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HYDROLOGICAL REGIME OF THE RIVERS OF THE KASHKADARYA BASIN AND ASSESSMENT OF LOCAL WATER RESOURCES

Abstract: *The article is devoted to the assessment of the hydrological regime of the rivers of the Kashkadarya basin and the local water resources of the oasis. In it, at first, the intra-annual distribution of river runoff by months of the basin and the coefficient of river nutrition were calculated. In the following parts of the work, the coefficients of variability of the river runoff of the basin and changes in water resources for two calculation periods were determined. At the end of the study, the main indicators of river runoff in the Kashkadarya basin were calculated. All calculations are performed for different accounting periods. The results obtained during the study were compared and analyzed with data from previous studies, and scientific conclusions were given.*

Keywords: *river, water discharge, runoff module, runoff layer, runoff volume, hydrological regime, runoff change during the year, coefficient of variation, water resources*

The hydrological regime of the rivers of Central Asia was studied in the middle of the last century by V.L.Shultz, O.P.Shcheglova, M.N.Bolshakov and others [1, 3, 4, 5]. In the future, similar studies were continued by G.N.Trofimov, V.E.Chub, Yu.N.Ivanov, A.A.Rasulov, F.H.Hikmatov and others [2, 6-8, 9]. The results of these studies have been used in the relevant fields of hydrological and water management calculations.

By now, over the next 40 years, a sufficiently large amount of material has been accumulated, which allowed V.E. Chub to clarify previously defined characteristics of the flow of the rivers of the Kashakadarya basin. The results of a

special study by V.E. Chub [3] made it possible to make a more detailed assessment of the local water resources of the Kashkadarya oasis, which differ in the completeness of the coverage of the hydrological material and, accordingly, their reliability. This assessment is necessary taking into account the longer series of observations and its implementation has become a time requirement. The results of such studies are necessary for solving problems related to the sustainable development of the country and its individual regions, such as the Kashkadarya Oasis.

In the last century, hydrological observations with different series of durations were conducted at 50 hydrological sites in the Kashkadarya River basin. Taking this into account, in this work we have selected hydrological posts with longer series of actual observations.

When using water resources for the purposes of irrigated agriculture, data on the intra-annual distribution of river flow are of particular importance. As is known by V. L. Shultz, the annual distribution of river runoff can be very significantly influenced by the thickness of the snow cover, which determines the position of the snow line, and the height of the glaciers. These hydrological indicators are also typical for the Kashkadarya basin. In this regard, we have calculated the annual distribution of the flow of the studied rivers using data from recent years of observations. The calculation results are shown in Table 1.

In the table we can see, that rivers of the Kashkadarya basin differ in a certain range of the time of the onset of the monthly maximum and by a different anual flow distribution. In the table we can see, that rivers of the Kashkadarya basin have been differ in a certain range of the time onset of the monthly maximum and by a different anual flow distribution. For example, at average catchment heights up to 2000 m (Kashkadarya - Varganza, Jinydarya - Jazz), the monthly maximum flow (20% or more of the annual) is observed in April. On the rivers Akdarya (Khazarnau), Tankhizydarya (Katagan), Yakkabagdarya (Tatar), the average height of catchments ranges from 2200 – 2750 m, the monthly maximum flow is observed in May and even in June.

Table 1

Intra-annual distribution of river runoff by months (in %) and values of the Schulz coefficient (δ)

River – post	Billing period		Months												δ
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Kashqadarya – Varganza	I	1933-1952	5,0	8,2	16,2	23,8	16,6	8,0	4,6	3,7	3,2	3,3	3,5	4,2	0,18
	II	1927-2020	3.3	5.1	10.6	15.5	10.4	4.6	2.6	1.93	1.7	1.8	2.2	3.1	0,15
Djinydarya–Jauz	I	1933-1952	4,6	12,3	7,9	20,0	18,3	7,6	4,9	4,3	4,7	5,2	5,3	5,0	0,26
	II	1941-2020	0,9	1,1	1,9	3,1	2,7	1,5	1,0	0,9	0,9	1,0	1,1	1,1	0,31
Akdarya-Khazarnau	I	1933-1952	2.6	2.9	4.5	8.6	13.9	21.7	19.0	10.8	6.3	4.0	3.2	2.9	0,74
	II	1927-2020	2.6	2.7	5.6	11.2	17.4	28.4	30.6	21.5	10.6	6.2	4.8	3.4	1,0
Tankhizidarya–Kattagan	I	1933-1952	2,0	2,2	3,5	9,6	22,8	28,0	15,9	5,9	3,3	2,5	2,2	2,2	0,39
	II	1951-2020	0.9	1.0	2.1	5.8	11.9	13.2	6.3	2.0	1.0	0.8	1.0	1.0	0,29
Yakkabagdarya–Tatar	I	1933-1952	1,8	1,3	2,7	9,0	22,7	28,0	17,3	6,5	3,5	2,70	2,40	2,19	0,44
	II	1930-2020	1.2	1.9	1.9	6.7	15.8	20.2	11.8	4.5	2.5	1.8	1.6	1.4	0,42

Notes: 1 – according to V.L. Schulz, 2 – results obtained by the authors.

This is evidenced by the graphs constructed on the basis of the data in Table 1, the average annual distribution of the runoff of characteristic rivers of the studied area (Figs.1 and 2). The results of calculations of the annual distribution of the flow of the rivers of the Kashkadarya basin were compared with the data of V.L.Schultz (Table 1).

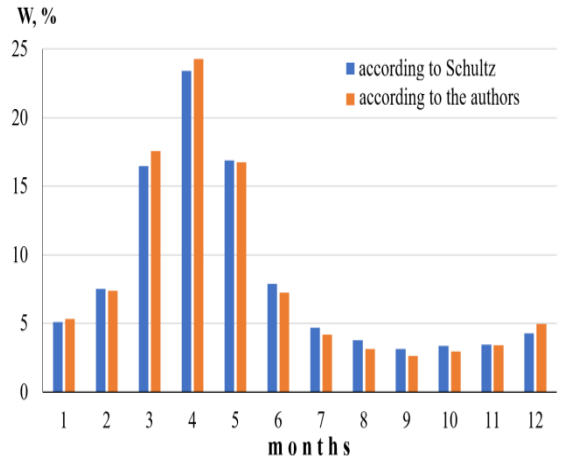

Fig.1. Average long-term intra-annual distribution of runoff by month (% of annual), p.Kashkadarya - K.Varganza

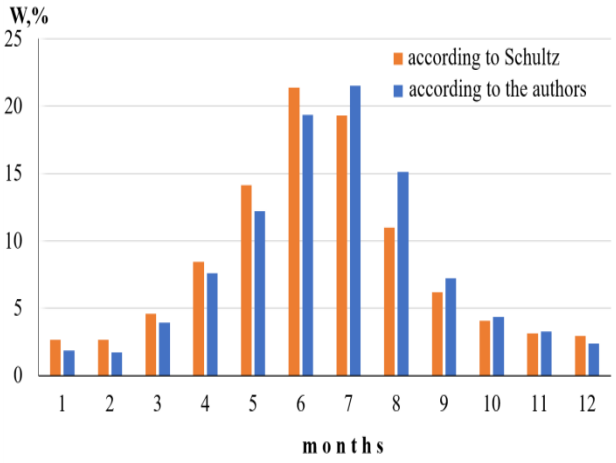

Fig.2. Average long-term intra-annual distribution of runoff by month (% of annual), p.Akdarya - K.Hazarnau

This paper presents an assessment of the indicators of runoff and the share of river power sources based on the materials of 5 hydrological posts with sufficiently long series of observations. For this purpose, the values of the coefficient δ were calculated and, based on them, the power sources of the rivers were clarified.The results are compared with the data of V.L.Schultz (Table 1).

The values of the parameter δ calculated by us with the involvement of materials from recent years of observations, are close with the given values (δ) of V.L. Schultz. However, it should be noted that in recent years, for most of the rivers in the Kashkadarya river basin, the runoff for the months of March-June is higher than had V.L. Schultz (Table 1).

It is known that V.L.Schultz attributed p.Kashkadarya in the group of snow-fed rivers, and according to our results, this river belongs to the snow-rain type. The rivers Jinydarya, Akdarya, Yakkabagdarya by V.L.Schultz were attributed to the snow-glacial type of source, which is also confirmed by our calculations.

As can be seen from Table 1, the values of δ decreased for the Tankhizydarya (Kattagan) and Yakkabagdarya (Tatar) rivers.The reason for this is the intensive melting of glaciers in the high-altitude part of the studied basin and a decrease in their area, as well as the size of eternal snow in the relatively low zones of the basins of these rivers. For example, as mentioned above, the total area of glaciers in the Kashkadarya basin according to V.L.Shultz was 20.3 km^2, and subsequently it was decreased by 23.6%.

In this work, the issues of long-term variability of the runoff of the rivers of the Kashkadarya basin are also considered on the basis of the materials of the 10 above-mentioned hydrological stations. We calculated the values of the coefficients of variation for three selected calculation periods (Fig. 3).

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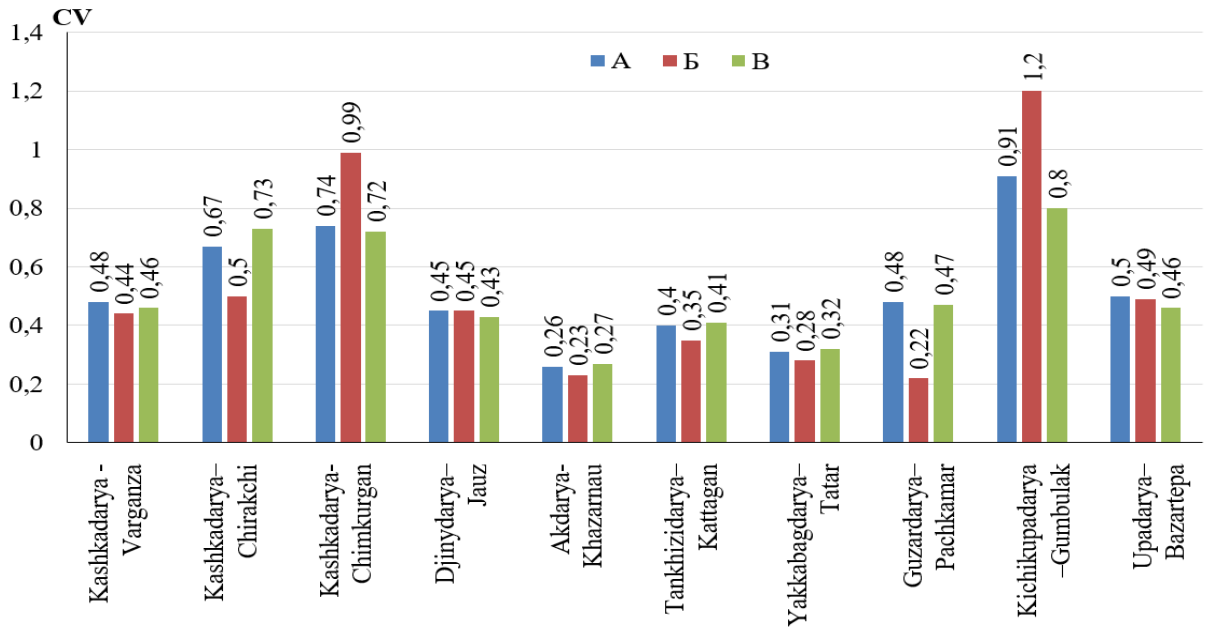

Fig.3. Values of the coefficients of variation calculated for the selected periods
Note: A – the period covering all the years of observations; B – the period up to 1970; C – the period from 1971 and subsequent years.

As can be seen from Figure 3, for each of the three calculation periods for the rivers of the upper part of the Kashkadarya (Varganza), the values of the coefficients of variation are almost the same, only in the last period (C) it is less relative to the previous calculation periods A and B. For the Tankhizydarya, Guzardarya, Kashkadarya (Chimkurgan) rivers, the coefficient of variation increased slightly in the last calculation period.

It should be noted that on the rivers of the Guzardarya basin, the values of the coefficient of variation of annual runoff fluctuate within significant limits. At the same time, for the Uradarya River, the values of the coefficient of variation in the last period significantly decreased compared to the second period. In general, for all three selected periods, the values of the coefficients of variation varied in the range of 0.24 – 1.13. If its minimum value falls on Akdarya (Khazarnau), then the maximum value is obtained for Kichik Uradarya River (Gumbulak).

The study of changes in river flow is of great scientific and practical importance for the planned organization of water management of any territory in the future. To this end, the corresponding calculations were performed for the following two periods: I. Conditionally natural period (inclusive up to 1970); II. The period of

intensive land development (1971-2018). When allocating these periods, the intensive development of the lands of the Karshi steppe is taken into account. Calculations were made on the basis of materials from 10 hydrological sections (Table 2).

Table 2

Changes in river water runoff for settlement periods (I, II)

№№	River - post	I			II			ΔW, 10^6 м^3	%
		Number of years	Q_{mid}, м^3/с	W_y, 10^6 м^3	Number of years	Q_{mid}, м^3/с	W_y, 10^6 м^3		
1	Kashkadarya – Varganza					5,09	160,5	-10,7	-6,7
2	Kashkadarya– Chirakchi				50	20,1	633,3	-132,9	-21,0
3	Kashkadarya – Chimkurgan				50	12,71	400,9	-126,2	-31,5
4	Djinydarya– Jauz				50	1,51	47,6	0,93	1,95
5	Akdarya–Khazarnau				50	11,62	366,5	-39,6	-10,8
6	Tankhizidarya– Kattagan				50	3,66	115,3	-36,01	-31,2
7	Yakkabagdarya– Tatar				50	5,44	171,5	-37,6	-21,9
8	Guzardarya– Pachkamar				50	5,53	174,6	0,9	0,53
9	Kichikupadarya– Gumbulak				50	1,41	44,4	-56,8	-127,9
10	Upadarya– Bazartepa				50	4,08	128,55	23,8	18,54

The average annual values of water flow rates (Q_{mid}) and annual runoff volumes (W_y) of selected rivers for the specified calculation periods are calculated. Then, for the studied rivers of the Kashkadarya basin, the difference in flow volumes (ΔW) was determined, calculated from the average annual water consumption for each of the two calculation periods. Analysis of the calculated values of the difference in flow volumes showed that in most cases there is a decrease in flow in the second calculation period: its minimum value (ΔW = 4.0%) corresponds to the Kashkadarya River, and the maximum value is 127.9% at the Kichikuradarya River. The reason for this is the increased water intake above the hydrological levels in the second billing period. Only in a single case (Jinydarya, Guzardarya and Uradarya,) the difference has a positive sign (Table 2). On average, the change in flow for all

rivers was -22.81%, which is the result of intensive use of river flow for irrigation purposes.

Based on the available materials on the water flow of the studied rivers, we calculated the following main indicators of river flow: average annual water flow rate (Q, m^3/s); flow modulus (M, $l/s \cdot km^2$); flow layer (Y, mm); flow volume - W, million m^3 (Table 3).

Table 3

The main indicators of the runoff of the rivers of the Kashkadarya basin, calculated for different calculation periods

River - post	A source	Billing period	F, km^2	Q, m^3/s	M, $l/s\ km^2$	У, mm	W, mln. m^3
Kashkadarya - Varganza	I	1926-1960	468	5,46	11,7	368	172,2
	II	1926-2002	511	5,22	10,2	322	164,5
	III	1927-2020	511	5,25	10,4	327	167,2
Djinydarya–Jauz	I	1941-1960	163	1,43	4,0	277	45,1
	II	1941-1990	152	1,56	10,3	323	49,2
	III	1941-2020	152	1,44	10,1	317	48,3
Akdarya-Khazarnau	I	1927-1960	845	12,3	14,6	459	387,9
	II	1927-2002	845	12,1	14,3	451	381,6
	III	1927-2020	845	12,08	14,5	459	387,9
Tankhizidarya–Kattagan	I	1926-1960	427	4,30	10,3	318	135,6
	II	1951-2002	425	4,11	9,7	305	129,6
	III	1951-2020	435	3,92	9,2	291	126,5
Yakkabagdarya–Tatar	I	1930-1960	504	6,74	13,4	422	212,6
	II	1930-2002	514	6,11	12,1	382	192,6
	III	1930-2020	504	5,94	11,8	372	187,3
Guzardarya - Yartepa	I	1928-1960	3170	6,0	1,89	60	189,2
	II	1928-1965	3170	5,95	1,88	59	187,7
	III	1928-1965	3170	5,95	1,88	59	187,7
Guzardarya–Pachkamar	I	1928-1964	1260	4,49	3,6	112	141,6
	II	1965-2002	1250	4,81	3,8	121	151,7
	III	1971-2020	1250	4,00	3,3	103	128,4
Kichikupadarya–Gumbulak	I	-	-	-	-	-	-
	II	1968-2002	1570	1,29	0,82	26	40,7
	III	1968-2020	1570	1,44	0,94	30	47,0

Note: I - according to V.L. Schultz; II - according to V.E. Chub; III - according to the authors.

The obtained results of calculations of the main characteristics of the flow of large rivers were compared with the data of V.L.Shultz and V.E.Chub (Table 3). As can be seen from this table, despite the differences in the calculation periods, the values of the average long-term characteristics of the flow of rivers almost coincide, especially with the results of V.E.Chub. This indicates that over the past 30-40 years

there have been no drastic changes in the hydrological regime of the rivers of the Kashkadarya basin.

Thus, we have clarified the values of the main indicators of river runoff: the average annual water consumption, the flow modulus, the layer and the volume of runoff. The obtained results were compared with the data of V.L.Shultz and V.E.Chub. Despite the differences in the calculation periods, the values of the average annual characteristics of river flow do not differ much.

The recorded water resources of the rivers of the Kashkadarya basin are characterized by the following values: the total volume of surface water runoff varies from 600 million m^3 to 1.9 billion m^3 per year, the total average annual flow rate of rivers is 44.9 m^3/s, and the average annual flow volume is 1.416 km^3.

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