Fundamentals of hydraulic calculations of water softening structures in drip irrigation technology (in case of Zarafshan river)

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Abstract. This article presents the results of field studies on the study of the process of sediment settling in the settling tanks of the drip irrigation system carried out on farms in the Akdarya and Ishtikhan districts of the Samarkand region, which are supplied with water from the Zarafshan River. Calculation of the process of settling sediments in sedimentation tanks was carried out according to the method of A.G.Khachatryan, and a graph of the relationship between the length of the sedimentation tank and the degree of sediment clarification was determined. As a result, recommendations have been developed to substantiate the optimal parameters of sedimentation tanks for various natural conditions.

1 Introduction

Resolution of the President of the Republic of Uzbekistan on October 25, 2019 Decision No. PQ-4499 "On measures to expand the mechanisms for promoting the introduction of water-saving technologies in agriculture" indicates the need to carry out special scientific and research work in the direction of more effective use of drip irrigation technologies in agriculture [1,2,3,4,5,6]. The recommended dimensions for the construction of the water softener of the sprinkler irrigation technology in cotton fields receiving water from the Amu Darya are as follows [7]: the average turbidity of water in the irrigation networks receiving water from the Amu-Bukhara machine canal is 2-3 kg/m3 and the average amount of cloudy particles in it if we take into account that the fraction is 0.25-1.1 mm, in the case where the capacity of the pump unit is 315 m3/h, the distance of the water stop is at least 25 m. The settling pond must consist of at least two chambers. According to calculations, the total length of the clarifier pool is 41 m, width is 13 m, of which the length of the first chamber is 25 m, the depth is 2.0 m, the length of the second chamber is 16 m, and the depth is 1.7 m. According to the above recommendations, the volume of water in the once-filled irrigators reaches 3-5 hectares, and the irrigation cycle for irrigating 20 hectares of land is 6 times. The above recommendations cause a lot of inconvenience for farms supplied with water from the Zarafshan River. In addition, due to the turbidity of the water flow of the Zarafshan River, the structures in the drip irrigation system quickly fail due to the turbidity. For this reason, improving water softener constructions in drip irrigation technology is one of the urgent issues. According to calculations, the total length of the clarifier pool is 41 m, width is 13 m, of which the length of the first chamber is 25 m, the depth is 2.0 m, the length of the second chamber is 16 m, and the depth is 1.7 m. According to the above recommendations, the volume of water in the once-filled irrigators reaches 3-5 hectares, and the irrigation cycle for irrigating 20 hectares of land is 6 times. The above recommendations cause a lot of inconvenience for farms supplied with water from the Zarafshan River. In addition, due to the turbidity of the water flow of the Zarafshan River, the structures in the drip irrigation system quickly fail due to the turbidity. For this reason, improving water softener constructions in drip irrigation technology is one of the urgent issues.

The purpose of the study: it consists of studying the turbidity processes of sedimentation facilities in the drip irrigation system, justifying their optimal parameters, and developing recommendations for their effective operation (as an example of the Zarafshon River).

Research objects: Farms in the Okdarya and Ishtikhon districts of the Samarkand region.

2 Method

In the course of the research, methods of field observation and, generally accepted methods in hydraulics, methods of comparing experimental results with hydraulic calculations were used.

3 Results and Discussion

Due to the turbidity of the Zarafshan River flow, the sedimentation of the turbidity along their length is not fully ensured due to the unimproved dimensions of the clarifiers in the drip irrigation system. If it is assumed that the water from the canals of the plot is constantly coming to the clarifiers, then the turbidity along the length of the constructed clarifiers does not have time to settle completely; as a result, during the irrigation of the fields, the outflow of turbid water is also observed from the system filters and pipe drippers. Therefore, it is necessary to research the improvement of the sizes of sprinklers in the drip irrigation systems of farms receiving water from the Zarafshan River basin.

Field research was conducted on drip systems installed in cotton fields in the Okdarya and Ishtikhon districts of the Samarkand region, which are supplied with water from the Zarafshan River. It was carried out at the "Qorateri Botir cotton" farm in the Okdarya district. A drip irrigation system was installed on the farm to irrigate 12 hectares of cotton fields (Figures 1-2). Water is supplied to the drip irrigation system from the site channel through sprinklers. In the system, the clarifier is built with two chambers covered with a membrane, and its dimensions are as follows:

Camera 1 Dimensions:	b= 11 m;	L= 17 m;	h= 2.5 m.
Camera 2 Dimensions:	b= 11 m;	L= 17 m;	h= 2.5 m.

The strainer dimensions were designed according to the initial recommendations of [7]. It is known that the water in the canal of this farm comes from the Zarafshan river basin system, and the turbidity level is high. Therefore, the flow turbidity is settled in the designed clarifier, and the clarified water is transferred to the drip irrigation system through pumps. Using field experiment methods, turbidity samples were taken to determine stream turbidity levels according to the scheme below.

Fig. 1. Membrane softener in drip irrigation system of "Korateri Botir cotton" farm.

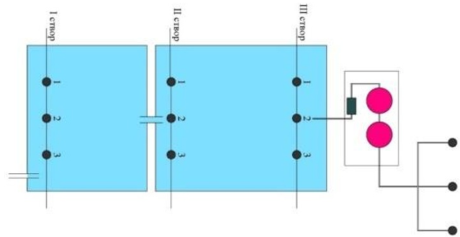

Fig. 2. Sampling scheme of turbidity in the clarifier of drip irrigation system of "Korateri Botir cotton" farm.

Using field experiment methods, turbidity samples were taken to determine the turbidity level of the stream according to the scheme presented above.
Turbidity samples were taken from 3 walls along the length of the clarifier, that is, from the beginning of the 1st chamber of the clarifier, the beginning and the end of the 2nd chamber, using a bathometer. In this case, 0.2h from 2 vertical frames according to the length of each frame; Samples were taken at depths of 0.8h. The obtained samples were analyzed in the "Hydraulic structures" laboratory of the "Hydraulic structures and engineering structures" department of "TIIAME" NRU, and its results are presented in Table 1 and Fig. 1.

Table 1. "Korateri Botir cotton" analysis of water softener on farm (size of softener is 34x11 meters)

№	Name		I cross section (g/l)	II cross section (g/l)	III cross section (g/l)
1	1 point amount	0.2h	2.18	1.526	1.090
		0.8h	2.25	1.575	1.125
2	2 point amount	0.2h	2.29	1.603	1.145
		0.8h	2.34	1.638	1.170
3	3 point amount	0.2h	2.11	1.477	1.055
		0.8h	2.27	1.589	1.135

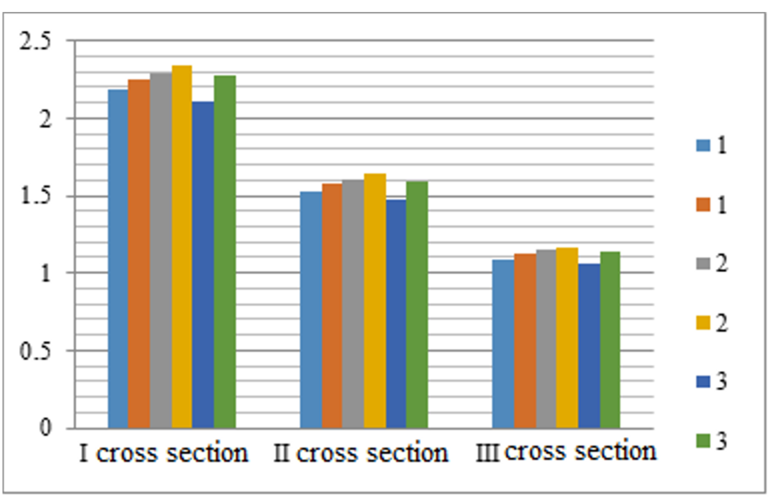

Fig. 3. Turbidity indicators by depth in clarifier walls

The analysis of the samples in the laboratory shows that the turbidity level of the stream from the beginning of the clarifier (1-wall-2.25 g/l) to the end (3-wall-1.125 g/l) decreased by 50%.

In the same way, subsequent research was carried out on Okdarya "Malikov Akhmad" farm, Ishtikhon district "Asalchi Eldor" and "Kadir Eshkuvatov" farms. The sizes of water softeners in these farms are the same as in the above farm "Qorateri Botir cotton" of Okdarya district and are designed to irrigate up to 20 hectares of a cotton field. In general, the analysis of the experiments shows that in the clarifiers in the experimental areas, the deposition rate of turbid sediments from the beginning to the end is from 20% to 40%. If it is assumed that the water from the site canals will constantly be coming to the clarifiers, then the turbidity along the length of the constructed clarifiers did not have time to completely settle; as a result, during the irrigation of the fields, turbid water was also released from the system filters and pipe drippers. That is, the turbidity in droppers ranges from 0.240 g/l to 1.139 g/l. Therefore, to reduce the risk of turbidity to the drip irrigation system in the farms of farms supplied with water from the Zarafshan River, their hydraulic calculations were carried out to further improve the optimal parameters of the clarifiers for various conditions.

Calculating the turbid settling process in the clarifiers was carried out according to the method of A.G. Khachatryan. The calculation procedure according to this method is carried out as follows [8-15].

The settling curve of turbidity in the clarifier is determined by the following formula:

$$S_{wo}^{T} = S_{wo}^{o} - \Delta S_{wo}^{T} \qquad (1)$$

here: S_{wo} is the ordinate of the subsidence curve for the case where there is no effect of the turbulent flow;

ΔS_{wo} is correction for turbulence.

The sinking curve in still water is determined by the following formula:

$$S_{wo}^{o} = 1 - \frac{1}{w_o} \int_{o}^{w_o} \underline{P}_{(w)} \cdot dw \qquad (2)$$

here: W_0 is hydraulic size in the coverage of the cooler;

$\underline{P}_{(w)}$ is fuzzy diffusion function.

The coverage of the filler is determined by the following formula:

$$w_o = \frac{\vartheta \cdot H_{av}}{L} \qquad (3)$$

here: ϑ, H_{av} are the average speed and depth in the sander, respectively; L is the length of the probe in the selected section.

The average depth in the strainer:

$$H_{cp} = \frac{\omega}{B} \qquad (4)$$

here: ω is the surface of the live section of the quencher;

B is the width of the cooler on the water level.
The size distribution of fuzzy fractions corresponds to Khachatryan's law:

$$J = \frac{C}{w} \tag{5}$$

here: J -< W relative turbidity of hydraulic magnitude;
C is constant function of fraction size distribution.

For account $P_{2.27}$ and $P_{0.09}$ the ordinate of the fuzzy curve on the fractional composition was used, that is, the hydraulic magnitude was 2.27 and 0.09 mm/s for the fractional composition with a diameter of 0.05 and 0.01 mm. In that case,

$$C = \frac{\underline{P}_{2,27} - \underline{P}_{0,09}}{\ln \frac{2.27}{0.09}} = 0{,}31 \cdot (\underline{P}_{2,27} - \underline{P}_{0,09}) \tag{6}$$

The total ordinate curve of the turbidity fraction composition, determining the constant S, is determined by the following formula:

$$\underline{P}_w = \underline{P}_{0,09} + C \cdot \ln \frac{w}{0.09} = \underline{P}_{2,27} - C \cdot \ln \frac{2.27}{w} \tag{7}$$

In this case, the ordinates of the subsidence curve are determined by the following formula:

$$S^o_{w_o} = 1 - \underline{P}_w + C = 1 - \underline{P}_{2.27} + C \cdot \ln(\frac{2.27}{w} + 1) = 1 - \underline{P}_{0.09} - C \cdot \ln(\frac{w_o}{0.09} - 1) =$$
$$= S^0_{2.27} + C \cdot \ln \frac{2{,}27}{w_o} = S^o_{0,09} - C \cdot \ln \frac{w_o}{0.09} = 1 - \underline{P}_{w_o} \tag{8}$$

The ordinates of the turbidity change curve are:

$$\underline{P}^o_w = \underline{P}_w - C = \underline{P}_{2.27} - C \cdot (\ln \frac{2{,}27}{w} + 1) = 1 - \underline{P}_{0.09} - C \cdot (\ln \frac{w}{0.09} - 1) =$$
$$= S^o_{2.27} + C \cdot \ln \frac{2.27}{w} = S^o_{0.09} - C \cdot \ln \frac{w}{0.09} \tag{9}$$

The turbulence correction is as follows:

$$\Delta S^T_w = \underline{P}_{кр} \cdot S^o_w \tag{10}$$

here: $\underline{P}_{кр}$ is comparative critical turbidity.

$$\underline{P}_{кр} = \frac{\rho_{кр}}{\rho_o} \tag{11}$$

here: $\rho_{кр}$ is critical turbidity.

Critical turbidity A.G. It is determined according to the Khachatryan formula [7,8,9,16,17,18,19,20]:

$$\rho_{кр} = \frac{0.2 \cdot u_в}{C} \cdot \underline{P}_{и.в} \tag{12}$$

here: $\underline{P}_{u.в}$ is comparative composition of the given turbidity fraction, in percent of the unit.

$$\underline{P}_{u.в} = \underline{P}_{0.09} + C \cdot \ln \frac{u_в}{0.09} \tag{13}$$

The main component of turbulent pulsation is as follows:

$$u_в = 0.065 \cdot \frac{n^{0.5} \cdot \vartheta^{0.5} \cdot (\vartheta - 0.05)}{H_{av}^{0,33}} \tag{14}$$

here: n is the stiffness of the core of the silencer;

ϑ is average speed in the cooler.

(1) and (5) in the cooler W_0 , we have the calculation formula for determining the settling curve of turbidity in a turbulent flow.

$$S_{w_o}^{T} = (1 - \underline{P}_{кр}) \cdot S_{w_o}^{o} = (1 - \frac{\rho_{кр}}{\rho_o}) \cdot S_{w_o}^{o} \tag{15}$$

The length of the break is calculated according to the degree of break of the blurs in it (3):

$$L = \frac{\vartheta_{cp} \cdot H_{av}}{w_o} \tag{16}$$

here: W_0 is coverage of the quencher providing a given level of deposition.

The coverage of the required quencher is determined by the following formula:

$$w_o = e^{\left(\frac{1 - \underline{P}_{0,09} - 1,41 \cdot C}{C} - \frac{S_{wo}^{T}}{C \cdot (1 - \rho_{кр})}\right)} \tag{17}$$

The above method is an effective method for sand and clay mud. This method gives satisfactory results when the speed in the coolers is 0.2-0.4 m/s.

The turbidity in the clarifier is found for the coagulation state as:

$$S_{w}^{TK} = S_{w>0,09}^{o} + \alpha \cdot S_{w<0,09}^{ок} \tag{18}$$

here: $S_{w>0,09}^{o}$ is level of stopping when the turbidity fraction is greater than 0.01 mm in the clarifier;

$S_{w<0,09}^{ок}$ is when the turbidity fraction in the clarifier is less than 0.01 mm ($w = 0,09 мм/с$) pause rate;

α is the coefficient that considers the occurrence of coagulation in the flow. In this case, the speed in the quencher $\vartheta_{cp} \le 0,1$ $м/c$ when $\alpha = 0,85$ equal to $S_w > 0.09$ value is determined by condition (2) as follows:

$$S_{w>0,09}^{ок} = \underline{P}_{w>0,09} - \frac{1}{w}\int_{0,09}^{w} \underline{P}_{w} \cdot dw = 1 - \underline{P}_{0,09} - \frac{1}{w}\int_{0,09}^{w} C \cdot \ln \frac{w}{0,09} \cdot dw = \tag{19}$$

$$= 1 - \underline{P}_{0,09} - C \cdot (\ln \frac{w}{0,09} - 1) - \frac{C \cdot 0,09}{w}$$

The first coagulation threshold is determined as follows:

$$П_1 = \frac{t_1}{H_{cp}} = \frac{500}{H_{cp}},\ c/мм \tag{20}$$

here: H_{cp} is average speed in the cooler, mm;

t_1 is the time of the beginning of the sinking intensity. s.
The second coagulation threshold is determined as follows:

$$П_2 = П_1 + \frac{8}{(\rho_{0.09} \cdot H_{cp})^{0.78}}, \ s/mm \tag{21}$$

here: $\rho_{0,09}$ is a turbidity that produces a turbidity $w < 0{,}09 мм/с, \ кг/м^3$

$$\rho_{0,09} = \rho_o \cdot \underline{P}_{0,09} \tag{22}$$

here: ρ_o is initial turbidity at the head of the clarifier, kg/m3.
Coagulated mass $П_2$ of the subsidence curve in the interval is defined as follows [10,21,22,23,24,25]:

$$S^{ок}_{w<0,09} = \underline{P}_{0,09} \cdot \left[1 - e^{-к(\frac{1}{w} - П_1)}\right] \tag{23}$$

where: K is the empirical coefficient

$$K = 0{,}15 \cdot (\rho_{0,09} \cdot H_{cp})^{1,3} \tag{24}$$

The total ordinate of the sedimentation curve of turbidity up to the second threshold of coagulation ($w \geq \frac{1}{П_2}$), according to (19, 20, 24), is determined from the following formula:

$$S^{TK}_{W} = 1 - \underline{P}_{0,09} - C \cdot (\ln \frac{w}{0{,}09} - 1 + \frac{0{,}09}{w}) + \alpha \cdot \underline{P}_{0,09}[1 - e]$$

$$= 1 - 0{,}15 \cdot \underline{P}_{0,09} - C \cdot (\ln \frac{w}{0{,}09} - 1 + \frac{0{,}09}{W}) - \frac{0{,}85 \cdot \underline{P}_{0,09}}{e^{к(\frac{1}{w} - П_1)}} \tag{25}$$

The effective length of the spacer is determined by the following formula:

$$L_p = L_{эф} = 1000 \cdot \vartheta_{cp} \cdot H_{cp} \cdot П_2 \tag{26}$$

Below is the water consumption from the ditch to the clarifier using the above formulasQ=0.3 m3/s, turbidity of the water in the stream: ρ =3.5-5.0 g/l [26,27,28,29,30,31,32], dimensions of the probe: b=13 m; H=4.0 m; For the case where L=30-300 m, the graph of the relationship between the length of the turbidity and the degree of turbidity is presented (Fig. 1). In the same way, calculations can be made in a special Excel program for any water consumption.

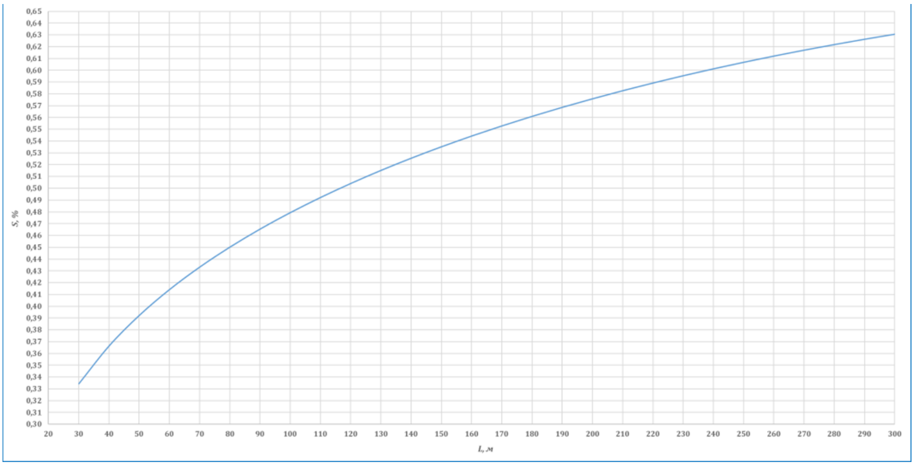

Fig. 4. *SWOP2= connection graph between f(L).*

4 Conclusions

1. In general, the analysis of the experiments shows that in the clarifiers in the experimental areas, the deposition rate of turbid sediments from the beginning to the end is from 20% to 40%. If the continuous flow of water from the site channels to the clarifiers is assumed, then the turbidity along the length of the constructed clarifiers did not settle completely; as a result, in the process of irrigating the fields, turbidity was also observed from the system filters and pipe drippers, i.e., the turbidity in the drippers ranged from 0.240 g/l to 1.139 g/l organizes.
2. The hydraulic calculation of the turbid settling process in the clarifiers was performed according to the method of A.G. Khachatryan. As a result, a graph of the relationship between the length of the turbidity and the level of turbidity in it was developed for different water consumptions. With the increase in the length of the turbidity, the stopping rate of turbidity increases; that is, the stopping rate is 30-40% in a 41-m-long pacifier and 60-70% in a 300-m-long one.
3. The laboratory analysis of the turbidity samples taken from the experimental plots shows that the turbidity of the flow entering the drip irrigation systems of farms supplied with water from the Zarafshan River is much higher compared to the conditions of the Amudarya, that is, the turbidity of the turbidity in the experimental plots is 2.25 g/l, 7.115 g/l, respectively. , was 0.502 g/l.
4. These studies are the results of preliminary studies carried out in the farms of the Samarkand region; in the future, it is necessary to carry out studies for other river basins and to further improve the optimal parameters of the clarifiers for different conditions.

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