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Efficiency of using dual regulation groundwater level in the conditions of the Republic of Karakalpakstan

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ABSTRACT: In article presents the results of research in the experimental area "Naiman" Khodzheli district of the Republic of Karakalpakstan in 2012. According to the data of field studies at the Naiman collector, the calculated parameters for dual regulation were obtained by building retaining structures and during the growing season the sluicing of the collector were carried out and the optimum soil moisture content and, consequently, an increase in the productivity of agriculture crop yields were achieved.

KEY WORDS: subsoil water, soil, regulation, irrigation, collector

I.INTRODUCTION

Dual regulation of soil moisture is the creation of artificial soil moistening by creating backwater on drains and collectors in dry and medium water years. Usually, the need for additional soil moistening is due to the discrepancy between the amount of incoming water and its spending on total evaporation and wedging into the drainage system.

Dual groundwater level control is used in cases when other methods of moistening are considered ineffective. Groundwater level control is applied on drainage and humidification systems, the basic scheme of which differs from conventional systems in that the entire collection network serves for drainage and at the same time for soil moisture by regulating the groundwater level. Such systems are called dual control systems, i.e. two-way control of water regime of the soil.

Water management in the drainage and humidification network is carried out using gateways arranged on the final reservoir. During the non-growing season, when the groundwater level is located at high elevations, the system works to discharge excess water. After lowering the groundwater level by the drainage rate of the pre-sowing period (1.5 - 2.5 m), the valves on the system are closed, the water is delayed, and a further decrease in the water level occurs due to the evaporation of moisture from the soil. With a decrease in the water level with the valves closed by 20-30 cm below the drainage necessary for the normal growth of crops. Water rises to the root layer through the capillaries and further, the plant uses it. Thus, the collector plays the role of drainage to lower the level of groundwater, and the same system moisturizes the soil creating backwater in it.

After water supply, after a certain time t, the depression curve reaches a certain height corresponding to a stationary position at which the direction of movement of the ground flow changes towards the collector. To solve this problem, one can determine the stationary position of the depression curve for a given increase in the water horizon in the humidifier by $\Delta h0$ (Fig. 1).

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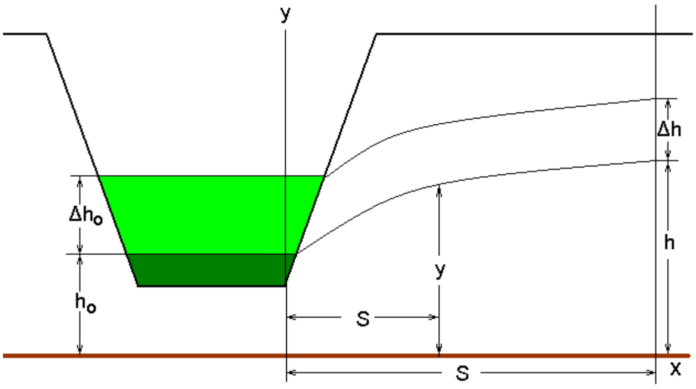

Figure 1 - The design scheme for the application of regulation groundwater level

In the presence of a collector (or a system of collectors), the equation of the stationary position of the depression curve is:

$$y^2 = -\frac{(h^2-h_0^2)x^2}{S^2} + 2\frac{(h^2-h_0^2)x}{S} + h_0^2; \quad (1)$$

For a single inflow to the collector on one side:

$$q = k\left[\frac{h^2-h_0^2}{S} - \frac{(h^2-h_0^2)x}{S^2}\right]; \quad (2)$$

at x = 0

$$q = \frac{k(h^2-h_0^2)}{S}; \quad (3)$$

Usually, when the horizon of water in the reservoir increases by Δh0, then after stabilization of the depression curve, the position of the groundwater level in the middle between the collectors changes by Δh, and the magnitude of the single inflow will be:

$$q = k\left[\frac{(h+\Delta h)^2-(h_0+\Delta h_0)^2}{S}\right]; \quad (4)$$

At the onset of the stationary position of the depression curve, the flow of the ground stream will look like:

$$\Delta h^2 + 2h\Delta h - (2h_0\Delta h_0 + \Delta h_0^2) = 0 \quad (5)$$

In this case, we obtain the value of Δh:

$$\Delta h = \sqrt{h^2 + 2h_0\Delta h_0 + \Delta h_0^2} - h \quad (6\ a)$$

knowing the values of Δh and h0.

To lower the level of groundwater in the middle between the reservoirs after the water horizon falls into them, the equation has the form:

$$\Delta h = \sqrt{h^2 + 2h_0\Delta h_0 + \Delta h_0^2} + h \quad (6\ б)$$

If the territory has a number of collectors (drains) to determine the time of groundwater level stabilization between the humidifiers, the formula is used as (a) the stable position of the groundwater level Δh in the middle between the humidifiers and knowing the distance between them help to determine the stabilization time (T) of the groundwater level mid between humidifiers:

$$f(\eta)_\beta = 1 - \frac{\Delta h}{\Delta h_0} \text{ and further } T = \frac{\beta}{kh_{cp}}\left(\frac{S}{2\eta}\right)^2 + t_0 \quad (7)$$

These calculation formulas can be used to calculate the double regulation of the groundwater level.

II. RESULTS AND THEIR DISCUSSION

To work out the practical basis of the above theory, a collector was selected, which was serving in the territory of the Naiman MTP, Khodzheili district of the Republic of Karakalpakstan, and was monitored. The irrigated area suspended from the collector is 2626 ha. The distance between the collector-drainage systems located on the experiment plot is 400–420 m. In order to conduct monitoring of the groundwater level, observation wells were installed on the test plot.

In March and April, after the land was washed, there was a sharp rise in the groundwater level and in places they merged with the surface waters. It should be noted that the total evaporation of cotton is, for the period May-September, about 6,700 m^3/ha with a yield of 25–26 q / ha when the groundwater level occurs between 1.6 and 2.0 m.

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From the first decade of April an intensive process of lowering groundwater levels started. By May 6, the groundwater level dropped to 2.3 m and, starting from May 7, an artificial rise of the level in the reservoir was carried out by sluicing. As a result of the sluicing, a widespread rise of the water horizon was observed, both in the reservoir and in the observation wells. Figures 2 and 3 show the fluctuations of the groundwater level in the wells, as well as changes in the water horizon in the reservoir. In the initial period, especially at the beginning of the sluicing, the groundwater level was under the influence of the collector, and subsequently higher than the level by 1.6-1.8 m and its regime was mainly formed under the influence of irrigation.

As can be seen from Fig. 2, the most intense decline in the water horizon was observed in well No. 1, located near the reservoir, while the decrease rate averaged 9.7 cm / day, and according to well No. 3 located far from the reservoir, the value of this indicator averaged 4, 2 cm / day.

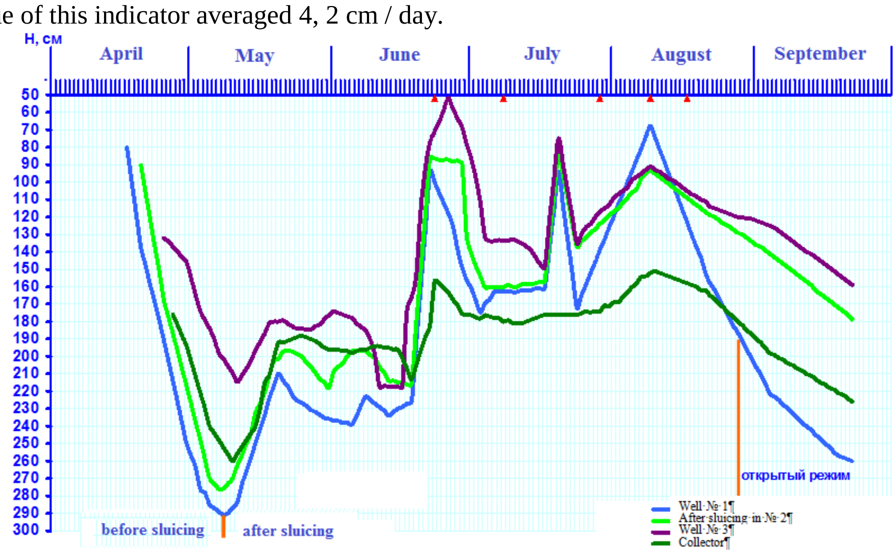

Figure 2 - Graph of groundwater level fluctuations of an experimental collector in the territory of the Naiman ICC in Khodzheili district of the Republic of Karakalpakstan

In tab. 1 shows the rate of decline and rise of the groundwater level in the period of the start of sluicing. In other periods, the groundwater level, i.e. peak position was most dependent on irrigation water supply.

Table 1 - The rate of lowering and raising the level of groundwater before and after sluicing

№ alignment	Number of wells	The rate of decline, cm / day Nn - Nk	The rate of rise, cm/day Nk – Nn
Alignment 1	1	7,8	9,0
	2	9,7	7,9
	3	4,2	4,2
Alignment 2	1	8,3	11,0
	2	7,0	9,0
	3	5,4	4,2

As can be seen from the table 1 as the distance from the collector increases, the rate of rise and fall significantly decreases.

In the process of sluicing, determining the magnitude of the backwater level in the reservoir (Δh and Δh0) is of particular importance. For calculation, the parameters are shown in fig. 3 Calculation of parameters is given below.

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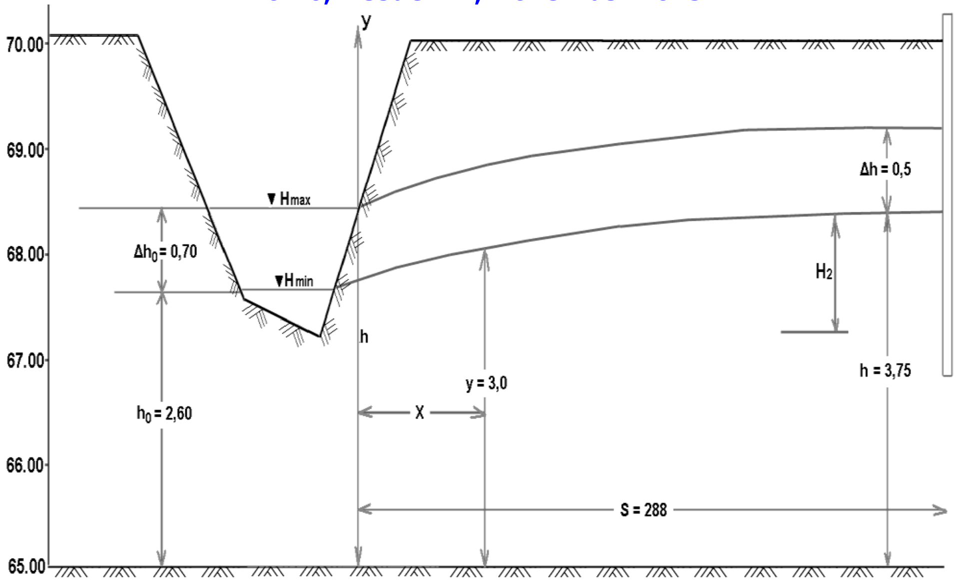

Figure 3 - Calculation scheme for determining the parameters of the sluicing at the experimental piot Naiman

Depending on the groundwater level, the position of the depression curve changes. The magnitude of the water inflow to the collector for different h and h0 are given in Table. 2

Table 2 - Water inflow to the reservoir at various values h and h0

(Cf = 1.2 m / day.)

№	date	h, м	h_0, м	$\Delta h = h - h_0$	q, m^3/day
1	20.07.12	4,75	3,40	1,35	0,07
	03.07.12	3,70	2,90	0,80	0,03
	21.05.12	3,35	2,50	0,85	0,04
	05.05.12	3,10	2,25	0,85	0,04
2	09.08.12	4,75	3,50	1,25	0,06
	22.06.12	4,0	3,05	0,95	0,05
	22.05.12	3,55	2,60	0,95	0,05
	05.05.12	3,35	2,45	0,90	0,05

According to the calculations of the Δh values, the curves of q = f (Δh) were drawn up.

In this case, the inflow per unit area is determined by:

$$q = k\left[\frac{h^2 - h_0^2}{S} - \frac{(h^2 - h_0^2)x}{S^2}\right] = 1{,}2\left[\frac{3{,}75^2 - 2{,}6^2}{288} - \frac{(3{,}75^2 - 2{,}6^2)10}{82944}\right] = 1{,}2\left[\frac{14 - 6{,}76}{288} - \frac{(14 - 6{,}76)10}{82944}\right]$$

$$= 1{,}2\left[\frac{7{,}3}{288} - \frac{73}{82944}\right] = 1{,}2[0{,}0253 - 0{,}000880] = 0{,}0293 = 0{,}03m^3/s$$

When x = 0:

$$q = \frac{k(h^2 - h_0^2)}{S} = \frac{1.2(14 - 6{,}76}{288} = 0.0301m^3/day$$

After reaching the stabilization of the depression curve, the position of the groundwater level between the reservoirs changes to a height Δh and then the single inflow to the reservoir is determined:

$$q = k\left[\frac{(h + \Delta h)^2 - (h_0 + \Delta h_0)^2}{S}\right] = 1{,}2\left[\frac{(3{,}75 + 0{,}5)^2 - (2{,}6 + 0{,}5)^2}{288}\right] = 1{,}2\left[\frac{8{,}4}{288}\right] = 0{,}035m^3/day$$

After reaching the stationary position of the depression curve, the flow of the ground stream does not change, then the right side of the equation should be equal to:

$$\Delta h^2 + 2h\Delta^2 - (2h_0\Delta h_0 + \Delta h_0^2) = 0$$

In this case, solving the equation for Δh, we can get the value of Δh and Δh0 by the formula:

$$\Delta h = \sqrt{h^2 + 2h_0\Delta h_0 + \Delta h_0^2} - h = \sqrt{3{,}75^2 + 2 \cdot 2{,}60 \cdot 0{,}70 + 0{,}70^2} - 3{,}75 = 4{,}25 - 3{,}75 = 0{,}5m$$

In the first approximation, the value of Δh can be taken as 0.5 m. In this case:

$$\Delta h^2 + 2h\Delta^2 - (2h_0\Delta h_0 + \Delta h_0^2) = 0 = 0{,}5^2 + 2\cdot 3{,}75\cdot 0{,}5 - (2\cdot 2{,}6\cdot 0{,}70 + 0{,}70^2) = 0{,}25 + 3{,}75 - 4{,}0 = 4 - 4 = 0$$

According to the calculation, the optimal value of Δh0 for these conditions turned out to be 0.70 m. During further operation of the collector, corrections were made to maintain the water level in the collector at the proposed level.

In general, the use of artificial backwater, i.e. The sluicing created favorable conditions for the formation of optimal soil moisture in irrigated lands, in the zone of influence of the experimental collector.

As noted above, the main purpose of dual regulation is to save water in dry years by creating an artificial backwater, i.e. by sluicing and thus raising the groundwater level to a certain value. In this case, a prerequisite is that the rise of the groundwater level should not cause secondary salinization.

When the groundwater level rises, if their salinity is high (above 4.0 g / l), then secondary soil salinity can certainly occur. Under this condition, the creation of an artificial rise is not recommended. However, the average value of soil salinization at the experimental site is not large and ranges from 2 to 6 µS / cm, therefore there is no danger of secondary salinization at this site.

III. THE MAIN CONCLUSION

In conclusion, based on the research and calculations, the following can be noted:

1. Taking into account the peculiarities of the local conditions (slight terrain slopes, low soil filtration rate and problems with water intakes) of the Republic of Karakalpakstan, it is necessary to revise the classical basics of reservoir and drain design. Lowering the groundwater level to 3.0 m, which is provided in the projects, is not necessary both in technical aspect and for economic reasons. It is necessary to introduce the term "optimal level of groundwater level," which provides the maximum yield at the lowest cost of water and labor resources.
2. Where the groundwater level has dropped below the optimum depth, conditions must be provided for artificially raising the level of sluicing on collectors. This makes it possible to maintain the moisture in the upper layer in the optimal mode and thereby save water supply during the growing season.
3. With groundwater salinity up to 2.5 g / l, the maintenance of the groundwater level at 1.5 - 1.6 m does not cause soil salinity in the upper layer.
4. The double regulation method should be applied in places where the groundwater level falls below 3.0 m with a salinity of not more than 3 g / l. Where groundwater salinity exceeds the limit of 3 g / l, this method is not recommended.
5. According to the results of the studies conducted in 2012, the application of the double regulation method, i.e. the creation of an artificial rise in the level of groundwater by sluicing saved water in the range of 1.2 -1.4 thousand m^3 per hectare and at the same time the process of secondary salinization of the soil does not occur
6. In order to prevent flooding of collector slopes during sluicing, the rate of rise of the water horizon should not exceed 8–10 cm per day, and at a decrease of 7–8 cm per day.

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