Assessment of water Zerafshan (hydropost Dupuli) and analogue Sokh (hydropost Sarikanda)

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Abstract: This article describes how to restore the river Zeravshan river-analogue - Cokh and carried out assessment of changes in mean annual, vegetation and non-vegetation water flow of the river Zeravshan on its length.
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1. Introduction

The intensive development of agriculture and industry in the 60s of the twentieth century led to the full use of surface and underground water resources of the Zeravshan river basin, their pollution by industrial waste and sewage. There was an urgent need for the transfer of runoff from the Amu Darya River and the Amu-Karakul and Amu-Bukhara canals were built in the 60s (throughputs, respectively, 48 m^3 / s and 124 m^3/ s) and Amudarya water began to flow in the lower river Zeravshan.

Currently, in order to meet the needs of all sectors of the economy in the Zeravshan oasis, intensive use is made of both our own water resources and the transferred runoff. Based on the foregoing, a quantitative assessment of the river flow forming in the mountainous part of the Zeravshan basin is an urgent task.

The purpose of this study is to restore the water flow of the Zeravshan- Dupuli, which characterize the formation of runoff in the mountainous area of the basin and assess the changes in the flow of water of the Zeravshan river by hydraulic rams for different periods corresponding to the stages of development of the national economy, in a changing climate.

2. Material and Methods

Under the conditions of the Zeravshan oasis, when the river basin can be divided into a mountain zone, where river runoff is formed and the plain territory where it is spent intensively, the most convenient are methods for assessing changes in river runoff under the influence of a complex of anthropogenic factors [5]. F.E. Rubinova [1], Yu.N. Ivanov, V.L. Chub [3,4], N.K. Lukina and others studied the changes in the river flow of the rivers of Central Asia under the influence of anthropogenic factors, the most important of which is irrigation. To solve the tasks, the average monthly water discharges of the Zeravshan and Sokh rivers were selected as initial data.

Based on the available hydrometric observations, the statistical characteristics of the average annual water discharge at the Zeravshan river gauging stations were estimated (table 1).

Table 1. Statistical characteristics of the average annual water consumption

River Point	average	max	min	σ	Cv	C_S
Zeravshan-Dupuli	161	218	117	23,1	0,14	0,33
Zeravshan-Ravathodja	64,7	118	42,4	18,2	0,28	1,17
Zeravshan-Ziyauddin	73,0	159	2,6	29,4	0,40	0,54
Zerafshan-Navoi	40,9	109	11,6	23,8	0,58	0,85
Zeravshan-Khazarinsk	39,3	145	7,52	30,0	0,76	0,85

It should be noted that the observations on the upper hydraulic ramp of Cape Dupuli, located in the territory of neighboring Tajikistan, were stopped back in 1997, so we chose the Sokh, Sarykand river as an analogue river.

The choice of this river as an analogue can be justified by the similarity of the natural conditions of the catchment basin, as well as the fact that the Sokh and Zeravshan rivers, according to the classification of V.L. Shults, belong to the ice-snow type rivers [6]. In order to restore water consumption, schedules were built for the relationship between the average monthly and average annual water consumption of the Zeravshan River - the city of Dupuli bridge and the Sokh, River, Sarykanda for the conditionally natural period from 1927-1962, the correlation coefficients, regression equations were determined and the average monthly water discharge of the Zeravshan river Dupuli bridge. was restored from them. The calculation results are shown in Table 2.

3. Results

As can be seen from the table, the closest relationship between the average monthly water discharge of the Sokh and Zeravshan rivers is characteristic for May and June (R = 0.82 and 0.80), and the correlation coefficients between expenditures from January to March are insignificant (respectively, R = 0, 44; 0.48 and 0.45)

Table 2. Statistical characteristics of the graphs of the relationship of the average monthly water discharge of the rivers Sokh, Sarykanda and Zeravshan, Dupuli for 1927-1962

month	equation of regress	coefficient of correlation, R	month	equation of regress	coefficient of correlation, R
I	y = 0,2203x + 3,339	0,44	VII	y = 2,6199x + 137,22	0,72
II	y=0,1881x+ 4,222	0,48	VIII	y = 0,1706x + 53,619	0,62
III	y = 0,132x + 5,6067	0,45	IX	y = 0,2191x + 17,701	0,76
IV	y=0,1345x + 5,4532	0,75	X	y = 2,8526x + 12,022	0,75
V	y = 0,1465x + 6,544	0,82	XI	y = 1,6261x + 29,407	0,75
VI	y = 0,1726x + 8,914	0,80	XII	y = 1,3492x + 26,224	0,66
Average annual y = 3,0174x + 27,928:					*0,71*

Interannual changes in the flow of the Zeravshan River show that the average annual and average flow rates during the growing season decrease markedly and this is confirmed by the negative values of the coefficients of the trend of water flow rates at the Dupuli main bridge, which are respectively -0.0258 and -0.086. In the lower reaches of the Zeravshan river. Khazarinsk trend value is respectively -2.5792 and -1.529. Non-vegetative water flow decreases only at the Khazarinsk post, on the upper sections there is a slight increase in river flow, which can be explained by the return of return water to the river from irrigated fields.

Table 3. Change in average annual, vegetative and non-vegetative water discharge of the Zeravshan River relative to the conditionally natural period (1930-57)

River-hydropost	unit of measuring	1930-1957	1958-1978	1979-1996	1997-2013
Changing average annual water discharge					
Zerafshan- Dupuli	m^3/s %	159 100	162 102	160,6 100,6	175 110
Zerafshan-Ziyauddin	m^3/s %	99,2 100	77,6 78,2	53,8 54,2	51,0 51,4
Zerafshan-Khazarinsk	m^3/s %	86,1 100	67 78	29,8 34,6	11,5 13,3
Changing average vegetative water discharge					
Zerafshan- Dupuli	m^3/s %	269 100	274 102	260 97	295 110
Zerafshan-Ziyauddin	m^3/s %	138 100	99,4 72	62,1 45	51,9 38
Zerafshan-Khazarinsk	m^3/s %	112 100	84,5 75	21,4 20	17,7 16
Changing average non-vegetative water discharge					
Zerafshan- Dupuli	m^3/s %	53,5 100	54,0 101	57,7 107,8	55,7 104,1
Zerafshan-Ziyauddin	m^3/s %	60,3 100	55,8 91,5	45,5 75,0	49,2 81,6
Zerafshan-Khazarinsk	$м^3/s$ %	60,2 100	49,5 82,2	26,5 44,0	3,4 5,6

At the next stage of the study, a quantitative assessment was made of changes in the annual, vegetative, and non-vegetative water discharge along the length of the Zerafshan River. According to the method used [5], the anthropogenic impact on the river flow is estimated in the hydraulic ramp of the Dupuli, located at the exit from the mountain zone, as a conditionally natural flow. Then, using the graphs of the connection of the summarized integral flow curves between the upper and lower hydraulic gates $\sum Q_{bottom}=f(\sum Q_{top})$, we determine the periods with varying degrees of anthropogenic impact on the flow of the Zeravshan River. According to the degree of anthropogenic impact on the runoff, we distinguished the following periods:

1) 1930–1957 the conditionally natural period; 2) 1958-1978, a noticeable decrease in runoff along the length of the river; 3) 1979-1996 increase in anthropogenic impact; 4) 1997-2013, the intense influence of anthropogenic factors. Considering the water consumption in 1930–1957 to be 100%, relative to it the changes in runoff at the Zeravshan river gauging stations for other periods are calculated (table 3).

For a more reasonable quantitative assessment of the anthropogenic impact on runoff, a second method was used to calculate runoff changes along the length of the river. For this, a coefficient K was introduced, calculated as the ratio of the flow rate of water in the lower sections to the flow rate of water in the Dupuli section ($K = Q_{bottom}/Q_{top}$) for the conditionally natural period, then multiplying this coefficient by the flow of water along the Dupuli hydraulic lock, we determine the water flow, which should to be observed. The difference between the restored and domestic runoff in the hydraulic outlets gives the magnitude of the decrease in the flow of the Zeravshan River.

The calculation results are shown in the following table 4. As can be seen from the table, in the conditionally natural period, the ratio of the water discharge of the upper hydraulic ramp of the Dupuli to the lower Ziyauddin and Khazarinsk is $К=_{Qziyaud}/Q_{dupuli}=0,62$ и $К=Q_{khazar}/Q_{dupuli}=0,54$ then taking these relations as a coefficient of transformation of runoff along the length of the river, according to the formula $_{Qrest}. = K * Q_{dupuli}$, water flows in the lower sections were restored. The difference of the observed (in household) water flow rates and the recovered water was calculated in absolute values m^3 / s and in relative %, the results are shown in table 4.

However, if using these methods it is possible to approximately calculate the integral value of the change in runoff over individual multi-year periods under the influence of the whole complex of anthropogenic factors, then to study the causes of these changes and identify the role of each factor separately, additional information characterizing meteorological conditions, as well as basic features and stages of development of economic activity directly in the zone of runoff use.

4. Discussions

The authors hope to carry out these types of studies in the future, considering a large number of factors (natural and anthropogenic) affecting the runoff, using various mathematical methods, in particular, the linear multiple correlation method, which, according to experimental data, allows us to create a multifactor mathematical model of changes in hydrological characteristics. Thus, an intensive decrease in runoff occurs along the length of the Zeravshan River, while the natural runoff formed in the upper reaches has even increased in recent years, which can be explained by the intense melting of glaciers in the upper part of the Zeravshan Basin.

Table 4. Changing average annual water discharge of the river Zerafshan in conditional-natural period (1930-57)

transit	Natural hydrologic regime of the river			
	period of observation	Q_{ziyaud}/Q_{dupuli}	Q_{khazar}/Q_{dupuli}	К
Ziyauddin	1930-1957	99/159		0,62
Khazarinsk	1930-1957		86,1/159	0,54
transit	Changing hydrologic regime of the river			
	period of observation	$Q_{dupuli,}$ m^3/s	$Q_{restor.}= Q_{dupuli}$*К, m^3/s	
Ziyovuddin	1958-1978	162	100,4	
Khazarinsk	1958-1978	162	87,5	
Ziyovuddin	1979-1996	160	99,2	
Ziyovuddin	1997-2013	175	108,5	
Khazarinsk	1979-1996	160	86,4	
Khazarinsk	1997-2013	175	94,5	
transit	period of observation	$Q_{observed}$	changing of discharge	
			m^3/s	%
Ziyovuddin	1958-1978	77,6	-22,8	-22,6
Ziyovuddin	1979-1996	53,8	-45,4	-45,7
Ziyovuddin	1997-2013	51,0	-57,5	-53,0
Khazarinsk	1958-1978	67,0	-20,5	-23,3
Khazarinsk	1979-1996	29,8	-56,6	-65,5
Khazarinsk	1997-2013	11,5	-83,0	-87,3

Changing average vegetative water discharge of the river Zerafshan in conditional-natural period (1930-57)

transit	Natural hydrologic regime of the river			
	period of observation	Q_{ziyaud}/Q_{dupuli}	Q_{khazar}/Q_{dupuli}	К
Ziyauddin	1930-1957	138/269		0,51
Khazarinsk	1930-1957		112/269	0,42
transit	Changing hydrologic regime of the river			
	period of observation	$Q_{dupuli,}$ m^3/s	$Q_{restor.}= Q_{dupuli}$*К, m^3/s	
Ziyovuddin	1958-1978	274	274*0,51=140	
Khazarinsk	1979-1996	260	260*0,51=133	
Ziyovuddin	1997-2013	295	295*0,51=150	
Ziyovuddin	1958-1978	274	274*0.42=115	
Khazarinsk	1979-1996	260	260*0.42=109	
Khazarinsk	1997-2013	295	295*0,42=124	
transit	period of observation	$Q_{observed}$	changing of discharge	
			m^3/s	%
Ziyovuddin	1958-1978	99,4	-40,6	-29
Ziyovuddin	1979-1996	62,1	-70,9	-53
Ziyovuddin	1997-2013	51,9	-98,1	-65
Khazarinsk	1958-1978	84,5	-30,5	-27
Khazarinsk	1979-1996	22,4	-87,6	-80
Khazarinsk	1997-2013	17,7	-106,2	-84

The additional transfer of river flow to the lower reaches of the Zeravshan River from the Amu Darya River is also spent on various industrial, municipal, agricultural and recreational needs. At the same time, the return flow from the irrigated fields accumulates in the lowering of the relief, forming irrigation-discharge lakes of the Bukhara and Navai district, such as Dengizkul, Shorkul, Ayakagitma, and is also discharged into the Tudakul reservoirs, which are widely used for recreational purposes; working year-round. Summarizing, we can say that every drop of beneficial moisture in a hot Central Asian climate is being spent purposefully.

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