SEDIMENT MOVEMENT MODE IN RIVERS OF UZBEKISTAN – ENVIRONMENTAL ASPECTS

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Central Asian rivers are rich in sediments that affect the construction of hydrotechnical constructions. In this article the influence of sediments on water quality and amelioration conditions of agricultural fields was analyzed and information was given on possibilities of controlling the sediment flow.

Keywords: water, channel, river, sediment, chemical parameters

The largest rivers of Central Asia such as the Amu Darya and the Syr Darya have reported the increase in sediments, which creates certain problems when they are used for irrigation purposes. Irrigation canals supplied from such kind of rivers not only deliver water to fields, but also contribute to fertilization of soils (Fig 1). It is known that ecological conditions of soils and value of yields depends on quality of irrigation water. It is necessary to take into account this factor since the river water that irrigates the areas brings a huge number of suspended sediments. The solution of this problem is particularly important for the channels of the Amu Darya system (where in some periods the turbidity of the stream reaches 20 kg.m^{-3} and the fractional composition of the sediments varies in large (0.001 : 1.5 mm) limits), passing in easily eroded soils and bearing greater amount of suspended particles of sediment containing valuable mineral fertilizers in its composition.

In the works of researchers (Klyukanova, S., Abu Alyants S., X., Latipov, I., S., H., Arifjanov, A. and others) it was noted that the sediments which come from the Amu Darya River into irrigated fields cause the increase in soil fertility and bring positive conditions for vegetation growth.

Material and methods

For a more detailed analysis of this problem, field experiments and analyses of other researchers' work were carried out.

The studies were carried out on the Mirishkor and the Big Fergana Channel (BFC). The Mirishkor channel takes water from the Amu Darya River. The length of the channel is 120 km, the flow rate of the channel is 130 m^3.s^{-1}; The width of the channel along the bottom is 24 m; depth of the channel -5.1 m; the shape of the channel is trapezoidal. The channel BFC takes water from the Syr-Darya River.

The results of field experiments performed in the Mirishkor and the Big Fergana Channels (BFK) showed that 60% of total suspended sediments consist of particles with diameter of less than 0.05 mm. Main parts of sediments, which can be used as humus and other mineral fertilizers, were collected in sediment reservoirs (Tables 1, 2).

Dissolved salts and mineral fertilizers composition of suspended sediments depend on sediment size.

Fig. 1 Map of Aral Sea basin
Source: Mirishkor and Big Fergana Channel

Table 1   Fractional composition of suspended sediments (the Mirishkor channel)

GP	Size of fractions (mm) in %				
	>0.25	0.25–0.10	0.10–0.05	0.05–0.01	0.01–0.005
GP – 620	0.0	0.7	36.8	53.8	28.8
GP – 720	0.1	0.8	26.5	56.5	31.7
GP – 1060	0.6	0.7	50.2	52.4	34.0

GP – distance from channel entry

Table 2   Fraction of suspended sediments in BFC

GP	Size of fractions (mm) in %				
	>0.25	0.25–0.10	0.10–0.05	0.05–0.01	0.01–0.005
GP – 930	0.0	0.6	31.4	58.3	8.6
GP – 1500	0.2	1.2	35.4	56.4	6.6
GP – 1710	3.2	22.5	22.5	27.4	6.5

GP – distance from channel entry

Table 3   Chemical composition of suspended sediments in the Mirishkor channel

Chemical composition	Diameter of suspended particles in mm		
	0.1…0.05	0.05…0.01	0.01
SiO	61.6	55.5	46.7
Al_2O_3	10.8	9.2	11.5
Fe_2O_3	3.6	3.9	6.1
CaO	9.3	10.6	12.7
MgO	2.1	2.7	3.9
K_2O	3.1	1.7	1.8
Na_2O	2.5	2.3	1.8
P_2O_5	0.12	0.15	0.21
CO_3	6.6	11.3	14.0

As shown in the result of the field experiment analysis, with decreasing size of sediments, the volume of chemical components such as SiO_2, Al_2O_3, Fe_2O_3 also decreases, but the amount of humus, potassium and calcium salts increases (Table 3).

Results and discussion

The results of the analysis show that a large volume of suspended sediments can be transported into irrigation channels.

But in the planning and construction of hydraulic, irrigation and drainage constructions specialized in regulation of water and sediments, the size of sediments is not always considered. These constructions often, with retaining river sediments, significantly destroy the natural hydrobiological regime of channels. Sediments in tanks, reaching volumes in hundreds of cubic meters, become an environmental problem in each area when removed.

Therefore, in the projection of hydraulic engineering constructions, specialized on the regulation of runoff regime in sediments, it is equally important to consider the fractional composition of river sediments.

The irrigational importance of suspended sediments is evaluated not only by mineral fertilizers. The passage of fine fractions to irrigation sets improves the hydraulic characteristics of channels, while reducing water loss due to filtration.

Based on terrain experiments performed in the channels, the dynamics of the distribution of suspended sediment particles along the depth and length of the channel flows were determined. Rational regulation of river sediment regimes can be achieved by considering the fractional composition of suspended sediments. Transportation of sediments by water flows depends on the regime of flow. Figure 2 shows changes in the composition of sediment fractions along the Mirishkor channel.

According to the results of field experiments, the share of particles with the diameter less than 0.01 mm is more
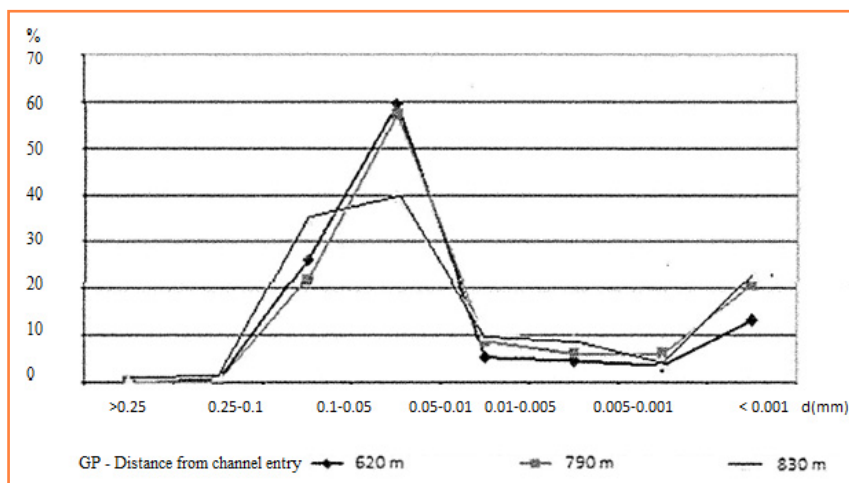
Fig. 2 Changes of fractional compositions of suspended sediments in the Mirishkor channel

than 55% in the Mirishkor channel. The average turbidity of water in the canal during the vegetation period is 0.7 g.l^{-1}. The proportion of sediments containing mineral fertilizers is 0.3–0.4 g.l^{-1}.

Channel flow capacity (on 640 m), during the vegetation period (May–September) is 100–110 m^3.s^{-1}. Based on the above, the amount of water-borne nutrients can reach up to 14 tons for the irrigated area without costs. The main problem is distribution of minerals along the field. It depends on the water intake system from the canal to the irrigated fields.

Conclusion

As the analysis results (Fig. 2) show, particles of large diameter are deposited in the channels. This creates difficulties in operation of the channel. To solve this problem, it is recommended to build a settler at the

beginning of the channel. The settling pool reduces the flow rate of water and large sediments are deposited on the bottom of the hold. Such tanks are modified so that after the end of the irrigation season, these sediments can be easily removed and used. The length of such sedimentation tanks is determined based on the Stokes Act which determines the settling rate depending on the size, shape and density of the grains, as well as the viscosity and density of the liquid phase of the suspension (Fig 3):

$$w = \frac{2(\rho_p - \rho_f)gr^2}{9\mu}$$

In formula w is the deposition rate, ρ is the density (p – solid component, f – fluid), g is the gravitational acceleration, and μ is the dynamic viscosity of the fluid. We calculate the

settling time of the selected particle from the water level to its impact on the bottom, and the flow velocity (v) vector determines the site of particle impact. This length is typically increased by 50%.

Using the above scheme (Fig 3), the formula for determining the length of the sedimentary pool can be written down as follows:

$$L = \frac{\vartheta H}{\omega}$$

where:
L – length of the sedimentary pool
ϑ – flow velocity
H – depth of flow in the settler

Fractional regulation regime of the sediment contributes to the solution of the following problems:
• Sedimentation of big sized sediments in reservoirs preserves the irrigation channels from debris and silting. Simultaneously, the passage of fine fractions of suspended sediments into irrigated fields improves the quality of irrigation water, which contains mineral fertilizers of humus, etc., which affect soil fertility;
• This activity can decrease the volume and cycle of sewage works in reservoirs, which saves resource and energy consumption, and improves the ecological situation of the given territory. It is pertinent to note here that the sedimentation of fine sediments brings to leads to the crystallization deposits, which makes it difficult to clean them with dredgers.

Thus, rational regulation of regime of the river sediments can significantly affect the ecosystem of water use in land reclamation.
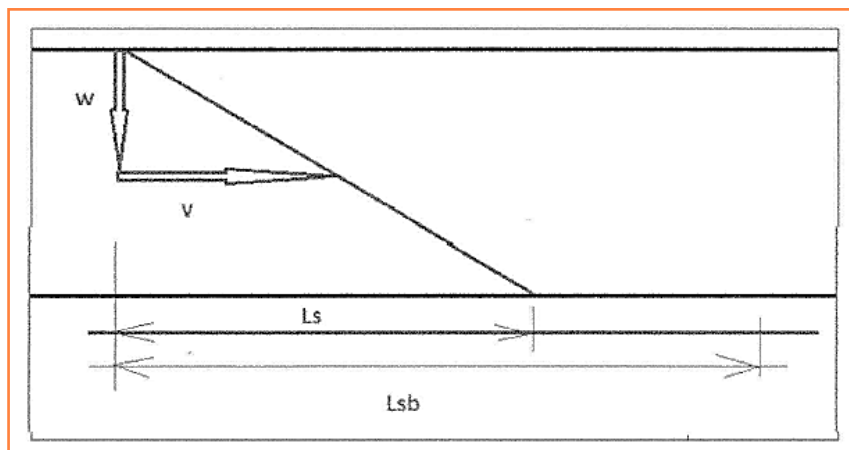

Fig. 3 Scheme of deposition of particles
Source: Custom sketch
Ls – length of particle sedimentation, L – length of the sedimentary pool

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