Results of analysis of physical and chemical composition of sludge sediments in Langar and Kalkama flood reservoirs of Kashkadarya region

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Abstract. The article presents the results of field research to determine the physical and chemical composition of sediments in the Langar and Kalkama reservoirs in the Kashkadarya region. Data on the volume of floods in Langar, Kyzylsuv, Kalkama, and Dehkanabad flood reservoirs in 2015-2021 were presented, and it was noted that in Langar in 2019, there were 3 times more floods than in 2015. The granulometric content of turbid sediments in the middle part of the Langar flood reservoir is 29.93% from 0.005-0.002 mm, 21.36% from 0.01-0.005, 21.36 from 0.05-0.01 mm, 25.35% from 0.1-0.05, 0.25-0.1 mm to 0.6%, 0.5-0.25 mm to 0.8%, 1.0-0.5 to 0.6%, i.e., the amount of particles smaller than 0.05 mm reaches 98%. This figure is 94-95% in front of the flood reservoir's upper and water discharge part. It is justified that mud from the Langar flood reservoir can be used as a building material in brick factories due to its high viscosity, and mud from the Kalkama flood reservoir can be used in construction as fine sand due to its low viscosity.

1 Introduction

The frequency of natural hazards on the planet is increasing due to global climate change. Floods are an example of such natural phenomena. In particular, in Central Asia, including the regions of the Republic of Uzbekistan, floods and other dangerous natural phenomena have become more frequent over the past decade due to climate change. As a result, short-term floods in tens of minutes or hours can damage bridges, roads, canals, fields, crops, and hydraulic structures in water and flood reservoirs. Floods are mainly caused by the accidental occurrence of accelerated precipitation, as a result of which the constant flow of rivers is combined with the flow of floods, causing great dangers in the short and long term. The accumulation processes of solid flow in the upper reaches of the flood reservoir consist of complex physical and hydraulic conditions which depend on hydrological, topographic, hydraulic, hydro-technic, operational, and several other factors[1-7]. Currently, there are no technically and economically effective measures to clean mudflows from muddy sediments.

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In general, it is practically impossible to completely remove the deposits in the upper basin from the zone of floodplains. However, if appropriate measures are not taken to reduce their number, such hydropower plants may become completely unusable after several years of use. In addition to determining the volume of turbid sedimentary deposits in the upper basin, it is important to study the characteristics of their location concerning the topographic conditions of the upper basin in solving the problem. Parameters of turbid sediments in river flood reservoirs, which have been used for several years, differ significantly from the design calculations. Most of the major floods in the country occur in mountainous and foothill areas. Therefore, it is important to conduct field research on existing floodplains, as well as to study their technical condition and develop recommendations for their reliable and safe operation [8-15].

2 Methods

The study used methods of processing statistical data on the literature review, as well as field and theoretical research.

3 Results and Discussion

The largest flood centers in the Kashkadarya region are the Kashkadarya, Guzardarya, Tanhozdarya, and Yakkabagdarya basins, as well as streams in the mountainous areas of the region. This is due to the accumulation of large amounts of sediments in the basins of water and mudflow reservoirs built in the river basins. The following is information on floodplains conducted by field surveys[11, 12].

The following diagrams provide information on the volume of floods in Langar, Kyzylsuv, Kalkama, and Dehkanabad flood-reservoirs in 2015-2021. As can be seen from the diagram, the number of floods in the floodplains in the studied years is expected to increase, especially in Langar, which is 3 times higher than in 2015 by 2015. In 2020-2021, a decrease was observed (Fig. 1).

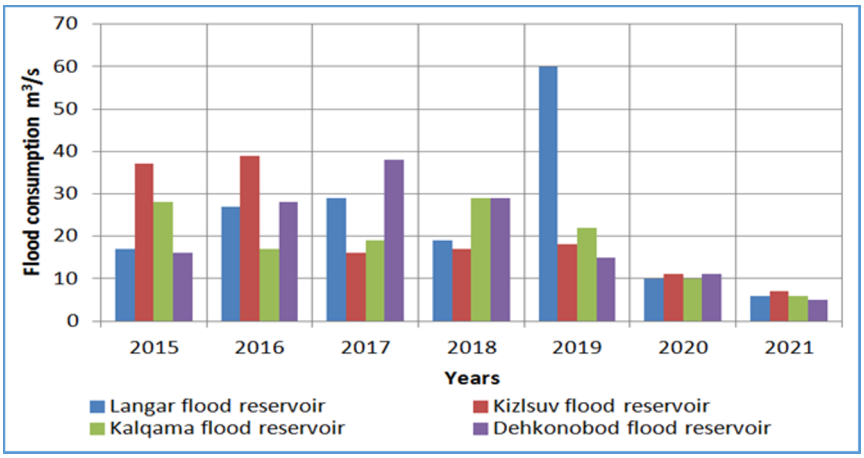

Fig. 1. Floods were observed in flood reservoirs in Kashkadarya region in 2015-2021.

Large influxes of mudflows lead to the inflow of sedimentary sediments formed by large rocks through streams into reservoirs and their re-formation with suspended sediments in the basins of mudflows. The study results of the characteristics of sedimentary sediments in

the above reservoirs show that more than 90% of the solid flow consists of soils with particles d <0.05 mm. Such soil particles mixed with water significantly affect the stream's physical and mechanical properties. In particular, the viscosity and specific gravity of the stream relative to fresh water create complex hydraulic conditions in the process of transformation of floods and mudflows in the upper reaches. According to the results of observations in the flood reservoirs, the muddy stream falling into the upper reaches moves along the deep ravine. However, in the direction of the dam, the particles of muddy streams are sorted and sink [16, 17].

Studies show that the location of muddy sediments in the floodplain basin depends on the fractional composition of the sediments coming from the river. For this reason, in July 2021, samples were taken to determine mudslides' physical and chemical composition in the Langar and Kalkama reservoirs. The diagram below shows the sample locations (Figure 2 and 3).

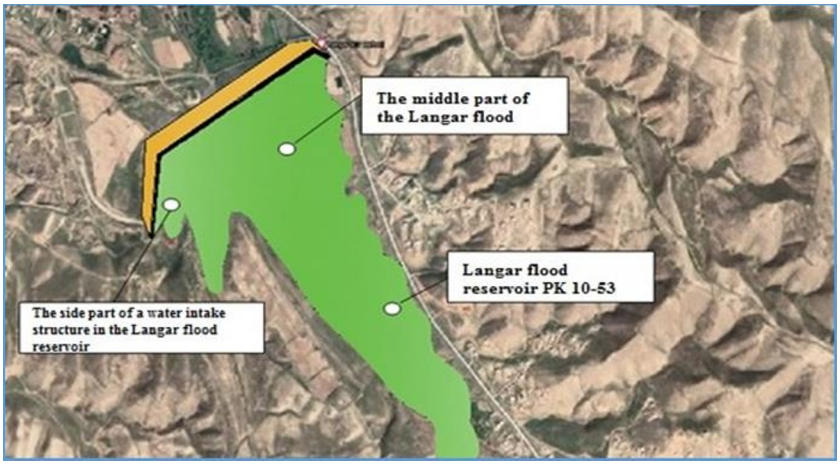

Fig. 2. Places sampled from the Langar flood reservoir

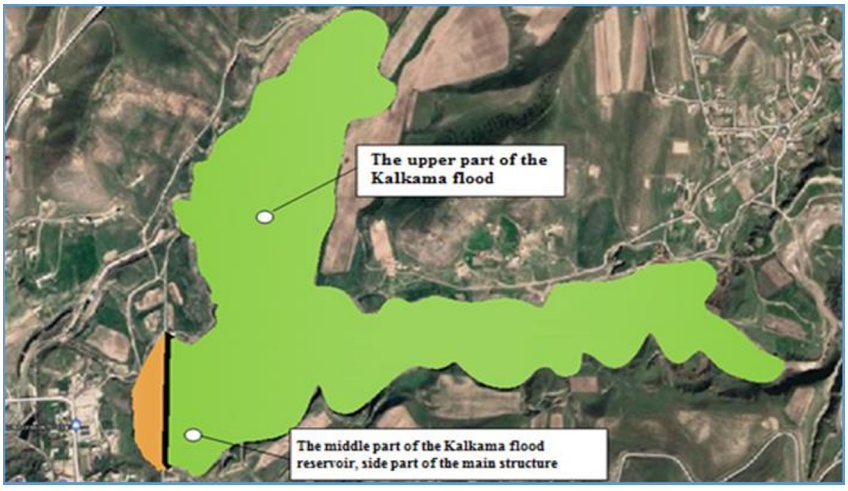

Fig. 3. Places sampled from the Kalkama flood reservoir

Samples of sediments from the Langar and Kalkama flood reservoirs were analyzed at the "Hydroproject" and "Soil Mechanics" Laboratories (Fig. 4).

Fig. 4. The process of analysis of mud and sediment samples in the laboratory "Hydroproject"

The results of the analysis of the granulometric composition of the sludge are given in Table 1 and the diagram in Fig. 5 below.

Table 1. Granulometric composition of turbid sediments sampled from the basins of the Langar and Kalkama reservoirs

№	Name of sampled flood reservoirs	Granulometric composition						
		1.0-0.5 mm	0.5-0.25 mm	0.25-0.10 mm	0.1-0.05 mm	0.05-0.01 mm	0.01-0.005 mm	0.005-0.002 mm
1	The upper part of the Kalkama flood reservoir	71.20	11.60	12.40	4.80	-	-	-
2	Langar flood reservoir PK 10-53	0.40	1.80	2.20	32.36	31.91	20.30	11.03
3	The middle part of the Langar flood reservoir	0.60	0.80	0.60	25.35	21.36	21.36	29.93
4	The middle part of the Kalkama flood reservoir, side part of the main structure	0.60	1.40	3.60	37.20	46.22	10.98	-
5	The side part of a water intake structure in the Langar flood reservoir	1.60	1.20	2.00	29.44	11.54	23.07	31.15

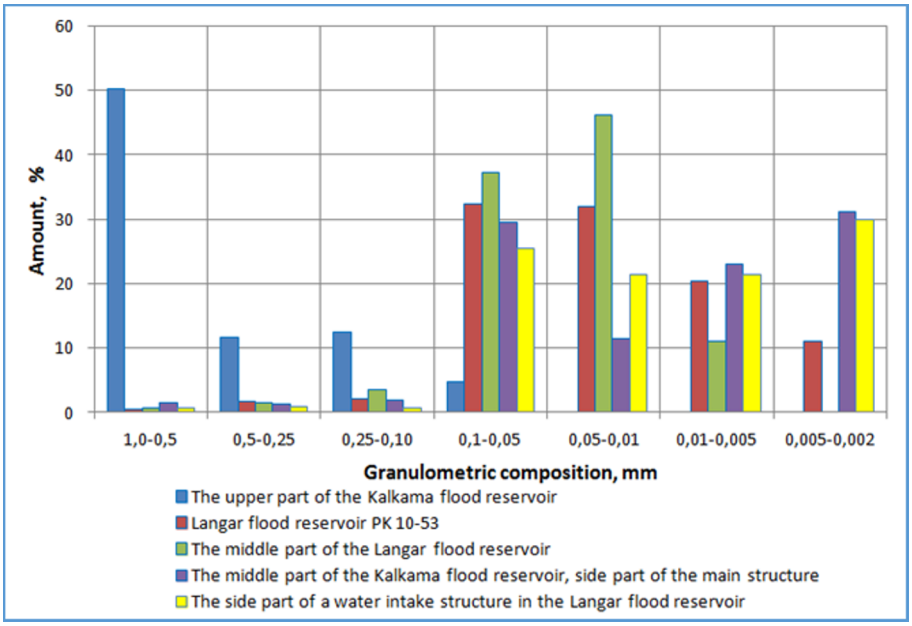

Fig. 5. Granulometric composition of turbid sediments sampled from basins of Langar and Kalkama reservoirs

According to the analysis of the granulometric composition of the sediments sampled from the basins of the Langar and Kalkama reservoirs, the average percentage of particle diameters and their weights are as follows:

In the middle part of the sample of the Langar flood-reservoir 29.93% to 0.005-0.002 mm, 21.36% to 0.01-0.005, 21.36 to 0.05-0.01 mm, 25.35% to 0.1-0.05, 0.6 to 0.25-0.1 mm %, 0.5-0.25 mm to 0.8%, 1.0-0.5 to 0.6%, i.e., the amount of particles smaller than 0.05mm reaches up to the 98%. This figure is 94-95% in front of the floodplain and the discharge section. This means that turbid particles of 1 mm and larger have already sunk into the reservoir's inlet and into it. It should be noted that, according to field observations, flood currents enter the basin of the Langar flood reservoir through a formed channel 12 km long from the entrance. The river flows into the river through the floodplains formed in the mountains in the upper part of the Kyzylkishlak area. As a result, rocks and streams with a diameter of 1 m and larger, which are displaced by the flood, are scattered at a certain distance in a 12 km long formed valley. Due to the high-velocity mudflow in the formed riverbed, due to the deformation of the riverbed and its banks, the composition of turbid sediments is re-formed and moves towards the flood reservoir. The analysis shows that it is advisable to take constructive measures in the formed basin to prevent the entry of primitive and suspended sediments into the reservoir.

In the Kalkama flood reservoir, the granulometric composition of turbid sediments is the same as in the Langar floodplain, but the mud is in the form of small sands (Fig. 6).

Fig. 6. The process of sampling sediments in the basins of the Langar and Kalkama flood reservoirs.

Table 2. Chemical composition of turbid sediments sampled from basins of the Langar and Kalkama flood reservoirs.

№	Name of sampled flood reservoirs	HCO_3	CL'	SO4"	Ca"	Mg'	Na'+K
		mg	mg	mg	mg	mg	mg
1	The upper part of the Kalkama flood reservoir	0.26	0.06	0.56	0.40	-	0.48
2	Langar flood reservoir PK 10-53	0.43	0.11	2.14	2.00	0.30	0.38
3	The middle part of the Langar flood reservoir	0.51	0.37	2.19	1.40	0.50	1.17
4	The middle part of the Kalkama flood reservoir, side part of the main structure	0.34	1.78	5.91	2.90	1.90	3.23
5	The side part of a water intake structure in the Langar flood reservoir	0.61	0.23	1.45	1.80	0.40	0.09

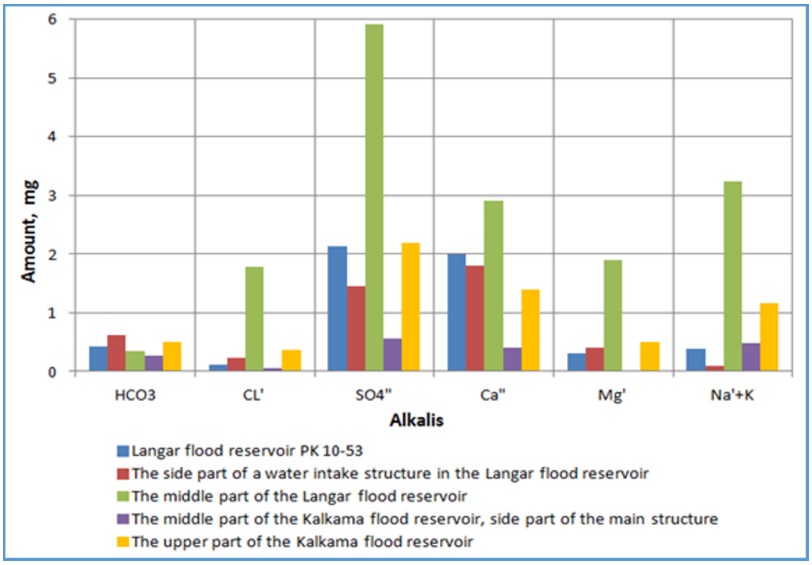

Fig. 7. Chemical composition of turbid sediments sampled from basins of Langar and Kalkama flood reservoirs

Table 3. Chemical composition of turbid sediments sampled from Langar and Kalkama flood reservoir basins.

№	Name of sampled flood reservoirs	Viscosity index, %		
		The upper limit, W1	Lower limit, Wp	The number of viscosity, Wn
1	Langar flood reservoir PK 10-53	33.35	25.21	8.14
2	The middle part of the Langar flood reservoir	40.68	26.45	14.23
3	The middle part of the Kalkama flood reservoir, side part of the main structure	27.50	24.25	3.25
4	The side part of a water intake structure in the Langar flood reservoir	45.15	28.23	16.92

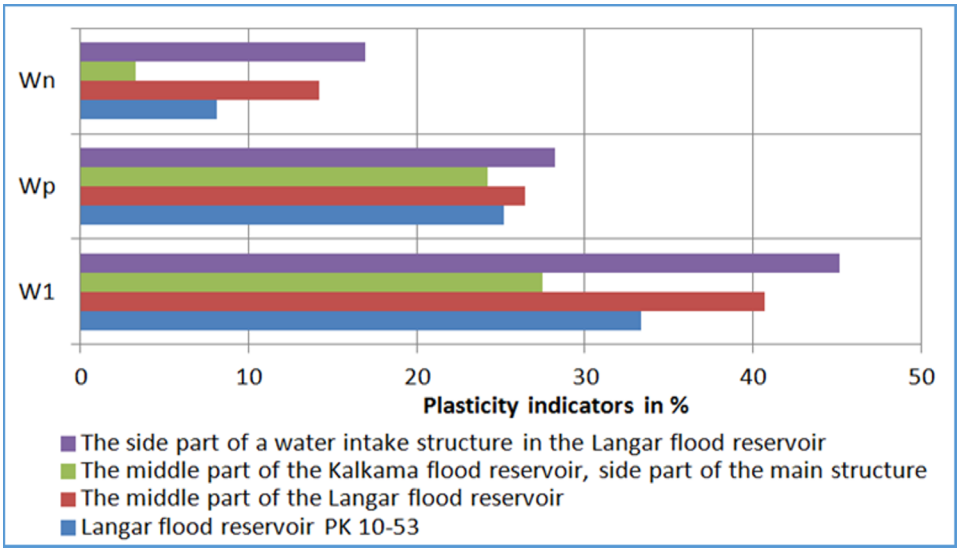

Fig. 8. The degree of viscosity of turbid sediments sampled from the basins of the Langar and Kalkama flood reservoirs.

Analysis of the chemical composition of the muddy sediments of the flood reservoirs shows that the viscosity level of the sediments in the Langar flood reservoir is much higher than in the Kalkama flood reservoir. In both of them, the levels of SO_4 and Ca are high. (Table 2, Fig. 7).

The study of the granulometric and chemical composition of turbid sediments in the above flood reservoirs shows that they depend on the granulometric composition of mud at the inlet, i.e., the number of fine particles increased from the inlet to the dam. The analysis shows that the mud in the Langar flood reservoir can be used as a building material in brick factories due to its high viscosity (Table 3, Fig. 8). The mud in the Kalkama flood reservoir can be used in construction as small sand due to its low viscosity [16-20].

4 Conclusions

The results of field research in Langar and Kalkama flood reservoirs in the Kashkadarya region revealed the following:

1. Data on the volume of floods in the Langar, Kyzylsuv, Kalkama, and Dehkanabad flood reservoirs in 2015-2021 are given. It can be seen from the diagram that in the studied years, the inflow of floods in the reservoirs is different. In 2019, the Langar flood reservoir received 3 times more floods than in 2015and in 2020-2021, a decrease was observed. As a result, the floodplain basin continues to be filled with turbid sediments.

2. In the middle part of the sample of the Langar flood reservoir bowl, the granulometric content of turbid sediments was 29.93% from 0.005-0.002 mm, 21.36% from 0.01-0.005, 21.36 from 0.05-0.01 mm, 25.35% from 0.1-0.05, 0.25 -0.1 mm to 0.6%, 0.5-0.25 mm to 0.8%, 1.0-0.5 to 0.6%, i.e., particles smaller than 0.05mm increase up to the 98%. This figure is 94-95% in front of the upper part of the reservoir and the discharge section. In the Kalkama flood reservoir, the granulometric composition of turbid sediments is similar to that of Langarniki, except that the mud is in the form of small sand.

3. The particle size of the muddy-sedimentary deposits in the upper basins is characterized by a decrease in the dam's direction from the flood reservoir's entrance. Deposits composed mainly of rock and sand particles were found in the upper storks.

4. Due to the high viscosity of the mud in the Langar flood reservoir, it can be used as a building material in brick factories. The mud in the Kalkama flood reservoir can be used in construction as fine sand due to its low viscosity.

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