

Section 5. Hydrology

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Hydrological regime of the lower reaches of Amudarja river in the conditions of intensive economical use of water resources

Abstract: In the article the issues of the change of Amudarja river flow along its length and in time in the conditions of intensive use of water resources are considered. The main attention is paid to the study of influence of the big irrigation canals on the decrease of the river flow, especially in the low reaches.

Keywords: water resources, hydrological regime, water intake, flow decrease, available water supply of the territory.

Introduction. The rise of the intensive use of the water resources for different economical purposes causes substantial changes of the water regime of rivers. In the conditions of Central Asia with developed irrigated agriculture and considerable water consumption for the industrial purposes the influence of anthropogenic factors had deep impact on the change of hydrological regime and overall decrease of the river flow. Amudarja river and especially, its low reaches are among these rivers.

The general theoretic and methodical issues of the research of hydrological regime of low reaches of Amudarja river in the natural conditions are described in details in the works of A. K. Proskuryakov [4], M. M. Rogov [6], V. L. Schultz [11]. Afterwards, in the conditions of intensified anthropogenic impact on the river flow these matters were considered in the works of I. A. Shiklomanov [10], F. E. Rubinova [7], V. E. Chub [9], F. Kh. Khikmatov [8] and others.

Familiarization and analysis of results of the above mentioned and other literary sources [1; 3] demonstrated that despite the voluminous number of publications, the hydrometeorological aspects of territorial redistribution of Amudarja river flow and water supply of its low reaches were not considered as the interrelated problem. That is why, **the objective** of this work is the study of dynamics of the water intake from Amudarja river by the big irrigation canals and their impact on the water supply availability in its low reaches. For reaching this goal we considered the following **main tasks**: study of dynamics of the use of water resources of Amudarja river; assessment of the water intake impact for irrigation purposes on the change of Amudarja river flow along its length and in time; assessment

of the water economy measures carried out in Amudarja river basin on the current and future water supply availability of its low reaches.

Background materials. For the solution of these problems the materials of standard hydrometeorological network observations of Amudarja river flow and big irrigation canals obtained from Uzhydromet, Ministry of water economy and agriculture of Republic of Uzbekistan, as well as results of studies on this problems published by former researches were used as the main background information. It should be mentioned that the materials of observations on big irrigation canals taking water from Amudarja river were used as the main initial data.

Results and their discussion. The territory of Amudarja low reaches is located down Tyuyamuyun waterworks facility and is one of the regions, where anthropogenic activity has a strong impact on the river water regime. At present 2336.5 thous. hectares of land usable for irrigation are located here. During the recent years about 697 thous. hectares of land are used for the irrigated farming.

In the second half of 50-s and beginning of 60-s of 20th century the intensive hydroeconomic construction development was observed in Amudarja river basin. In the middle and low streams of Amudarja river a number of new big irrigation canals were constructed. Currently, more than 60 canals take water in the middle and low streams from Amudarja river for irrigation. The biggest of them in the middle river stream are: Karakum canal (where the water intake in vegetation period reaches 800–850 m³/s), Karshi main canal (350–375 m³/s) and Amu-Bukhara canal (400 m³/s). Downstream Amudarja river the water is taken in by Shavat, Tashsakin, Pakhtaarnin,

Kyzketken and other canals the maximum discharge values of which in vegetation period are 200–350 m³/s.

In the result of the more intensive water intake along the river length the significant reduction of the volume of Amudarja river takes place. This process is especially manifested in the middle river flow, and it intensifies more in its low reaches. The Fig.1 shows that since the middle of 50s up to the beginning of 80s the volume of water intake in the middle stream from Amudarja river by all canals is being increased. During the next years the water intake to canals was stabilized. However, in 2001 the least volume of water intake was observed in all canals during the last 30 years which is caused by the low water. This is especially observed in Karakum and Karshi main canals. In whole, during the last decades (2000–2012) the total mean year water intake from

Amudarya river by big canals in its middle stream is 17,9 km³ a year. During 2000–2012 their extreme values were distributed as follows: mean maximal mean year water intake corresponds to 2006 (20.2 km³), while the minimal one corresponds to 2001 (12.9 km³).

The analysis of the available hydrological materials shows that the general regularity in the long-term variations of water availability along the river length was stable up to the end of 50s of 20th century. Anthropogenic changes of the river flow were especially revealed since the beginning of 60s of the 20th century. This is determined by the intensive development of irrigated areas and building of the hydraulic works in Amudarja river basin [7]. According to this, the water regime of Amudarja river up to 1960 can be considered as the conventionally-natural one.

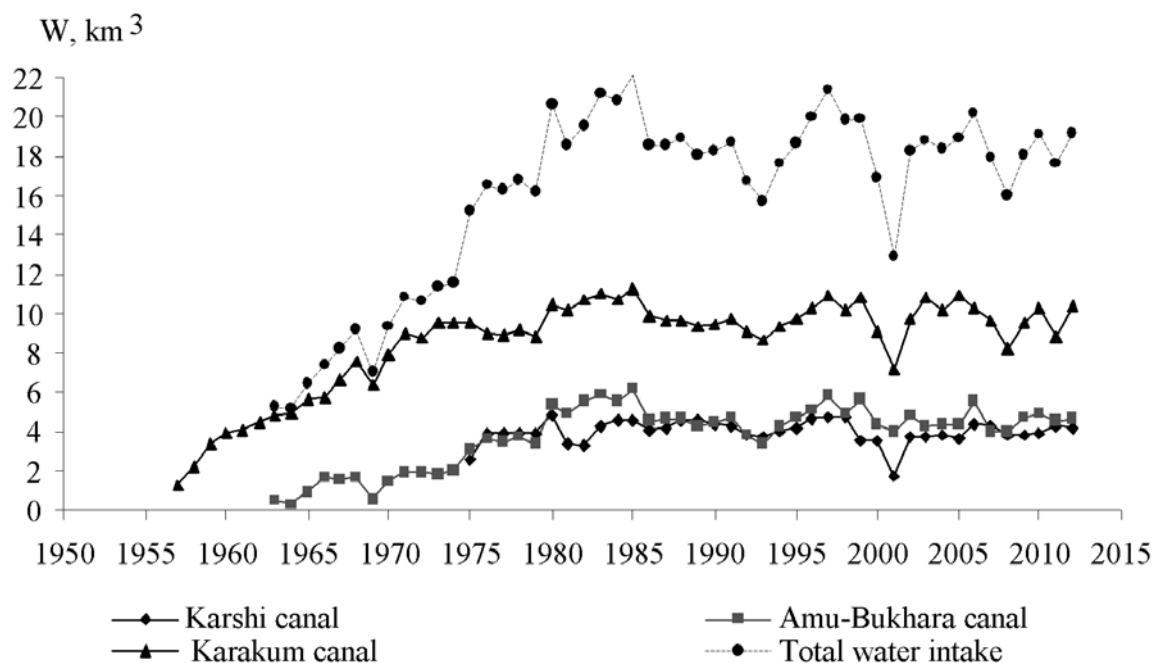


Fig. 1. Dynamics of water intake from Amudarja river by the big main canals in its middle stream

The data of observations at Kerki hydrological station characterizes the liquid flow regime in the upper part of Amudarja river in the natural conditions up to 1960 as during this period the water intake for irrigation upper Kerki town was not more than 0.5–1 % of the river flow registered in this cross-section. With putting the Karakum canal into operation the water intake was about 10 % of the river flow in this cross-section. In the conventionally-natural period the water intake in Kerki — Chatly section was almost constant, being 10–19 % of the river flow near Kerki town. Since 1960 the water intake in this section reached 20–28 % of flow near Kerki town [2]. Due to the construction and putting Takhiatashash water distributor into operation in 1974 the water flow became to be fixed in Samanbai cross-section opened 15 km. down Chatly cross-section. In the result of these measures the data for Chatly-Samanbai can not characterize the natural regime of Amudarja river [5].

In general, the analysis made with the account of impact of anthropogenic activities on Amudarja river flow has made it

possible to divide the whole investigated period to the following two periods: the conventionally-natural period (CNP); period of intensified impact, i. e. the period of the intensive economical use of Amudarja river resources.

In its turn, the second period was divided to the following rated periods: 1) 1931–1954; 2) 1955–1966; 3) 1967–1979; 4) 1980–1990; 5) 1991–2011. In distinguishing these rated periods the years of putting of big irrigation canals and other hydraulic works into operation were taken into account.

The first of these periods — 1931–1954 characterizes the conventionally-natural period when the impact of the economical activities on Amudarja river flow was minimal. The second period is characterized by the intensive hydro-economic use of water resources of Amudarja river basin. That is why the selected rated stages of the second period are also distinguished by the intensity of the water resources use. The calculations made for the study of the change of the annual flow of Amudarja river made it possible to estimate their changes in time and along its length (table 1).

Table 1. – Changes of the annual flow of Amudarja river in time and along its length

Hydrological station	Investigated periods									
	CNP		The period of the intensive anthropogenic impact							
	1931–1954		1955–1966		1967–1979		1980–1990		1991–2011	
	Q, m ³ /s	W, km ³	Q, m ³ /s	W, km ³	Q, m ³ /s	W, km ³	Q, m ³ /s	W, km ³	Q, m ³ /s	W, km ³
Kerki	2096	66.1	1805	56.9	1639	51.2	1298	40.9	1402	44.2
Tyuyamuyun	1966	62.0	1718	54.2	1359	42.8	893	28.2	854	26.9
Chatly-Samanbai	1534	48.4	1197	37.8	803	25.3	183	5.77	235	7.41

The digits shown in table 1 show that in 1931–1954, i. e., during the conventionally-natural period the mean annual volumes of Amudarja river flow were 66,1 km³ near Kerki town and 48.4 km³ near Samanbai village. Thus, during this period only 73.2% of the annual flow passing through the cross-section near Kerki town up reached Samanbai section. That is why, the further calculations made for the other accepted rated periods we made referring to these flow correlations, i. e., the ones which were registered in the cross-sections near Kerki town and Samanbai village during conventionally-natural period.

In the first rated period due to the intensive development of irrigated lands in the middle and low stream of Amudarja river the big main Karakum, Karshi, Amu-Bukhara and other canals were put into operation. This caused the substantial increase of water intake from the river. In the result of this, water intake from the river began to increase both along its length and in time. During this period the annual water intake in the middle stream increased from 9.1 to 26.3 km³ while in the low reaches it increased from 12 to 3.8 km³. It was observed that along the length of the studies river the annual water volume decreased from 56.9 to 37.8 km³ in average (Table 1).

The analysis of the fulfilled calculations has shown that in all rated periods along the length of Amudarja river the tendency to the decrease of water flow was recorded. In the second rated period the annual water volume in Kerki cross-section was 51.2 km³, in average, and in Tyuyamuyun

it was 42.8 km³ and in Samanbai it was 25.3 km³ a year. The average annual decrease of the river flow recorded in Samanbai cross-section is 59.1% in relation to the upper cross-section of Tyuyamuyun.

Similar situation (i. e., flow reduction) is also observed in the third and fourth rated period. In Kerki cross-section in the last rated period the mean annual flow volume was 44.2 km³, in Tyuyamuyun — 26.9 km³ and in Samanbai — 7.41 km³ a year. These volume values near Kerki town are only 66.9%, in Tyuyamuyun — 43.3% and in Samanbai — 15.3% in relation to the conventional-natural period. This was caused by the increase of water intake from Amudarja river as well as the uneven water distribution along the river and canal length. As a rule, in the result of this, the upstream water users are in more beneficial position than the downstream ones.

The degree of Amudarja water resources use is definitely characterized by the factor of the flow intake which equals to the correlation between the total water intake upper the investigated cross-section and the inflow from the flow formation zone. This factor is determined by the water supply availability of the river and water supply availability of the year, from one side and by the level of the economic use, from another side. At every level of the water-economy construction activities the factor of the flow intake is increased from the high water availability years to the low water ones. The factor of the flow intake is increased in time and along the river length.

Table 2. – Mean annual factor of the flow intake from Amudarja river during 1946–2010

Rated period	The source of the water intake	
	Middle stream	Down stream
1946–1950	0.02	0.18
1951–1955	0.02	0.17
1956–1960	0.06	0.22
1961–1965	0.14	0.37
1966–1970	0.16	0.36
1971–1975	0.33	0.83
1976–1980	0.50	1.43
1981–1985	0.81	5.04
1986–1990	0.90	2.29
1991–1995	0.63	1.43
1996–2000	0.92	3.09
2001–2005	0.86	3.08
2006–2010	1.04	3.87

The analysis of results of the fulfilled calculations has shown that in the middle stream of Amudarja river the factor of the flow intake during the investigated period was increased from 0.02–0.06 to 0.92–1.04, while in its low stream it increased from 0.17–0.18 to 1.43–5.04 (Table 2).

The main conclusions. Thus, the information presented above gives us the reason to conclude that the development of the new irrigated length, putting of the big irrigation

canals into operation and construction of hydraulic structures in Amudarja river basin in a whole, caused the flow redistribution in time and along the river length. During the implementation of these activities the substantial changes in Amudarja water regime have taken place. This defines the necessity of the further detailed studies of hydrological regime of Amudarja low reaches to guarantee the water supply availability of the Priaralje region.

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