2,12$ mln. m^3.

Gonsequently, in the current climate and especially erosion situation of the Tartar catchment basin, the average annual total flow of water entering Mataghis Reservoir will be about 35 thousand m^3. The results of the study conducted on the determination of the regime of storage of sediments of Tartar River and Mataghis Reservoir, the amount and the storage of their accumulations need to be verified by comparing them with the data of the original measurements.

Conclusion

The analysis of implemented work enables to make a number of suggestions which will help to increase the effectiveness of operatoion of the reservoir:

1. It is necessary to reconstruct the regular measurements of fluid and rigid outlets of main rivers of AR.
2. To measure the floodmarks of upper surface of accumulated sediments once in 5 years by 200m. steps.
3. To regularly wash-remove sediments partially through ground gates.

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տեխնիկական վիճակի հետազոտում և անվտանգ շահագործման միջոցառումների մշակում, Եր. 2013, գիրք 2, 37 էջ:
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ՄԱՏԱՂԻՍԻ ՋՐԱՄԲԱՐՈՒՄ ԿՈՒՏԱԿՎԱԾ ՋՐԱԲԵՐՈՒԿՆԵՐԻ ՔԱՆԱԿԱԿԱՆ ԳՆԱՀԱՏՈՒՄԸ

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Մատաղիսի ջրամբարը կառուցվել է Թարթառ գետի հունում, դրա գետաբերանից 58 կմ հեռավորության վրա: Ջրամբարը շահագործման է հանձնվել 1974թ.: Նմանատիպ

կառուցվածքները շահագործման հանձնելուց հետո, որոշակի պարբերականությամբ նախատեսվում է մոնիթորինգի իրականացում, որի ժամանակ հավաքագրվում են տվյալներ հիդրոտեխնիկական կառուցվածքների, ֆիլտրացիոն հոսքերի, ջրամբարի թաս մուտք գործած ջրաբերուկների և այլ պարամետրերի մասին: Մասնավորապես, գետի ջրաբերուկային ռեժիմը մեծ ազդեցություն ունի ջրամբարի թասում բերվածքների տեղադրման քանակի և ծավալի գնահատման հիմնահարցում, ինչը հնարավորություն կտա մշակել միջոցառումներ, որոնք կնպաստեն ջրամբարի շահագործման արդյունավետության բարձրացմանը: Նշված խնդիրներին է վերաբերում ներկայացվող հոդվածը: Աշխատանքում բերված են նաև Թառթառ գետի հիդրոմետրիկական չափումների հիման վրա կատարված մշակումների արդյունքները:

Բանալի բառեր. ջուր, գետ, ելք, ջրհավաք ավազան, բերվածք, ջրամբարի օգտակար ծավալ, մեռյալ ծավալ:

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КОЛИЧЕСТВЕННАЯ ОЦЕНКА НАНОСОВ, ОТЛОЖЕННЫХ В МАТАГИССКОМ ВОДОХРАНИЛИЩЕ

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Матагисское водохранилище построено на р. Тартар, в 58 км от устья реки и сдано в эксплуатацию в 1974 г. Для таких объектов, после сдачи в эксплуатацию, намечается проведение мониторинга, при котором собираются сведения о гидротехнических сооружениях, фильтрационных течениях, наносов, других параметров. В частности, режим наносов реки имеет большое влияние на процесс отложения наносов в чаше водохранилища, в том числе для количественной и объемной оценки, что позволит разработать мероприятия для повышения эффективности эксплуатации водохранилища. Вышеизложенной проблеме посвящена настоящая статья. В работе приведены также результаты разработок, проведенные на основе гидрометрических исследований р. Тартар.

Ключевые слова: вода, река, расход, водосборный басейн, наносы, полезный объем, мертвый объем.

- *Հետազոտությունն իրականացվել է ՀՀ գիտության կոմիտեի ֆինանսական աջակցությամբ 19YR-1E011 ծածկագրով գիտական թեմայի շրջանակներում:*
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