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## **INFLUENCE OF HYDROTECHNICAL FACILITIES ON INTERNAL RUNOFF DISTRIBUTION OF THE NARYN RIVER**

***Annotation:** the article is devoted to the study of the influence of hydraulic facilities on the intra-annual runoff distribution of the Naryn river. In particular, the paper highlights the issues of changing the water regime in the lower reaches of the Naryn river as a result of the operation of the Toktogul reservoir in irrigation and energy regimes. It is shown that under natural regime conditions, more than 70% of the annual runoff of the Naryn river passes during the flood period, and in recent years. Elsewhere under reservoir operation conditions in an enhanced energy regime, the runoff volume during the flood period is only 25-27%.*

***Keywords:** river, reservoirs, water consumption, estimation periods, natural regime, irrigation regime, energy regime, runoff volume, winter low water period, high water period, autumn low water period, water regime changing.*

**Introduction.** As it is known, the construction of large hydraulic structures began on the territory of the Republic of Kyrgyzstan since the 1960s. Most of these structures were built in the middle and lower reaches of the Naryn river. And the largest of them is the Toktogul reservoir, which was used in 1975 [2, 4, 6]. After the reservoir was put into operation in 1975, since that time there has been a sharp change in the water regime of the Naryn river, especially in its lower reaches. Unfortunately, this process has not been sufficiently studied so far.

The purpose of this work is to assess the impact of hydraulic structures, in particular, the Toktogul reservoir, on the intra-annual runoff distribution of the Naryn river in its lower reaches. In this work, data on the mean monthly and mean annual water discharges of the Naryn river for the period 1953-2017, recorded at the Uchkurgan hydrological station, were used as source materials.

In order to achieve this goal, the entire observation period studied 1953–2017 was divided into the following estimation periods:

- the first estimation period covers 1953-1975, which characterizes the natural water regime of the Naryn river;
- the second estimation period includes 1976-1990, when the Toktogul reservoir was operated in the irrigation regime;
- the third estimation period includes 1991-1994 and is transitional, since during these years, the operation of the Toktogul reservoir gradually began to switch from irrigation to energy regime;
- the fourth estimation period refers to 1995-2013 which is characterized by a complete transition to the energy regime of the Toktogul reservoir operation;
- the fifth estimation period (2014–2020), includes the period of operation of the Toktogul reservoir in an enhanced energy regime.

**Main results and their discussion.** For each of the selected calculation stages, an analysis of the intra-annual distribution of the Naryn river runoff by months was performed (Fig. 1 - 5).

The first calculation stage, as noted above, reflects the natural water regime of the river. Naryn. During this estimation period, the maximum average long-term monthly water discharge was observed in June ( $1080 \text{ m}^3/\text{s}$ ), and the minimum average long-term monthly water discharge in January was  $166 \text{ m}^3/\text{s}$  (Fig. 1).

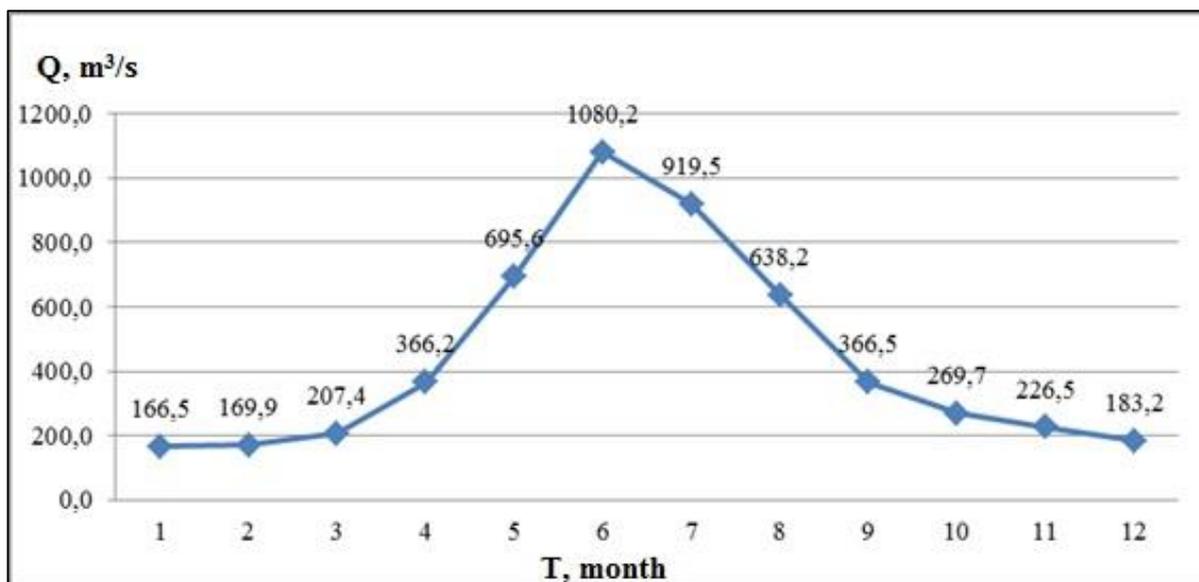


Figure 1. Intra-annual monthly runoff distribution of the Naryn river (Uchkurgan hydrogauge, 1953-1975)

The second estimation period takes into account the period when the Toktogul reservoir was put into operation and began to work mainly in the irrigation regime (Fig. 2).

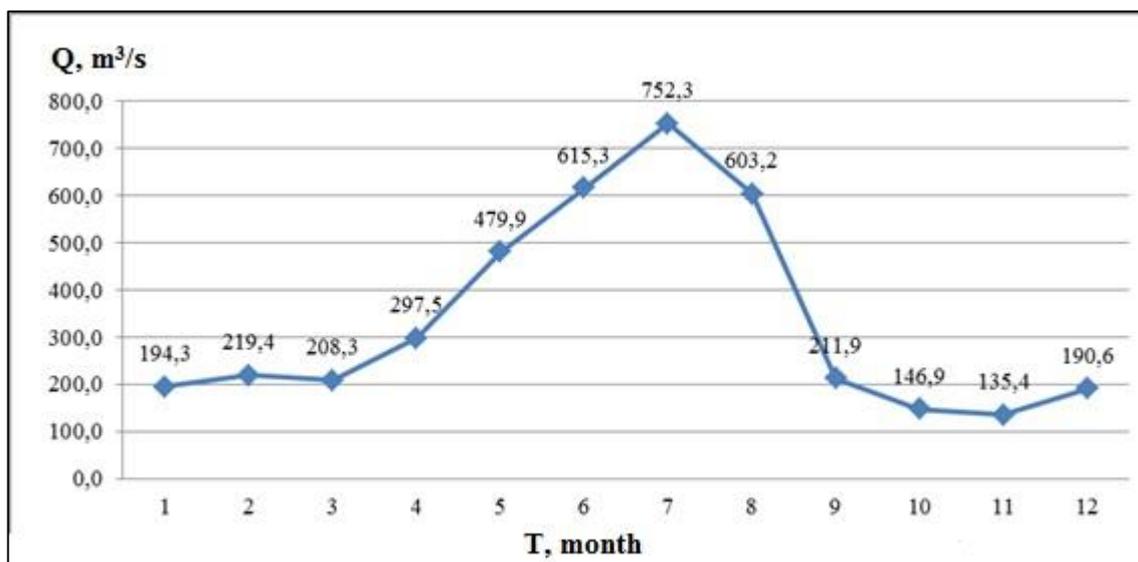


Figure 2. Intra-annual monthly runoff distribution of the Naryn river (Uchkurgan hydrogauge, 1976-1990)

During the second settlement stage, i.e. when the Toktogul reservoir operated only in the irrigation regime (1976-1990), significant changes were observed in the intra-annual distribution of the flow of the Naryn river in its lower reaches. The average long-term maximum monthly water discharge was observed

in July, i.e. in the hydrograph of this period (Fig. 2), its crest was shifted to the right side relative to the hydrograph built for the natural regime (Fig. 1).

During the third - transitional period (1991-1994), i.e. during the transition from the irrigation to the energy regime of operation of the Toktogul reservoir, three ridges appeared in the hydrograph: in the autumn and winter low water periods, as well as during the flood period (Fig. 3).

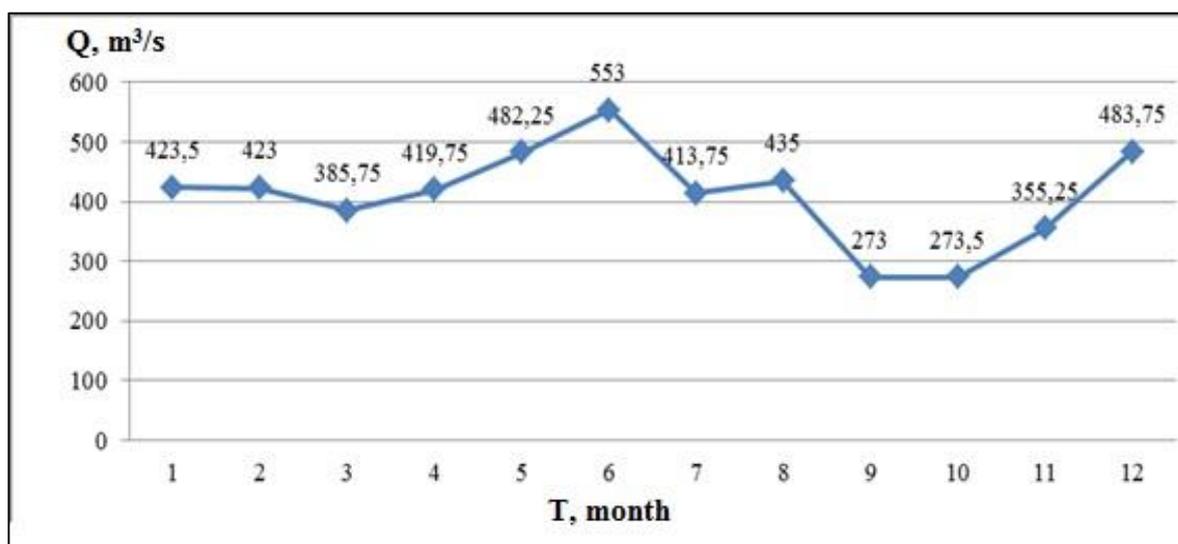


Figure 3. Intra-annual monthly runoff distribution of the Naryn river (Uchkurgan hydrogauge, 1991-1994)

During these years, the operation of the Toktogul reservoir gradually switched from irrigation to energy regime. The shape of the hydrograph built for this regime has changed dramatically. As can be seen from this hydrograph (Fig. 3), the amplitude of the average monthly water flow is only 280 m³/s and, therefore, it has a smoother appearance. In addition, it should be noted that the average flow rates of low-water months, especially from December to March, increased by 2.5-3 times, and the summer months (June-August), on the contrary, decreased by 2.0-2.5 times.

During the fourth settlement period (1995-2013), the Toktogul reservoir was operated completely in the energy regime. This mode of exploitation has drastically changed the shape of the hydrograph of the Naryn river. Now the shape of the hydrograph has a concave appearance (Fig. 4).

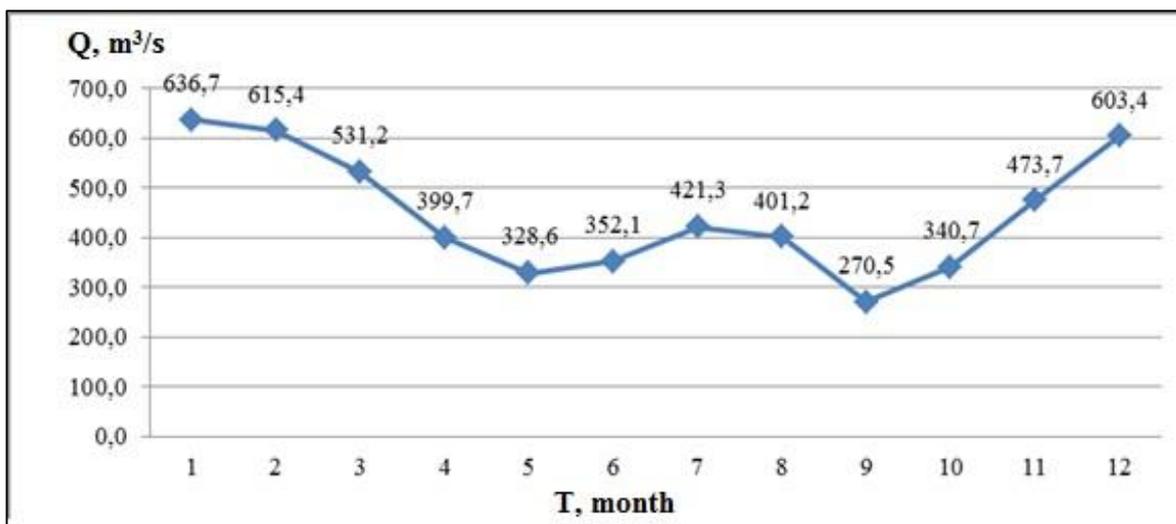


Figure 4. Intra-annual monthly runoff distribution of the Naryn river (Uchkurgan hydrogauge, 1995-2013)

The hydrograph of this settlement period is characterized by increased, almost 4 times, water discharges of low-water months compared to the natural regime. Here, on the contrary, the costs of the growing season decreased by 2.5-3.0 times.

The situation in the last settlement period (2014-2020) sharply worsened and became a more serious problem in the hydrological regime of the Naryn river (Fig. 5).

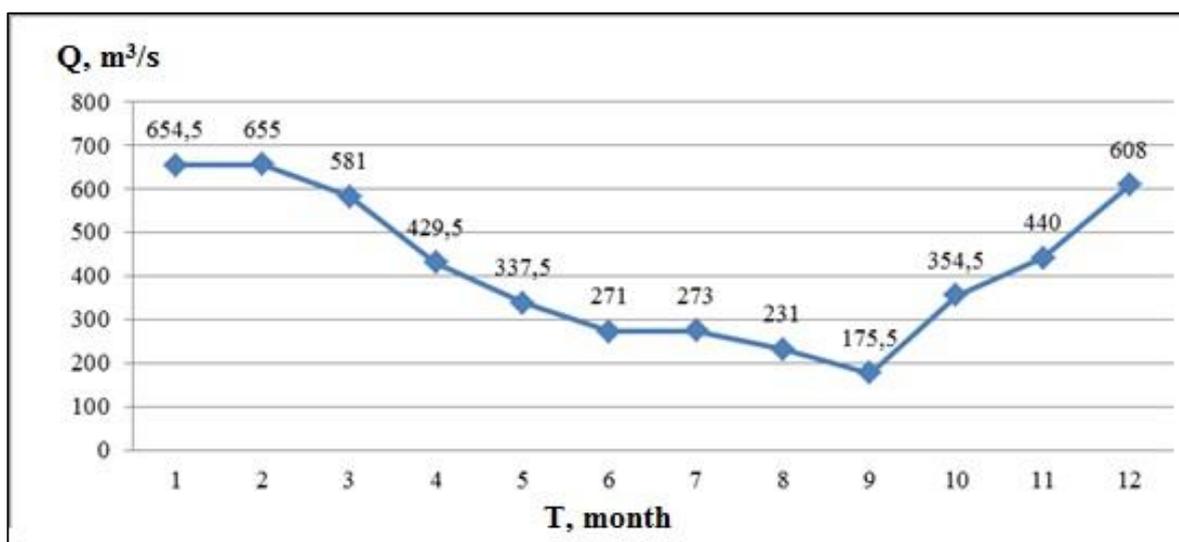


Figure 5. Intra-annual monthly runoff distribution of the Naryn river (Uchkurgan hydrogauge, 2014-2020)

The hydrograph of this computational period is characterized by a sharp decrease in water flow in the summer months, i.e. flood period. This unfortunately happens when the demand for irrigation water in the irrigated fields of Uzbekistan and Kazakhstan is very high. This situation leads to an acute shortage of water on irrigated lands for both republics.

Analysis of the results of the study allows to make following conclusions:

- in the period 1953-1975, when the Naryn river had a natural water regime, 16-18% of its annual runoff passed during the winter low water period, and in recent years its share is 40-45% of the annual runoff, which is approximately equal to half its annual flow;

- during the period of natural water regime, more than 70% of the annual flow of the Naryn river fell on the flood period, and today the volume of the flow of the flood period is only about 25% of its annual flow. This means that the volume of runoff during the flood period of the Naryn river became almost 3 times less than the volume of runoff during the natural regime;

- there is a situation similar to the winter low water in the autumn low water period. If, under the natural regime, 10-14% of the annual runoff passed during the autumn low water period, then in recent years its share has been 26-30% of the annual flow of the Naryn river;

- the problem of water shortage in irrigated lands can be solved by creating several seasonal reservoirs on the territory of Uzbekistan. It should be noted that such reservoirs (Rezaksay, Kengkul, Yazyavan) are already in operation.

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