ESTIMATION OF SEDIMENT VOLUME DURING WATER INTAKE FROM THE AMUDARYA RIVER TO PUMPING STATIONS

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Abstract

The article examines methods for ensuring guaranteed water supply and investigates sedimentation processes in the main settling basin. Based on a comprehensive study of the water conveyance channel, recommendations were developed to improve its operation. The hydraulic and alluvial regimes of sediments in the water conveyance channel were analyzed, and the results were summarized. Furthermore, recommendations were proposed for organizing sediment removal operations and appropriately placing dredgers along the channel length. The placement of dredgers was performed considering the distribution of sediment volumes along the channel, as well as the type and operation mode of each dredger.

Keywords: riverbed, water conveyance channel, riverbed processes, sediment, recommendation, improvement, sediment deposition, settling basin, pumping station

Introduction

Predicting the influence of pumping station operating modes on flow dynamics and hydrodynamic characteristics is one of the most important tasks in channel hydraulics. It should be noted that the Amudarya River ranks second in the world in terms of turbidity. Accordingly, a significant amount of suspended sediment is transported along the riverbed into the conveyance channel. Some of these sediment particles may pass through the irrigation channel and reach agricultural fields, complicating the operation of pumping stations.

To increase the efficiency of pumping stations and reduce abrasive wear on pump units, it is crucial to ensure a guaranteed water supply, maintain proper water levels in the forebay, and improve sediment removal technology [1–3].

Studying the dynamics of sediment flow in the forebays of pumping stations allows for the determination of sediment intensity and direction, which directly affects reliability and operational efficiency. Measures to increase the water conveyance capacity of channels and provide a guaranteed water supply to pumping stations with minimal sediment volumes are essential tasks for the operational services of pumping stations. Modifying the water supply schedule and altering hydraulic and alluvial flow regimes in the supply channels significantly changes the natural course of riverbed processes, making flow prediction challenging. Therefore, research on riverbed processes in pumping station channels and their impact on conveyance capacity continues to attract considerable scientific attention [4]. However, despite numerous studies, practical solutions remain incomplete [5–6]. The complexity arises from the multi-factor nature of channel flow processes occurring in space and time, as well as the high sediment load of water entering pumping station channels from the Amudarya River [6].

Research Methodology

Field studies were conducted at the intake sections of the Karshi main canal cascade pumping stations, and the hydraulic performance of the conveyance channel was assessed. These studies form the methodological basis of this work.

Results and Discussion

The Amudarya River, being the second most turbid river in the world, carries a large amount of sediment along the riverbed into the conveyance channel. Sediment particles may enter the channel intermittently, either settling or remaining suspended in the flow, which complicates the operation of water intake units and the water abstraction process from the river (Fig. 1).

Figure 1. Water intake structure from the Amudarya River to the Karshi Main Canal

The calculation of sediment removal expenditures was carried out according to the following procedure. The fight against sediment primarily focuses on the larger fractions of sediment in the initial sections of the channels. Sediment is removed mechanically, using electric and diesel dredgers (Fig. 2).

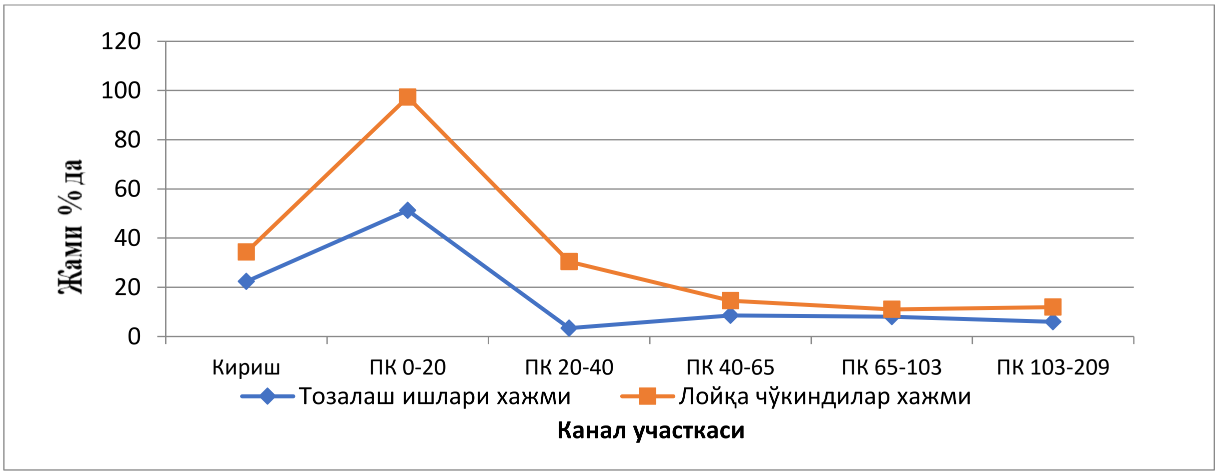

Figure 2. Sediment deposition and average removal volumes along the length

The main difficulty in organizing sediment removal operations is determining the volume of sediment accumulated in the main and inter-farm settling basins.

The total volume of sediment entering the channel intake section consists of the sum of suspended sediment (W_{sus}) and bedload sediment (W_{bed}),

$$W_{ум} = W_{муал} + W_{туб}$$

The volume of sediment entering the water conveyance channel from the river is determined by the water intake volume, the turbidity of the river water, and the clarity of water in the main and inter-farm channel sections:

$$W_{муаллак} = \frac{\sum Q\rho_0}{\gamma_н}$$

Here:

- ΣQ– total water consumption (flow), in m³ for a decade or a month;
- ρ_0– average ten-day or monthly turbidity of water at the channel intake, in kg/m³;
- γ_l– density of sediments in water (for settling basins, typically 1250 kg/m³).

Due to measurement difficulties, the volume of sediment entering the channel can be expressed as a percentage relative to the volume of settled sediment. According to our measurements, in the head section of the KMK, the flow of bedload sediment accounts for 10–28% of the total sediment load.

The total volume of sediment entering the pumping station's water intake channel, considering both suspended and bedload sediment, can be determined using the following formula:

$$W_л = \frac{\sum Q\, \rho_0 (\eta_b + K_g)}{\gamma_л}$$

Here:

- $K_g = 0.15–0.2$during the flood period;
- $K_g = 0.2–0.27$during low-water periods;
- η_b– the clarity of water at the outlet.

The value of the water purification coefficient is determined either by calculating the sedimentation regime in the main settling basin or based on data from special field observations:

$$\eta_b = \frac{\rho_0 - \rho_{чик}}{\rho},$$

Here:

- ρ_{out}– turbidity of water at the outlet of the settling basin.

When calculating the sediment volume in the main settling basin, the turbidity at the channel intake (ρ_0) is assumed equal to the turbidity of the river at the water intake. The calculated turbidity at the outlet of the settling basin (ρ_{out}) is multiplied by the channel's efficiency coefficient,

$$\rho_{чик} = \rho_т * K_c$$

$\rho_т$- Sediment transported in transit

$$K_c * K_n \approx \eta * \rho\ \% \approx \frac{0.4 * 83}{100} \approx 0.33,$$

Based on the results of field studies conducted on the Karshi Main Canal (KMK) and an assessment of its conveyance capacity, the following conclusions can be drawn:

Taking into account the operational mode of the pumping stations, a method has been developed to determine the sediment deposition dynamics along the length of the water supply channel. As a result, the efficiency of dredgers and the units of pumping stations can be improved.

To reduce sediment flow into the KMK intake channel, the structure of the channel intake section should be reconstructed in a way that directs the main portion of the sediment along with the overflow water, thereby improving the circulation of the river flow. A portion of the flow with lower sediment concentration enters the channel. Improving operating conditions at pumping stations and increasing the channel's conveyance capacity requires the development of hydraulic schemes for the placement of dredgers.

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