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RESEARCHES OF MELIORATIVE EFFICIENCY OF DRAINAGE SYSTEMS

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Abstract

Currently, more than 200 cities and towns in the Republic of Uzbekistan are ameliorative disadvantaged, where urgent measures are needed to improve their lands based on scientific recommendations. The reason for this is the anthropogenic impact of irrigation on the natural environment, the consequence of which is a large-scale rise in the groundwater level (GWL) in the irrigated agriculture zone, the occurrence of secondary salinization and land flooding on a regional and local scale - within the lands of settlements and cities.

Keywords: Irrigation equipment and irrigation technology, humidification diagram, dwelling length, irrigation time, irrigation rate, wetted perimeter, furrow irrigation, wetting uniformity, sustainable development.

Introduction

Large-scale work is being carried out in Uzbekistan for the sustainable development of farms on irrigated lands. The total area of irrigated land in the republic is 4280 thousand hectares, where more than seventy thousand farms operate. To ensure sustainable economic, technical, meliorative, ecological, landscape development of each farm, an important task has been designated, paying special attention to the strategy for the further development of Uzbekistan in 2017-2021.

Results

The SANIIRI twenty-year study showed high ameliorative efficiency of vertical drainage in the irrigation zone of the Hungry Steppe.

• Starting from the 60s, vertical drainage also began to be introduced in the cities and regional centers of the republic: Golestan, Kokand, Kagan, Nukus, Bukhara, etc.

• Operation of the vertical drainage system for 30-35 years allowed in these cities to regulate the level of groundwater (from 0.5 to 2.2 m. In Gulistan and from 1.2 to 3 m. In Kokand and remove piezometric pressure in the underlying aquifers.

• On the instructions of the Ministry of Housing and Communal Services (former), the state of drainage use in 55 cities and regional centers was surveyed (in the 80s). In 52 settlements, the GWL ranged from 0.36 to 2.5 m. Only in 3 settlements, then the rate of drainage was reached.

Discussion

In the current market economy conditions, the development of an innovative water-saving equipment and crop irrigation technology has great national and scientific importance. The purpose of this study is to improve the environmental management of the territory by modernizing the technical state of irrigation and land-reclamation systems and their operation.

In the process of research, they were used in determining resource-saving equipment and technology of irrigating cotton along furrows based on mathematical modeling based on the Saint-Venant equation. Field studies were carried out according to the method of TIIIMSH, NIIIVP, NIISSAH (formerly SoyuzNIHI).

Conclusions

The ameliorative efficiency of any type of drainage is determined by its effect on the regime of groundwater and pressure water, on the salt regime of the soil, on the drainage of the territory and on the yield of agricultural crops. Vertical drainage at the Pakhtaaral state farm is the first pilot production system in the Republic of Uzbekistan consisting of 74 high-production wells, which was fully commissioned in late 1967 (N. Reshetkina, Kh. I. Yakubov).

The situation created in the country on the use of drainage systems in urban environments requires a radical restructuring in the design, construction and operation of drainage facilities.

This should include a set of environmental protection measures, part of which is the elimination and elimination of the main sources of flooding, reduction of infiltration water loss from open watercourses and water bodies, as well as water loss from urban utilities.

Over the past 20 years, horizontal drainage work has increased by more than 3.5 times, but the number of drainage wells with a reduced capacity of less than 50% has doubled. Despite the fact that during this time the cleaning and restoration of the work of drainage wells is fully mechanized, they still continue to divert enormous material, energy and human resources.

On the territory of the cities of Gulistan, Kogan and Nukuss, due to the premature “aging” of wells, the replacement of pumping and power equipment increased from 2 to 5–7 times a year and many pumps were replaced by submersible pumps of lower productivity (more than 80% of ECV-10 were replaced by ECV-6), and at the same time the GWL is restored to the drainage period. This means that the template scheme for the use of drainage of irrigated areas for urban areas has not justified itself, especially since there is still no consensus on the use of further drainage from ceramic pipes, plastics, pipelines without filtering and other structures.

The solution of the problem in the protection of the territory due to the groundwater pressure: The presence of pressure water significantly reduces the efficiency of drainage facilities laid down in the upper horizon and in most cases necessitates an artificial reduction of pressure in the underlying. The author has considered a method for calculating an intercepting drainage well that opens the upper layer of a three-layer aquifer (Fig. 1), based on the hydrodynamic theory and the finite difference method. At the same time, assumptions were used that within the low-permeable layer (Fig. 1, layer 2), for which K2 K1 conditions are satisfied, filtering occurs only in the vertical direction, and in the underlying layer (Fig. 1, layer 3) the groundwater pressure during drainage operation remains unaltered.

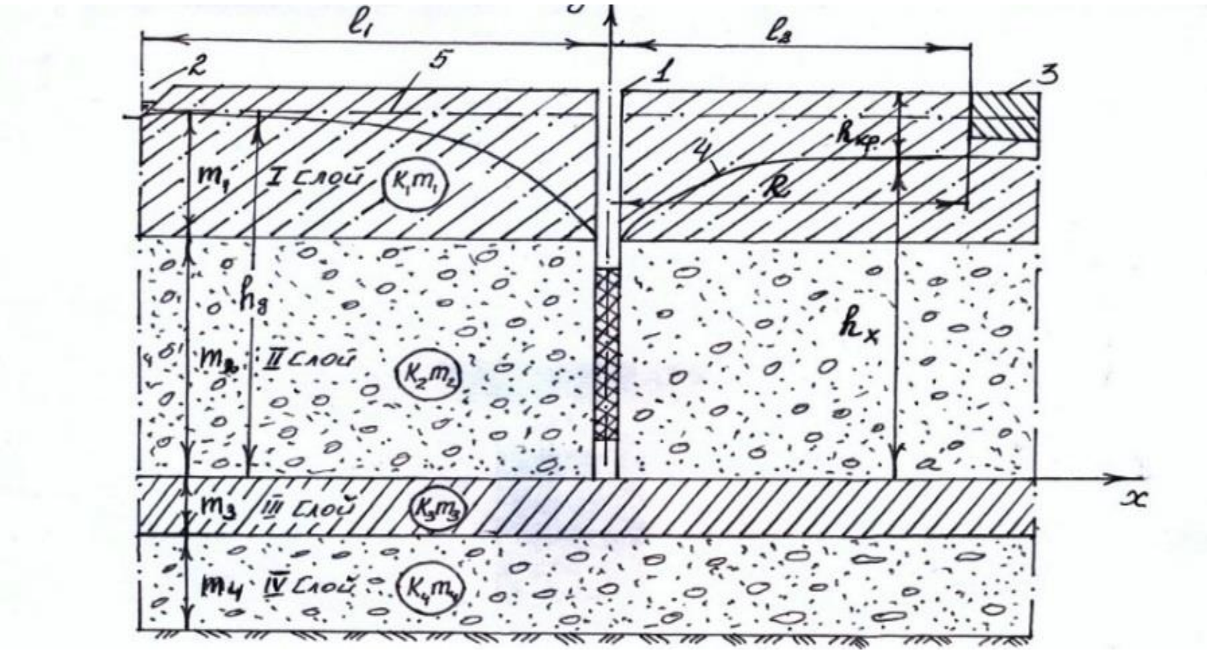

Fig. 1. Scheme of intercepting vertical perfect well in a three-layer reservoir.

1 - drainage well; 2 - boundary open drainage; 3 - protected area; 4 - depression surface during drainage work; In a section: I - the top flooded layer; II - lower permeable layer; III - low-permeable separating layer; IV - aquifer with pressure water;

The name of the additional power during the operation of the drainage well is established by the stationary nature of filtration, which is described by the equation.

$$K(\frac{\partial}{\partial x}(\bar{h}\frac{\partial h}{\partial x})) + \varepsilon_0 + \varepsilon_T + \varepsilon_w = \mu\frac{\partial h}{\partial t}; \quad (1)$$

Where: $\varepsilon_0 = \varepsilon_1 - \varepsilon_2 + \varepsilon_3$; $\varepsilon_T = f(x, hx, t)$;

$\varepsilon_ц = -\frac{K_3}{м_3}(h - H_0)$; H=$H_0$=const; $\bar{q} = \frac{q}{R_2}$;

K_1, K_2 и K_3 – filtration coefficient of the drained, lower permeable and low permeable aquifer;

m_3 – power of the waterproof (separating) layer;

h and H – heads in the drained 1 and 2 and the underlying 4 pressure horizons;

μ - coefficient of saturation or yield.

Equation (1) is nonlinear, so its solutions can be obtained only by a numerical method. Therefore, we produce its linearization according to the second method, then in places (1) we get:

$$U^{II}\text{-}\lambda^2\bar{U} + (\alpha H + \bar{q}) = 0,\ U=0.5h^2, \quad (2)$$

$$\lambda = \frac{2K_3}{Kм_3 h_{cp}}; \quad (3)$$

Where: λ – flow parameter;

h_{cp} – average power of the second layer (Fig. 2).

Separate the filtering area shown in fig. 1 into two zones, considering:

0 < x <∞ ; and from the zero axis “У”, X < 0 left, X > 0 right zone.

Then the boundary conditions in these zones are described as:

a) for the left zone:

$$\begin{cases} x = 0; h\Big|_{x=0} = h_0 \\ -x = l_1; h = h\Big|_{x=0} \end{cases} = h_g(R_1 l_1) \quad (4)$$

b) for the right zone:

$$\begin{cases} x = 0; h = h\Big|_{x=0} = h_G \\ x = \infty; h = h\Big|_{x=0} \end{cases} = h_g(R_{21} l_2); \quad (5)$$

Obviously, the flat problem of gravity to the well reduces to integrating equation (5) under initial conditions z = h_0 at t=0 after the function is set

$q_c = q_c(t)$, (6)

In the well-known approximate hydraulic theory of Dupuis-Forgeimer, the flow q of the stationary filtration flow in relation to Fig. 1 is expressed by the dependence:

$$q = \frac{K(h_g^2 - h_0^2)}{2(l_1 - x)}, \ 0 < x < L \ , \quad (7)$$

к – filtration coefficient,

h_q – head on the left side power circuit,

l – distance from the center of the well to the power circuit.

Given that the equation (6) qc = qc(t), h = h(x, t) and resolving it with respect to h, we obtain, in accordance with the above assumption, an approximate equation of the free surface with a non-stationary flow to the well:

$$h = \sqrt{h_g^2 - \frac{2q_c}{K}}(l_1 - x), \quad (8)$$

In equation (8), includes a known function

$q_c = q_c(t)$. When implementing the method, the question remains open about choosing the first approximation $q_{c1} = q_{c1}(t)$. It seems natural to use for this purpose also the Dupuy equation (7) putting in it X=0 and correspondingly h = z(t) and correspondingly h = z(t) :

$$q_{c1} = \frac{K_{cp}(h_g^2 - h_0^2)}{2(l_2 - h_0)}, \quad (9)$$

In principle, this process can be continued indefinitely, substituting successively in equation (2) q_{c1}, q_{c2} and each time re-integrating it with the initial condition (5) we will receive the appropriate approximations for the law of water decrease in the well h = f(t).

If we take into account the resistance in the filter zone of the well, then we have the UPV at the wall of the well:

$$h_z = h_0 + \Delta h, \text{ м} \quad (10)$$

Where:

h_0 – the position of the dynamic equation in the well;

Δh - head loss in the filter zone, m

Finding further approximations because of the extremely cumbersome results obtained loses its meaning. Therefore, the obtained numerical results by a full-scale experiment and simulated (performed by the author) shows their satisfactory convergence. However, in case of bilateral asymmetric inflow to the well of formula (8-9), it remains in force only for the left zone (Fig. 7).

For the right zone, the power loop is removed from the well a distance L=∞, then in the specified formulas should be replaced L= l_2 – R , Where R- well effect radius in case h_z=0 or h_z=h_0 range of protective drainage in the case.

As noted above, when entering the well $K = K_ф$ тhe depression curve at steady flow to the structure at the boundary of the gravel filter and the ground will experience refraction. For this case, according to the Dupuis formula (7), we can write:

$$q = \frac{K_2(h_л^2 - h_я^2)}{2(R - r_c)}, \quad (11)$$

On the one hand, and on the other

$$q = \frac{K_2(h_л^2 - h_0^2)}{2r_c}, \quad (12)$$

Eliminating from the last two equalities h_{z1} we get:

$$q = \frac{K_1 K_2}{2} \frac{h_л^2 - h_я^2}{K_2 r_c + K_ф \ (R - r_c)}, \quad (13)$$

Dividing and multiplying the right-hand side by R, you can carry it to the form of the Dupuy formula, if you enter the designation:

$$K_{пр} = \frac{K_1 K_2 R}{K_1 r_c + K_2 (R - r_c)}, \quad (14)$$

Theoretical analysis and practical results show that the flow rate of a two-layer system and a clogged well filter in the stationary filtration mode does not change if instead of a depression curve with a “jump” at the border at the filter zone, consider the curve determined from the Dupuis equation after replacing $K = K_{пр}$ reduced filtration coefficient.

Hence the opportunity to solve the problem of flooding the basement at $K_1 \neq K_2$ to organize the same iterative process as in the case of filtration from an open stream to a trench. Thus, the solution of the problem is reduced at what distance, to install drainage lines, in order to reach $h_{кр}$, in order to keep the basements from flooding.

Consider a one-way flow of groundwater to a sufficiently large diameter well with a constant level in it.

The level invariance ensures the operation of the pump by pumping out of the well q_c with a constant flow rate. Let at some moment in time t = 0 the drainage is turned off and the well begins to flood. Equating the inflow of groundwater to the well (per unit area) and the accumulation of water in it during d_t, we obtain the differential equation:

$$\frac{dh}{dt} = \frac{q_c}{d_k}, \quad (15)$$

Drainage action range in a three-layer formation ($\lambda \neq 0$) lw compared to single layer ($\lambda = 0$) lw may be more or less depending on the pressure of the water in the lower layer H_m. If H_m is large and h, then, with, vice versa. Then:

$$\frac{l_w}{l_w} = \sqrt{\frac{\bar{\varepsilon}}{\bar{\varepsilon} - \lambda^2 (q_e - q_{cp})}}, \quad (16)$$

For the flow of water into the drainage well, the corresponding equation (15-16) is obtained. For small values of the flow, instead of (14), we can write:

$$q = q^* + q\lambda, \quad (17)$$

$$\text{Where, } q^* = K\frac{q_k - q_\partial}{l_1} + \varpi(l_1 + l_2), \quad (18)$$

From formula (2) we obtain

$$q\lambda = \frac{2\pi K_2 m_2}{R_{пр} \ell_п} \quad (19)$$

From the formulas it can be seen that if there is a flow in the drain, it is more by the value of q, which depends on the factors determining the filtration process. Consequently, that the position of the reduced GWL and the amount of water inflow into the drainage are significantly affected by both the flow parameter and the pressure of the lower layer H. Regardless of the value of λ, if H> h_{cp}, the depression surface is higher than in the absence of flow, there is a reverse process. This condition is illustrated in Fig. 8, which shows depression curves in dimensionless quantities when the perfect drainage well is in operation.

The following parameter values are accepted:

$K_{др}/K_1=10^{-1}$; $\omega/K_1=10^{-2}$; H/h_e=1 и 0;

$h_{др}/h_e$ = 0,3; h_{cp} /h_e=0,6; m_3/h_e=0,5, both taking into account the connection with the underlying pressure layer (curves 1 and 3) and without taking into account (curve 2).

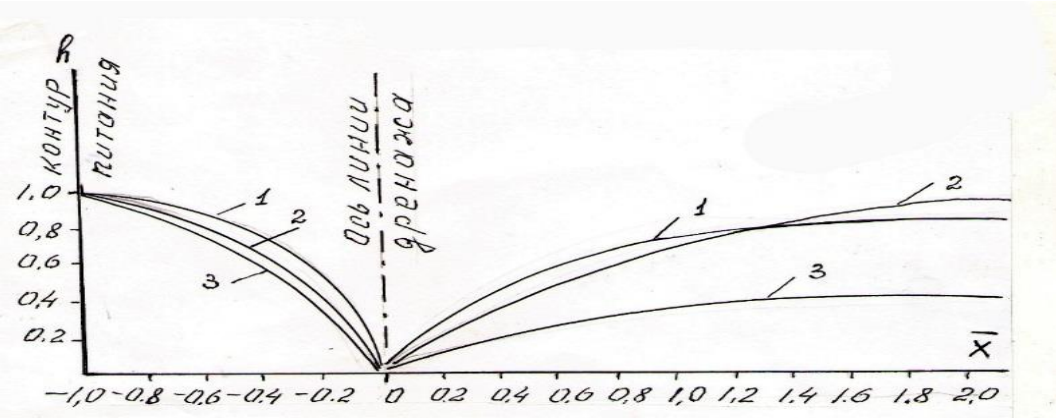

Fig. 2. The location of the depression curve during the operation of a perfect vertical well in a three-layer formation:

1- head in the underlying layer H = he; 2- no connection between layers; 3- head in the underlying layer H is absent.

It should be noted that hydrodynamic imperfection of drainage does not change the fundamental nature of the assessment given - it only affects the quantitative indicators.

Therefore, if there is a relationship between the individual layers, it is more legitimate to take H=he. Then the main parameter affecting the position of reduced levels during drainage operation is the flow parameter $\lambda^2 -$ the larger it is, the higher the position of the reduced levels. This is the main reason for the lack of effectiveness of SVD in the operation of them in the conditions of pressure of pressure water.

For achievement $h_{Kp}=3\div5$, м in the area of flooding of the land of the settlement, you can determine the position of the axis of the drainage line from the village border with

$$\frac{l_2}{R} = \frac{h_{Kp}}{l_e}, \text{ from here } l_2=\frac{R*h_{kp}}{h_e}, \text{ м} \qquad (20)$$

With the following parameter values:
R=500 м, h_e=10 м, h_{Kp}=4 м: we will receive:
$l_2 = \frac{500*4}{10} = 200$м.

Thus, it is possible to consider a more effective drainage device not in the village itself, but in access to them in order to intercept infiltration water. At the same time, not taking into account the flow of water in three-layer formations often lead to a significant distortion of the results, therefore, the flow in general cannot be neglected. It is also impossible to exaggerate the role of the flow factor in this respect the dominant role is played by the permeability and thickness of the separating layer, as well as the pressure in the underlying formation.

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