Calculation of the consumption of pumped water for filtration when watering cotton

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Abstract. In Uzbekistan, in recent years, there has been a shortage of water resources used for irrigation. Therefore, during the growing season, it is necessary to use possible additional sources of irrigation. Such waters can be water pumped out from vertical drainage wells.

The object of the study is land irrigation pumped out from vertical drainage wells by pumped water in the Fergana region in the economy of Musazon Ismoilov. Irrigated crop-cotton. The research method is used to estimate the size of the absorption of clarified and turbid water in the furrow by applying a mathematical filtration model. For the distribution of turbid flow velocities, the distribution of turbid flow according to OG Natishvili was considered, and the flow rate flowing through the cross-section was determined.

Scientists and specialists have found that when using groundwater pumped out by vertical drainage wells, due to their clarity compared to irrigation water containing suspended sediments (i.e., turbidity), more intensive absorption occurs. For uniform moistening of the field, it will be necessary to increase the supplied irrigation rates.

According to the application of a mathematical model, it was found that the speed of the turbid flow is greater than the speed of the pure flow. This is because 15-20% of the flow rate of clean water (pumped out of the vertical drainage well) goes to filtration. With the result obtained, it can be concluded that the water pumped out from vertical wells can be used as an additional source of irrigation in case of a shortage of water resources during the growing season.

INTRODUCTION

Due to global warming, there is a shortage of irrigation water for irrigation of agricultural land in the country**.** At the same time, vertical drainage wells operate on the territory under consideration in the Fergana region due to the low level of groundwater [5, 6]. The main purpose of vertical drainage wells is to maintain the groundwater level at a certain level. The salinity of these waters ranges from 1 to 3 g / l and can be used for irrigation during the growing season [1, 2]

METHOD

The research method for this problem is statistical data processing. The size of the absorption of clarified and turbid water in the furrow was estimated by applying a mathematical filtration model. The regularity of the distribution of velocities along the depth of the pure flow as the initial ones is taken to the equation of Yu.A. Ibad-zade [15]

The object of the study is land irrigation pumped out from vertical drainage wells by pumped water in the Fergana region in the economy of Musazon Ismoilov [16].

RESULTS AND DISCUSSION

To assess the size of clarified and turbid water absorption in the furrow by applying a mathematical filtration model. Knowing the filtration costs, you can estimate the rate of water absorption in the field. To assess the filtration rate, consider the difference between the velocity distribution of clean and turbid water in this problem. To determine the regularity of the distribution of velocities over the depth of a pure flow, we take the equations of motion of the following form as the initial ones [15]:

$$\frac{\partial u}{\partial t}+\sum_{i=1}^{n}u_i\frac{\partial u_j}{\partial x_i}=F_i-\frac{1}{\rho}\frac{\partial p}{\partial x_i}+\sum_{i=1}^{n}\frac{\partial}{\partial x_i}\frac{1}{\rho}A\frac{\partial u_j}{\partial x_i} \qquad (1)$$

The discontinuity equation has the form:

$$\sum_{i=1}^{n}\frac{\partial u_j}{\partial x_i}=0 \qquad (2)$$

In these equations, the following notation is introduced: $i = 1,2,3 \;\; j = 1,2,3$; $n = 3$, u_i is velocity vector components; t is time; F_i are components of external forces; g is acceleration of gravity; ρ is density of water; p is pressure; A is turbulent exchange coefficient; x_i are coordinates of a rectangular system; the coordinates are arranged as follows: $x_1 = x$ - with the flow; $x_2 = y$ - in depth from the surface to bottom; $x_3 = z$ - across the stream; F_i is acting external gravity:

$$F_1 = gi_0;\; F_2 = -g',\; F_3 = 0$$

The equation of one-dimensional steady motion has the form:

$$\frac{\partial u_x}{\partial t}=\frac{\partial u_y}{\partial t}=\frac{\partial u_z}{\partial t}=0$$

$$u_y = u_z = 0$$

Under these assumptions, equations (1) and (2) take the form (Yu.A. Ibad-zade and others [15]:

$$u_x\frac{\partial u_x}{\partial x}=gi_0-\frac{1}{\rho}\frac{\partial p}{\partial x}+\frac{1}{\rho}\frac{\partial}{\partial x}A\frac{\partial u_x}{\partial x}+\frac{1}{\rho}\frac{\partial}{\partial y}A\frac{\partial u_x}{\partial y} \qquad (3)$$

Axis pressure change and Oz equal to zero,

$$\frac{\partial p}{\partial z}=0 \qquad (4)$$

Axle pressure Oy varies with the density and gravity of the water:

$$\frac{\partial p}{\partial y}=\rho g \qquad (5)$$

Acceleration of speed change little changes over Ox $\frac{\partial u_x}{\partial x}=0$. From dependencies (3, 4, 5) it follows that:

$$\frac{\partial p}{\partial x} = 0 \tag{6}$$

With these considerations, the equation of motion (4) has the form:

$$\frac{1}{\rho}\frac{\partial}{\partial y} A \frac{\partial u_x}{\partial y} + g i_0 = 0 \tag{7}$$

The distribution rate on the free surface and on the bottom of the reservoir has the following boundary conditions:

$$\left.\begin{array}{l} u_x = u_0 ... at ... y = 0 \\ u_x = u_D ... at .. y = H \end{array}\right\} \tag{8}$$

The coefficient of turbulent exchange (A) is important in solving a wide variety of theoretical and practical problems. To determine the coefficient of turbulent exchange (A) based on the logarithmic and parabolic laws of distribution of velocities with a vertical axis, using the logarithmic equation or a parabola with a vertical axis to express the velocity profile, we find the distribution curve, (A) - takes zero or close to zero values at the pipe walls, maximum values at the pipe centers and zero at the pipe axis. To obtain a smooth increase in the coefficient of turbulent exchange from the bottom to the surface of the flow, the approximate form is as follows:

$$A(y) = \frac{A_{cp}}{\sum_{i=0}^{n} a_i y^i} \tag{9}$$

Here a_i are coefficients to be determined; A_{cp} is average value of the coefficient of turbulent exchange:

$$A_{cp} = \frac{\rho g H u_{cp}}{2mC} \tag{10}$$

H is flow depth; u_{cp} is average vertical speed; $m = 0.35C + 3$ for $10 \le C \le 60$. C - Chezy coefficient. Substituting formula (4.41) into equation (4.40), we obtain:

$$A(y) = \frac{\rho g H u_{cp}}{2mC} = \frac{1}{a_0 + a_1 y + a_2 y^2 +} \tag{11}$$

Let's first consider the simpler case, suppose that $a_0 \neq 0$, $a_1 = a_2 = ... = a_n = 0$ then (4.42) the formula has the form:

$$A(y) = \frac{\rho g H u_{cp}}{2mCa_0}$$

After substituting the obtained expression into formula (7) and some simple changes, we obtain a second-order differential equation:

$$\frac{d^2 u_x}{dy^2} = -\frac{2mCa_0 i_0}{H u_{cp}} \tag{12}$$

A particular solution (4.43) of the differential equation, the solution of which expresses the distribution of the velocity of pure water along the vertical, has [14] view:

$$u_x = u_0 + \frac{\left(\frac{2mu_*}{\sqrt{g}}\right)\left(\frac{a_0}{2} + \frac{a_1 H}{3} + \frac{a_2 H^2}{4}\right) - (u_0 - u_Д)}{a_0 + \frac{a_1 H}{2} + \frac{a_2 H^2}{3}} \left(a_0 + \frac{a_1 H\eta}{2} + \frac{a_2 H^2 \eta^2}{2}\right)\eta - \tag{13}$$
$$- \frac{2mu_*}{\sqrt{g}}\left(\frac{a_0}{2} + a_1 \frac{H}{3}\eta + a_2 \frac{H^2}{4}\eta^2\right)\eta^2$$

where $\eta = \frac{y}{H}$ is relative depth. Formula (13) is a three-term parabola. From formula (13) it is obtained for $a_1 = a_2 = 0$ zero and at $a_2 = 0$ first approximation of the equation. Let's admit, what $a_0 = a_1 = a_2 = 1$, then at $a_1 = a_2 = 0$ and $a_0 = 1$ we obtain the formula for the velocity distribution:

$$u_x = u_0 + \left[\left(\frac{mu_* a_0}{\sqrt{g}}\right) - (u_0 - u_D)\right]\eta - \left(\frac{mu_* a_0}{\sqrt{g}}\right)\eta^2 \tag{14}$$

Formula (13) is a three-term parabola. The three-term form of the parabola for the distribution of velocities was proposed by I.I.Agroskin and G.T. Dmitriev in the form:

$$u_x = u_0 + 2m_1 N\eta - N\eta^2 \tag{15}$$

Comparing expression with formula (15), we obtain:

$$N = \left(\frac{mu_* a_0}{\sqrt{g}}\right) m_1 = N + u_D + \frac{u_0}{2N}$$

for bottom speed - the formula:

$$u_D = 2u_{sr} - u_0 - \frac{2mu_*}{3\sqrt{g}} \cdot$$

Thus, in a more general case, the vertical distribution of the pure water velocity is determined by formula (15), from which, as a special case, simplified formulas can be obtained. To find the flow rate of the net flow, we obtain the product of the velocity distribution by the transverse area - ω .

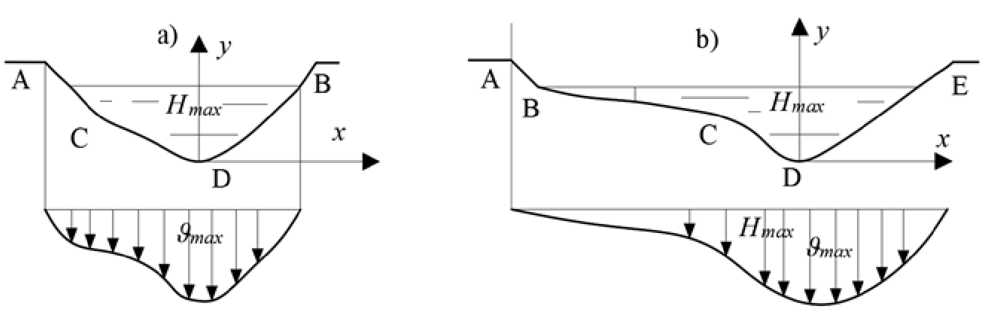

FIGURE 1. Diagrams of the distribution of velocities in various forms of the furrow.

For the distribution of the turbid flow velocities, consider the distribution of the turbid flow from O. G. Natishvili [14], and determine the flow rates flowing through the cross-section.

The distribution of turbidity along the flow depth is determined by applying the turbulent diffusion equation. Let us compose the balance equation of the suspended matter for the control volume (A) and, according to Yu.A. Ibadzade [13], we obtain:

$$u_x = \frac{dS}{dx} dxdydz = \frac{1}{\rho}\left[-A_1\left(\frac{\partial S}{\partial x}\right)_1 + A_2\left(\frac{\partial S}{\partial x}\right)_2 \right] dzdy + \\ + \frac{1}{\rho}\left[-A_3\left(\frac{\partial S}{\partial y}\right)_3 + A_4\left(\frac{\partial S}{\partial y}\right)_4 + w(S_3 - S_4) \right] dxdz \quad (16)$$

where w is hydraulic particle size. Axis movement Ox small therefore, changes in the magnitude $A = \frac{\partial S}{\partial x}$:

1) the change in concentration along the longitudinal axis and transverse axis (Ox) is insignificant in comparison with the change in depth;

2) area in the distance a turbidity from the water surface S_a, then $\frac{\partial S_a}{\partial y} = 0$ Integrating the equation for the distribution of turbidity in the boundary conditions $S=S_D$ at $\eta = 0$ and $S = S_0$ at $\eta = 1$, we obtain the formula for determining the depth distribution of turbidity:

$$S = S_0 + (S_D - S_0)(1-\eta)^{\left[(u_0 - u_D) + \frac{mu_*}{\sqrt{g}}\right](1+aS_{sr})\frac{w}{u_*^2}} e^{-\frac{2m}{\sqrt{g}}\frac{w}{u_*}(1+aS_{sr})\eta} \quad (17)$$

The flow distribution rates for filtration are determined by the difference between the flow rates of turbid water (16) and pure water (17)

As you know, the distribution of turbidity is the rate of distribution of turbidity concentration in pure water. When turbidity settles on the bottom of the furrow, clogging occurs, and the filtration rate decreases. Water consumption there increases due to colmatation. Water flow rates for filtration can be determined by the difference in clean and turbid water flow rates. Consider the differences of equations (18) and (19):

$$\vartheta_* = S_0 - u_0 + (S_D - S_0)(1-\eta)^{\left[(u_0 - u_D) + \frac{mu_*}{\sqrt{g}}\right](1+aS_{cp})\frac{w}{u_*^2}} e^{-\frac{2m}{\sqrt{g}}\frac{w}{u_*}(1+aS_{cp})\eta} - \\ - \left[\left(\frac{mu_* a_0}{\sqrt{g}}\right) - (u_0 - u_D) \right]\eta - \left(\frac{mu_* a_0}{\sqrt{g}}\right)\eta^2 \quad (18)$$

Taylor series expansion: $e^{-\frac{2m}{\sqrt{g}}\frac{w}{u_*}(1+aS_{cp})\eta} \approx 1 - \frac{2mw}{\sqrt{g}u_*}(1 + aS_{cp})$

Then equation (19) takes the form:

$$
\vartheta_* = S_0 - u_0 + \left(S_D - S_0\right)\left(1 - \frac{2mw}{\sqrt{g}u_*}\right)^{-1}\left[1 - \frac{2mw}{\sqrt{g}u_*}\left(1 + aS_{sr}\right)\right] - \\
- \left[\left(\frac{mu_* a_0}{\sqrt{g}}\right) - \left(u_0 - u_D\right)\right]\eta - \left(\frac{mu_* a_0}{\sqrt{g}}\right)\eta^2 \qquad (19)
$$

Filtration costs (Q) are determined by the following formula:

$$
Q = \omega \cdot \vartheta_* \qquad (20)
$$

ω - channel cross-section. Table of distribution of turbidity and distribution of pure water and the difference in velocities along the depth of the flow. Filtration consumption.

TABLE 1. Calculated values of water consumption for filtration into the furrow for turbid and clarified pumped water

Vertical depth H, m	Turbidity, kg / m ^{2}							
	Observed	Calculated by formulas			Furrow cross-sectional area, m^2	Turbidity consumption, m / s	Furrow length, m	Furrow length consumption, m / s
	S	S	u_x	ϑ_*	ω	Q	L	Q_L
0.15	3.058	3.025	2.814	0.211	0.1	0.0211	200	4.22
0.20	2.713	2.678	2.429	0.249	0.1	0.0249	300	7.49
0.25	2.641	2.486	2.401	0.085	0.1	0.0085	350	2.975
0.30	3.023	2.825	2.705	0.120	0.1	0.0120	250	3.00

For example, if the groove has a parabolic cross-section in Fig. 1, then it is determined by the formula

$$
\omega = \int_{\eta_1}^{\eta_2}\left(u_0 + 2m_1 N\eta - N\eta^2\right)d\eta \qquad (21)
$$

H is flow depth; u is average vertical speed; $m_1 = 0.35C + 3$ for $10 \le C \le 60$. C is Chezy coefficient. Where $\eta = \frac{y}{H}$ is relative furrow depth.

CONCLUSION

The turbid flow rate (S) is greater than the pure flow rate. This is explained by the fact that the sedimentation of particles of a turbid flow leads to clogging of the bottom and sides of the furrow, and by this, reduced filtration consumption and the decrease in the speed of pure water is because 15-20 % of the consumption of pure water goes to filtration. As a result, it can be concluded that the water pumped out from vertical wells can be used as an additional source of irrigation in case of a shortage of water resources during the growing season.

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