ON ESTIMATION METHODS AND RATIONAL USE OF WATER RESOURCES IN CENTRAL ASIA

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Mountainous Tajikistan is a zone of formation of the Aral Sea basin river run-off. It occupies about 45% of the basin's mountainous zone, and gives more than 50% of the region's river run-off. The run-off quality of the large rivers is of the 1st class of purity; the dynamic supply of the ground waters with a mineralization level of less than 1 g/l is about 18,7 km^3/year.

A separate analysis of the initial data of hydrometeorological observations for the periods of stable state (1930-1990) and rapid shallowing (1961-1990) of the Aral Sea has shown that in the period of 1960-1990 the average annual run-off at the territory of the Republic of Tajikistan decreased from 57.01 km^3/year to 53.6 km^3/year.

The bulk of the river run-off is generated in severe mountainous conditions. The flow starts in the rapid riverbeds, and its main part is formed in the high water period (more than 60-70%). Nonstandard methods are necessary for the calculation of this flow, because the known stationary methods of measurement cannot accurately determine the rapid flood flow volume. In addition to the classical measurement method at stations, a balance calculation method is proposed to estimate the average annual run-off of mountainous rivers. This is represented by the following equation:

$$Q = S \times A(1-k), \quad (1)$$

where $k = E/A + F/(SA) \ll 1$, Q is the average annual river run-off, S is the catchment area (km^2), A is the average perennial value of atmospheric precipitation per unit river catchment area (km), E is the average value of moisture evaporation per unit catchment area (km), F is the average value of underground water discharge out of the catchment area (km^3). It has been shown that at k = 1/3 the method (1) agrees, with a high accuracy, with the known data of researchers whose calculations were made with the use of other methods (Table 1)

Table 1. Calculation of the run-off and flow rate of Tajikistan rivers by the water balance method

River	Catchment area, thou. km^2	Average precipitation, m^3/hectare	k-coefficient	Run-off, km^3/year	Average flow rate, m^3/s	Data from the literature [2, 3]	
						km^3/year	m^3/s
Vakhsh	39,1	7750	1/3	20,15	640	21,2	670
Kafirnigan	11,7	7750	1/3	6,04	191	5,7	170
Zarafshan	11,0	7750	1/3	5,68	180	5,2	165
Region river basins	324,0	7750	1/3	167,4	5305	170,0	5387

It has been shown that the method of water balance and formula (1) perform well to solve the "inverse" problem of hydrometeorology, that is, to calculate the value of A, namely, the intensity of atmospheric precipitation in the basins of small mountainous rivers and water flows difficult of access. Large water losses for filtration from canals are observed. For instance, in the Kara-Kum canal (L>1100 км), whose path passes through sand and clay sand sediments, in the first years of exploitation losses for vertical filtration constituted 70-90%. At present, these losses are, on average, about 52% and more than 30% on the whole for the region. Low field cultivation level, without meeting irrigation norms, has led to a rapid rise of the ground water level up to a "critical" (< 1,5-2 m) depth from which water evaporation and salinization of the fertile ground layer take place. An obvious example here is the irrigation of intermontane Tajikistan valleys, where, due to the absence of a side outflow, there was a rapid rise of ground waters. This has led to the salinization and swamping of large areas and to an abrupt decrease in the yield of cotton.

Within the framework of the theory of hydraulic radius, it has been proved that a canal is most profitable if its geometrical parameters satisfy the following relations:

(R, χ, ω are the hydraulic radius, the wetting perimeter, and the cross-section area of the canals). We have

1) for a canal with a semiellipsoidal cross-section:

$x^2/B^2+y^2/H^2 = 1;\ 2B = 18H,\ R = 0{,}75H,\ \chi = 2\pi B/3,\ \omega_{el} = \pi BH/2 \equiv 9\pi H^2/2,$

2) for a canal with a parabolic cross-section:

$2B = 2{,}191H,\ p = 0{,}6H,\ R = 0.5447H,\ \chi = 1.38B = 1.512H$, and

3) for a canal with a trapezoidal cross-section:

$$\omega = 0{,}5H(B+b) = [b + 0{,}5H(ctg\beta_1 + ctg\beta_2)]H;$$

$$\chi = b + H(\sin\beta_1 + \sin\beta_2)/\sin\beta_1 \sin\beta_2,$$

where b and B are the canal width at the bottom and the water surface, respectively, H is the flow depth, and $a_1, a_2, \beta_1 > 0,\ \beta_2 > 0$ are the depth and inclination angles of the left and right canal slopes. The trapezoidal canal with the radius $R = H/2$ has the greatest transmission capacity if its width satisfies the following relation:

$$b/H = (1 - ctg\beta_1)/\sin\beta_2 + (1 - ctg\beta_2)/\sin\beta_1.$$

It has been shown by analyzing the data of in situ measurements that canals change their shape in operation, depending on the ground structure slope and strength, the flow rate, and transmission capacity, and tend to take the shape of one of the most profitable profiles considered above. Figure 1 shows the variation of the Kara-Kum canal cross-section at the dam site 0.7 km from the Amu-Darya river.

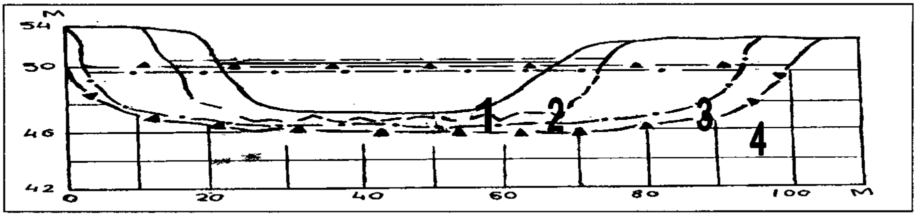

Fig. 1 1960, 2: 1965, 3: 1970, 4: 1974.

One can see that the designed trapezoidal profile, varying considerably in time, tends to a semi-ellipsoidal shape, which is also most profitable for navigation, since $B_k = 18H$.

In valleys with cohesive soils (loess, loam, clay etc.), the most profitable profile of a canal is a curvilinear trapezium consisting of a combination of straight lines with semicircular curves (parabola, semiellipse, etc.). At furrow irrigation, the most effective in the hydroagrotechnical respect is a furrow shaped as an isosceles triangle with depth angles of 45°.

A model of combined use of river and ground waters is proposed. The effectiveness of the model is demonstrated by using an example of development of a water- and soil-preserving irrigation technology in Tajikistan valleys.

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