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

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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-Darya-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, this may lead to an increase in the rate of sedimentation. Therefore, the study of sediment settling processes in sedimentation 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, is relevant.
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.

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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

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.

3 Results and Discussion

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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.

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

<table>
<thead>
<tr>
<th>№</th>
<th>Name</th>
<th>I cross section (g/l)</th>
<th>II cross section (g/l)</th>
<th>III cross section (g/l)</th>
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<td>1</td>
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<td>2.18</td>
<td>1.526</td>
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<td></td>
<td>0.2h</td>
<td>2.25</td>
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<td>0.2h</td>
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<tr>
<td></td>
<td>0.2h</td>
<td>2.27</td>
<td>1.589</td>
<td>1.135</td>
</tr>
</tbody>
</table>

The analysis of the samples in the laboratory shows that the turbidity level of the stream
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 the filters ranges from 0.240 g/l to 1.139 g/l. Therefore, to reduce the risk of turbidity to the drip irrigation systems, 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:

\[ S_{wo}^T = S_{wo}^o - \Delta S_{wo}^T \]

Here:

- \( S_{wo} \) is the ordinate of the subsidence curve for the case where there is no effect of the turbulent flow;
- \( \Delta S_{wo} \) is correction for turbulence.

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

\[ S_{wo}^o = -\frac{1}{W_o} \int_{w_o}^{w} P_{wP} \cdot dw \]

Here:

- \( w_o \) is hydraulic size in the coverage of the cooler;
- \( P_{wP} \) is fuzzy diffusion function.

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

\[ L = H_{av} \]

Here:

- \( H_{av} \) is the average speed in the sander, respectively;
- \( L \) is the length of the probe in the selected section.

The average depth in the strainer:

\[ B = \frac{H_{av}}{c} \]

Here:

- \( B \) is the surface of the live section of the quencher.
\[ B \text{ width of the cooler on the water level.} \]

The size distribution of fuzzy fractions corresponds to Khachatryan's law:

\[ w_{CJ} = \frac{w}{CJ} \]

Here:

\[ J \text{ - relative turbidity of hydraulic magnitude; } \]

\[ С \text{ is constant function of fraction size distribution.} \]

For account \( 27.2 \) and \( 09.0 \) 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,

\[ S_{w_0} = -P_w + C = -P_{w_0} + C \cdot \frac{w}{w_0} = -P_{w_0} - C \cdot \frac{w_0}{w} \]

\[ = S_{w_0} + C \cdot \frac{w_0}{w_0} = S_{w_0} - C \cdot \frac{w_0}{w} = -P_{w_0} \]

\[ P'_w = P_w - C = P_{w_0} - C \cdot \frac{w_0}{w} = P_{w_0} - C \cdot \frac{w}{w} \]

\[ = S_{w_0} + C \cdot \frac{w_0}{w} = S_{w_0} - C \cdot \frac{w}{w} \]

\[ \Delta S^T_w = P_{w_sp} \cdot S_{w} \]

\[ \text{Here:} \]

\[ P_{w_sp} = \frac{\rho_{w_sp}}{\rho_o} \]

\[ \rho_{w_sp} = \frac{\rho_{w_sp} \cdot \rho_o}{C \cdot P_{w_sp}} \]
The main component of turbulent pulsation is as follows:

\[ L = \frac{\mathcal{G}_{cp} \cdot H_{av}}{w_o} \]

where:

- \( L \) is the length of the break calculated according to the degree of break of the blurs in it (3);
- \( w_o \) is the coverage of the quencher providing a given level of deposition.

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

\[ S_{w>\alpha}^{ok} = S_{w>\alpha}^o + \alpha \cdot S_{w<\alpha}^{ok} \]

where:

- \( S_{w>\alpha}^{ok} \) is the first coagulation threshold determined as follows:

\[ S_{w>\alpha}^{ok} = \int_0^w P_{w>\alpha} - C \cdot \int_0^w w \cdot dw = \int_0^w P_w \cdot dw = \int_0^w \mathcal{G} \cdot \left[ C \cdot \frac{w}{w} \right] \cdot dw = \]

\[ \Pi = \frac{t}{H_{cp}} = \frac{C}{H_{cp}} \]

\[ \mathcal{G}_{cp} \] is the coefficient that considers the occurrence of coagulation in the flow. In this case, the speed in the quencher \( \mathcal{C}_{w>\alpha} \) equal to 09,0 when the speed in the cooler \( \mathcal{C}_{w>\alpha} = 85,0 \).
The second coagulation threshold is determined as follows:

\[ S_{2}^{\text{TR}} = -P - C \cdot \frac{W}{P} - C \cdot \frac{W}{P} - \alpha \cdot P \cdot \left( -e^{\frac{-E}{W}} \right) \]

\[ K = \frac{P}{\rho \cdot \phi} \cdot \frac{H}{w} \]

\[ \rho = \rho_{0} \cdot P \]

where:

- \( \rho \) is the initial turbidity at the head of the clarifier, kg/m³.
- \( K \) is the empirical coefficient.
- \( \rho_{0} \) is the turbidity that produces a turbidity.
- \( W \) is the effective length of the spacer.
- \( P \) is the total ordinate of the sedimentation curve of turbidity up to the second threshold of coagulation.
- \( S_{2}^{\text{TR}} \) is the coagulated mass of the subsidence curve in the interval.

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

\[ W_{\text{ef}} = \frac{21000 \cdot \rho H L}{c_{\text{sp}} c_{\text{r}}} \]

Below is the water consumption from the ditch to the clarifier using the above formulas.

\[ Q = 0.3 \text{ m}^3/\text{s}, \quad \text{turbidity of the water in the stream: } \rho = 3.5 - 5.0 \text{ g/l} \]

For the case where \( L = 30 \text{ - 300 m} \), 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.
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.

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.

References


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