Scientific basis of subirrigation as a factor of increasing the efficiency of using the underground and ground water in arid zones

Muradov Shuhrat Odilovich

The South regional scientific centre of the Academy of the sciences of Uzbekistan,
Karshi, Uzbekistan 108100
E-mail: m.oikos@rambler.ru

Abstract: The necessity of the use of subirrigation in arid zones is motivated on the base of experimental-theoretical researches. The principles of the calculation of the device was stated for regulating the drainage sewer. The way of the cascade building of the device was offered. The results of the research permit to raise water supply of the irrigated lands and to improve the hydro ecological conditions of the aeration zones..
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Introduction

At present the problem of rational nature use, including water use in arid regions is more complex, than it was several decades ago [29]. Today the lack of water resources seems to be greater in separate regions of Uzbekistan. In this connection of the main problem, standing before water farming organizations in nearest prospect, is an economy of irrigation water by using the water saving technologies. In meliorative regulating complex the special role must belong to the water reverse technology, which is one of the instruments of solving the main task of the land reclamations (according to V. R. Williams and A. N. Kostyakov) – reinforcing biological and decelerating the geological circulation of water and chemical materials [25]. One of the sources of economizing water resources is the use of subsoil water in favourable technical-economical basis for watering the plants, providing optimization of water-saline regime of the irrigated lands, reducing the degree of pollution of natural reservoirs of drainage water, as well as reducing water dams of natural water. The technology semi-water reversible meliorative cycle includes three stages: "irrigation-accumulation of subsoil water-moistening", is semi-reserved process that permits a part of sewer from big geological circulation to direct to a small biological circulation. Regulating the interdependence of the ground and underground water plays the defining role in supplying the favourable ecological situation on the irrigated lands. For this purpose, first of all, it is necessary to decrease or exclude infiltration feeding of the subsoil water, to create and support the determined correlation of moisture and heat in the soil [24].

1. Methods and object of the research

For increasing water stability, one of the reserves is drainage water. However its effective use controls the absence of the technical decisions on regulating drainage sewer in the open collector-drainage nets. In arid zones this problem hitherto has not practically found its scientific decision and broad application. The extent of the collector-drainage net, including the sewer of water, grows from year to year, so at present amounts of water reached such sizes that it is not only possible, but also necessary to use them in the industries of the economics, otherwise getting for limits of the system they pollute the ground water sources, the soil and subsoil water. The volume of the drainage sewer in the world on different estimations comprises 300 to 1000 kms^3 [18], but as a whole in Uzbekistan 20-23 kms^3, for 92-95% they are formed on irrigated lands [10].

The world experience water farming work and our perennial researches (1975-2010 years.) confirm that introducing the modernized ways of regulating the drainage sewer permit to control the subsoil waters promoting the application of subirrigation and hereupon to improve the hydro ecological conditions, water supply of the irrigated lands and mainly to reduce the geological intensity and to increase the biological circulation of water and materials. As I.P.Aydarov note that using the drainage and particularity pickling actions is bound to one more important circumstance, to which nobody paid attention in time, but which subsequently became the reason of the conflict between the USA and Mexico. The fact is that drainage has sharply increased the intensity of the geological circulation of the salts, but elimination of the mineralized drainage water in Colorado district has resulted in deterioration of the quality of the river water (quotation from the book by

V.A. Kovda, 2008, p.386). In 1970 N.N. Verigin and G.K.Aslanov also noted that it is reasonable to create the ascent of the level till the lower part of the root inhabited layer and to realize thereby the underground irrigated lands (the subirrigation) (quotation from the book by N.N. Verigin and others, 1979, p.33).

2. Results and discussion of the research

2.1 Motivation of subirrigation

In the arid zone of the system of the double regulation (the subirrigation) it is necessary to realize under fresh subsoil waters. Their level does not follow to lower [23]. On the contrary, under such conditions the lower process occurs, accompanying the accumulation of humus and improvement of the structure of the soil. The need for irrigation water in these cases falls in 1,5-2 times. The ttechnical-economic analysis has shown that at hydro carbonate type of pickling of the soil, without additional preventive measures, it is possible to use the subirrigation on the lands with mineralized subsoil water -1,5 g/l, but at sulphate -2,0 g/l [21]. By achieving the subsoil water in the meliorative territory and mineralizing 2-3 g/l it is reasonable to begin the reduction of the irrigation rates and numbers irrigation at the expense of subirrigation. In desalination of subsoil water till 3g/l in thick mass of water-bearing horizon 8-10m the subirrigation can comprise approximately 50-60% total water consumption for cotton plant, lucernes. The surface irrigation rates can be decreased herewith till 1-3 thousandm^3/hectare [16]. The separate researchers such as M.Ibrohimov, R.Ishchanov and H.Jabbarov (2006r.), S.Isayev (2007r.), B.Suvanov, ZH.Masharipov (2008r.) recommend to use subirrigation at mineralizing HW till 3r/l, but E.Koybakova (2002) till 7 g/l. According to the data of F.M.Rahimbayeva (1964), cotton may select the root till 45,5% from the rate of water consumption from subsoil water, located at the depth 1 m below the surface of the land, and at the levels of subsoil water 2 and 2,5 m, their contribution in water consumption decreases, accordingly, till 26,8 and 20,6%. At the average level of the subsoil water on sandy soil fields, over 1,4 m and 0,7 m, the magnitude of watering from subsoil water has comrpised 12-47% from water consumption practices [32]. According to the studies of S.Isaeva (2007) in Central Fergane, at the expense of irrigation the method of subirrigation, the productivity of cotton increased to 1,5-3 centner/hectare, the number of irrigation decreased to 1,5 and more times. The experiences in Kasbi region of Kashkadarian pool have defined the economy of irrigation rates which has formed 3150 m^3/hectare and increasing the productivity till 7 centner/hectare [13]. In Kharezm Province at weaksalted subsoil water the double regulation of subsoil water has allowed to reduce the irrigation rate till 1,2-1,5 times and raise the productivity of the cotton plant till 6-13 c/hec [7].

The studies on the perspective motivation of the subirrigation were noted by many scientists and specialists (B.S.Maslov, V.S.Stankevich, V.YA.Chernenok,1981; SH.O.Muradov and others, 1988; A.Saparov, F.Vyshpoliskiy, 2002; F.Vyshpoliskiy, H.Muhamedjanov, 2002; E.Koybakova,2002; A.Karimov, K.Mirzadjanov, S.Isaev, 2002; P.I.Pylenok, V.V.Borodychev, A.M. Saldaev, 2004; P.I.Pylenok, 2004; M.Ibrohimov, R.Eshchanov, H.Jabborov, 2006; G.Yuldashev, S.Zokirova, 2007; S.Isayev, 2007; B.Suvanov, ZH.Masharipov, 2008; V.A.Kovda, 2008; S.Isaev, T.Rajabov, 2008; B.Suvanov, 2009).

As I.Forkutsa, YU.Shirokova and R.Zommer note (2006) that it is necessary to treat more responsibly to control and regulate the level of subsoil waters. At the same time F.Karadji, V.Muhamedjanov, F.Vyshpoliskiy (2002) persuasively emphasize that using the retaining buildings will inevitably raise the water supply of the irrigated lands (particularly in years, containing little water) at the expense of increasing the expenditures of underground water on subirrigation. The studies of I.K.Duyunova (1978) in Chuysky valley have shown that at the depth of 0,8 m in subsoil water, the moisture of the soil forms (in respect of the volume) 34-36%, or 75-80% full of moisture power, normal growth of plants is supported (p.93). The expediency of the use of this direction is confirmed by the economic calculations. The cost of the capital investments will not reach to 50 dollars, working expenses- 8 dollars for one hectare. The flow management of the drainage-sewage water will not destroy the sequences of the execution of technological operations on cultivating agricultural practive, it will also reduce the amount of irrigation and the volume of the loss of water on physical evaporation [14]. As note A.Karimov, K. Mirzadjanov and S.Isayev (2002r.), drainage-sewage water present the significant volume in Central-Asian regions. On the one hand it is connected with significant areas of the irrigated lands, more than 7.0 mln hectares only in the pool of the Aral Sea, on the other hand, the inefficiency of the irrigation systems, as a result of which only 30-35% water, withdrawn from the sources disperses productive. Over 40% of water, withdrawn from the sources, participates in forming the drainage-sewage water. Considering the amounts of these waters, it is followed to acknowledge that the problem of the productive utilization of these sewers is more actual.

A.P.Aydarov and A.I.Golovanov also sagaceously confirm (2005): "Construction of collector-drainage systems, providing maintenance the level of subsoil water at necessary depth, simultaneously plays the negative role, since sharply

enlarges the intensity of the geological circulation and geochemical migration". Complementing this thought, A.Saparov and F.Vyshpoliskiy (2002) note that the parameters of the irrigation systems must provide not only for cleaning salts, but also accumulation organic mineral compounds in the soil, at the expense of reinforcement of the small biological circulation of materials.

This also demands a greater degree of the modernization of drainage nets. The analysis hydro ecological conditions of Uzbekistan has shown that on the irrigated lands of the republic it is possible to apply the subirrigation in Fergana valley, Samarkand, Kashkadarya and Surhandarya provinces. The researches were proved that most favorable circumstances for this possess the upper Natural-water farm regions (PVHR) in the south of Uzbekistan - a zone of fresh subsoil water.

The analysis of the chemical compound of the subsoil water (SW) of irrigated lands in regions have allowed to reveal the subsoil water all main hydrochemical types, among which predominating - sulphate. At the same time as shown by the analysis of the dynamics of the subsoil water regions, there exists parching the zone of aeration, water supply of these districts in the years of containing little water (1925, 1926, 1927, 1986, 2000, 2001) varies within 52-67%. The identical picture of the exhaustion of subsil water, reduction of their level exists in many countries of the world, first of all, in India, Libya, Saudi Arabia, the USA. reduction a level of subsoil water more than on 30 m on territory has occurred in the North China where over 100 mln. People live. It is determined that 10% of the world's wheat crops are produced with the use of the subsoil water[27].

2.2 Motivation to the needs of subirrigation in the south Uzbekistan

In the south of Uzbekistan (2010) mineralization of the collector-drainage water, according to the data of the regional hydrogeological-meliorative expedition (RHGME), in the upper regions of Kashkadarya pool varies in the following limit: Kitab district - 0,5-0,6 g/l; SHahrisabz - 0,6-0,7 g/l; Chirakchi - 2,0 - 2,2 g/l; Yakkabag - 3,0-4,0 g/l. The water supply of these regions is correspondingly equal to 55,68,61,57%. On Surkhan-Sherabad pool it comprises as followings: in the region of Denau - 0,42; Shurchi -1,09; Oltinsoy - 0,74; Kumkurgan -0,85 g/l. The water supply accordingly formed 82, 84, 89, 95%.

The analysis of the meliorative measures, promoting the decision of this problem, has shown that in the farm regions annually, for the purpose of increasing the water supply, install on drainage net from 30 before 50 earth dams (the jumper) for the head of the sewer and further water pumps on irrigation. In the upper regions of Surhan-Sherabad pool, according to the data of RHGME, thereby withdraw 114,88 mln. M^3 water on irrigation for 5893 hectares. These dams partition off the whole sewer, the level of the subsoil water increases, the process of heating and pickling of the land is activated, the zone of aeration decreases till the minimum.

Regarding the practical irrigation of the past years, fresh nature of the subsoil water and increasing sulphate salts in the subsoil water in the upper and the middle regions of the south of Uzbekistan, for the purpose of economizing water resources, regulations of water-air and water-saline regimes and improvement of hydro ecological conditions of the irrigated lands, we shall consider the necessary measures for applying the subirrigation by building the modernized construction for regulating drainage sewer in the mouth part of drainage, as well as with provision for relief, water-farming and meliorative hydrological conditions of the cascade of the buildings.

2.3 Motivation of the technical decision of the subirrigation

The suitable type of the drain may be called the self-regulating. The similar result is obtained if at the end of the open drain to set the threshold up with cut. Such buildings settle down on drainage lands. As K.V.Guber notes(2006), the term and first designs of the water-reverse drainage-moisturing systems are offered by I.V.Minayev in 1977r. The device for regulation of the drainage sewer and including regulative organ, differing from that for the purpose of ensuring the self-regulation of the sewer, total area of the cross-section decreases by the depth and is defined from the following:

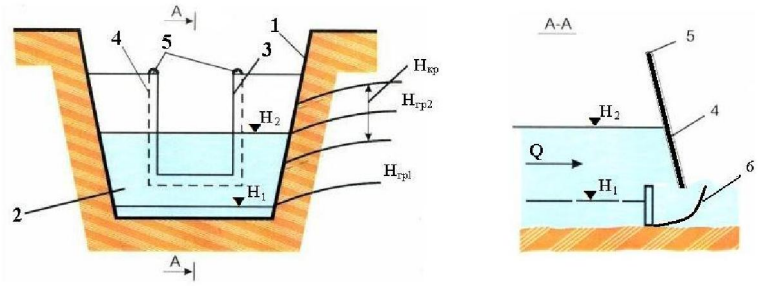
$$T = \frac{h}{\sqrt[8]{(Q\frac{n}{i})}} \quad (1)$$

here h-depth of filling the drain; Q-expense of water; n- roughness; i-gradient of the drain.

This device for regulation of drainage sewer (author's certificate 990952, 1491953,) is introduced (1990) on the collector of Akrabad in Kashkadarya pool. In the further studies this device was some modernized (author's certificate 1656053), which was shown in Picture 1.

The studies have shown that the device must be installed not in single, but in cascade order. Then economic effect of the building, connected with the phenomenon of subirrigation in the irrigated lands, increases with growing of the areas, in which occurs the ascent of the level of subsoil water. For quantitative estimation of the areas with subirrigation, the location

scheme of the device - "CASCADE" was suggested by us.



Picture 1. The calculating scheme of the modernized construction

Here: 1 – drain; 2- waste-gate (or threshold from plate or metal); 3-cut; 4-shield; 5-joints; 6-extinguisher of the sewer. Ngr1- level of subsoil water under free motion of water in drain; Ngr2-level of subsoil water at building the device; Nkr -an interval of the critical depth of bedding of subsoil water; R- hydro dynamical pressure; H1 - a level of water in the drain under free moving of the flow; H2 - a level of water in the drain at building of the device.

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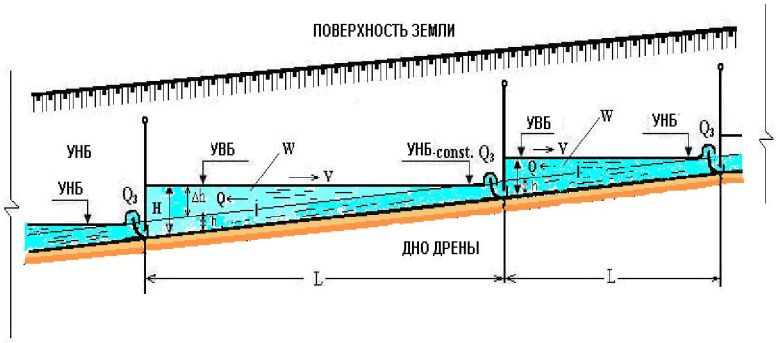
Considering insignificant levels of water under free motion (N;) as well as the experience of the separate researchers [2], we shall consider the construction of the cascade device for regulation of the drainage sewer at maximum distance from each other (Pic.2). The elaborated following formula is offered for calculating the maximal distance between the waste-gates:

$$L = \frac{H}{i} \qquad (2)$$

where i-gradient of water surface under free motion or the depth of of the drain.



Pic.2. The calculating scheme of the length of the head water under the cascade regulation of drainage sewer.

Δh – increase of water level on normal depth at the expense of the controlled building;

N – level of water in fold at building device; Ni - a level of water under free motion of the flow; L - a maximum length of the reach; V - velocity of the spreading waves; Q - an expense of water in drain; W - a regulated volume; UNB - a maximum level at the period of vegetation; Q3 - regulated expense;

Conclusions

The zone of the efficient buttress under sluice, is installed equal to 200m by the perennial studies of specialists about sandy ground with the coeficient of the filteration 13-17 m/day

As K.P.Pak (1975) notes that the reasons of pickling of the soil can be different, but the most important of them is reduction of the level of subsoil water (p.7). Summarizing that subirrigation prevents from salting which results in soda salting. It can be recommended for watering the winter wheat under weak-mineralized (less than 3g/l) subsoil water. Thereby it is possible to realize the control (management) underground, in particular, subsoil water.

And as a Swedish scientist [5] notes that by the word "management" it must be understood all measures on creating and maintenance of the system of the stable use of the subsoil water, both in qualitative, and in quantitative aspect. As Eric Eriksson and Sivert Yohansson (2000) note that finding out, using and controlling the subsoil water are constant processes, providing the needs of the present and future generations for water and correcting the mistakes of the past.

Resuming it is possible to note that subirrigation in arid regions of the world is not only necessary for improvement of hydroecological conditions, and increasing the water supply of agricultural practices, but also for water-bearing fulfilling the works.

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