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PROBLEMS OF HYDROMORPHIC SALINE HOLLOWS RECLAMATION STATE IMPROVEMENT AND THEIR SOLUTIONS

S.M. Mkrtchyan, S.N. Eroyan
Institute of Water Problems and Hydraulic Engineering after Academician I.V. Yeghiazarov

Solutions of hydromorphic saline hollows' problems are directly related to implementation of open circulation of salt-water balance of "irrigation – aeration zone-ground-drainage water" system. This is possible by management of drainage systems operation mode and correct calculation of parameters which will also enable to use a certain volume of drainage flow for irrigation purposes.

Key words. *hydromorphic, salinization, desalting, drainage, saline balance.*

Introduction

In tropical and subtropical mountain regions of streams waters accumulation and discharge are located hydromorphic hollows. Their formation is conditioned by flow of streams of surface and underground waters from regions where uppermost mountain ranges are fed and displaced from regions of middle elevation to lowland areas. The cause of that natural phenomena are atmospheric precipitations which finally are accumulated in intermountain hollows thus forming hydromorphic reclamation mode (waterbearing stratum of strong and weak pressures) [1-7].

Research results

The cause of the above phenomenon are atmospheric precipitations which eventually are accumulated in intermountain hollows forming hydromorphic reclamation regimes in strong artesian and some certain areas (like Ararat valley) as well as subartesian weak pressure aquifers [1-7]. Streams flowing along the downslope transport different chemical elements worn away from rock layers, which eventually turn into sulfate, chlorine and sodic salts in Ararat and many other hollows. Under these conditions three natural negative proccesses are becoming prevalent [2,3,6,8-11]:

- increasing the mineralization of underground water,
- formation of groundwater low depths according to earth's surface, creating hydromorphic reclamation condition,
- salinization of soil-ground aeration zone.

The mineralization of hydromorphic saline groundwater of hollows is exceeding the permissible levels (0,5-1g/l) , totaling from 1 to 8g/l and more. In Ararat Plain decreased from 8 -10g/l [2] and in 2014 does not exceed 3.5 g /l [1].

Ground water depths are ranging from 0-3-3,5m [1-7] which causes an intense surface evaporation at the expense of underground water resources.

The main reasons for hollow salinization are the high mineralization of groundwater and it's close distance from the earth surface, which is accompanied by intense evaporation - accumulating salts in the soil. The above mentioned negative natural processes are accompanied by deterioration of active soil layer reclamation state, and therefore not normal crop development (harvest fall).

An important circumstance is also the groundwater location small depths (0 to 3)m are located on not optimal close distances from crop root system. Therefore, subsoil irrigation takes place with impermissible high mineralization water. In other words, for normal development of crops, plants feeding with groundwater must be avoided.

From the aforesaid it follows, that for the improvement of hydromorphic saline hollows most important measures to be taken are the following:
- regulation of groundwater location,
-chemical reclamation (mainly for strong, and very strong soils),
- soil desalinization,
- to provide conditions for crops normal development.

Solution of the mentioned problems will allow to implement:
1) reduction of hydrodynamic pressure impact on the groundwater location,
2) neutralization of the basic reaction of sodic saline salts,
3) lowering of groundwater location,
4) creation of optimal depths for crops,
5) exception of subsoil irrigation, if the mineralization of groundwater is higher than the maximum permissible level,
6) prevent irrigation water secondary salinization from soil ,
7) procurement of irrigation water on the expense of groundwater, which will provide reduction of cost price and evaporation,

To raise soil fertility certain agricultural techniques and land reclamation measures (humus, organic matter, minerals, nutrients, etc.) will be needed.

Researchers of many countries (including Armenia) have tried to find solutions for the problems mentioned in the purpose of reclaiming sodic saline–alkaline soil, in case of plateau soil-hydrogeological different conditions [2-14], grouping this soils into two types:
- weak and medium salinized,
- strong and very strong salinized.

To chemical reclamation is subjected mainly the soils of second class [9-12].

Hydromorphic sodic saline soils are also located in Ararat plain which is surrounded by Ararat, Aragatsotn and Geghama mountain ranges. Problems related to underground water were included in work programs and analyzed by the Ministry of Water Economy of Armenia (1925-1948), then in Hydraulic Engineering and Land Reclamation (1949-1963) and in Water Problems and Hydro-engineering (from 1964 up to date) institutes [2-8, 13-15]. Application of vertical drainage in USSR territory was first implemented in Armenia - in Arazdayan steppe in 1930 (Kostiakov A.N., Agricultural Amelioration., M., Nauka, 1959).

Issues of Ararat hydromorphic hollow sodic saline salt chemical reclamation still in 1942-1957 period were included in work programs of the Soil Science Sector of the Academy of Sciences of Armenia , and from 1958 up till now in programs of the Research Institute of Soil Science, Agrochemistry and Land Reclamation of RA [10.11].

Ecological crises are unavoidable in hydromorphic hollows. To fight against these crises hydraulic facilities, such as drainage systems, have been constructed, which are able to change location of ground waters as needed, decrease the groundwater mineralization, create optimal defined by differences of groundwater (Hg) and pieszometric line (Hp) location, as shown in Figure 1.

$$(\Delta Hp)=Hg-Hp \qquad (1)$$

In conditions of Ararat hydromorphic plain the vertical and horizontal drains long-term operation experience confirms that in case of $\Delta Hp=5\text{-}20$ cm, the horizontal drainage operation is economically profitable, while in case of- $\Delta Hp> 20$ cm - the vertical is more profitable.

Open or closed horizontal drainage optimum depths are ranging from 3 to 3.5 m with the persuasion radius from 200m to 250 m, and the watershed depth is 3.5-4-4.5 m (by the example of the Ararat Valley). Electric pumps with 60-80 l/s performance of vertical drainage provides reduction of hydrodynamic pressure and groundwater location, in radius R = 500 -550m and 2.5 m average depth [2-6,13,14].

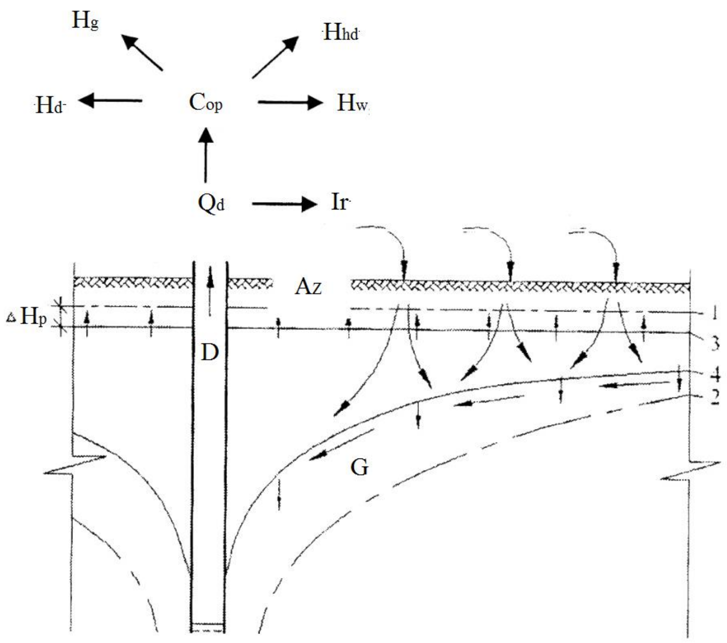

Figure 1. Components of drain water usage expressed in percentage norms
Ir- irrigation water; C_{op}- openness degree of the salt water balance; H_d- drain; H_g- desalination; H_{ag} - desalination of the zone; H_{hd} - taking into account hydrodynamic pressure; H_w- irrigation flow of washing regime; A_z- zone of aeration; G- ground water; D- drainage; ∆Hp - piezometric pressure, cm.

After regulation of groundwater location the implementation of chemical reclamation is becoming the priority task. Reclamation of sodic saline salts with sulfuric acid is accompanied by counteraction of basic and acidic factors, in the result of which the light-lilac water vapor rises from water and soil surfaces is visible to the naked eye. Therefore, the chemical reclamation is accompanied by causing an undesirable ecological environment. However, chemical reclamation is a compulsory necessity for neutralization of some basic and physical-and-chemical reactions. Thus, during chemical reclamation by sulfuric acid the following counteractions take place [10, 11]:

$$2Na_2CO_3 + H_2SO_4 = Na_2SO_4 + 2NaHCO_3,$$

then,

$$2NaHCO3 + H2SO4 = Na2SO4 + H2O + CO2 \quad (2)$$

and in case of using $FeSO_4$, due to hydrolysis free sulfuric acid and iron hydroxide are obtained.

$$FeSO_4 + H_2O = H_2SO_4 + Fe(OH)_2. \quad (3)$$

The basic reaction in a soil substrate is neutralized due to the chemical influence between suiphuric acid and sodium, calcium and magnesium carbonates and bicarbonates of sulphuric acid. Due to these processes water soluble salts appear, which by thorough wash out are transported into much deeper layers of the ground [4,5,10,11]. This process is accompanied by reduction of hydrodynamic pressure and upward transportation of underground water, removing with it the natural salts formed from the soil and the ameliorant. Therefore, it is necessary to carry out desalting of the deeper layers to avoid a further secondary salinization. (Figures 1 and 2) [4, 5, 8,13,15].

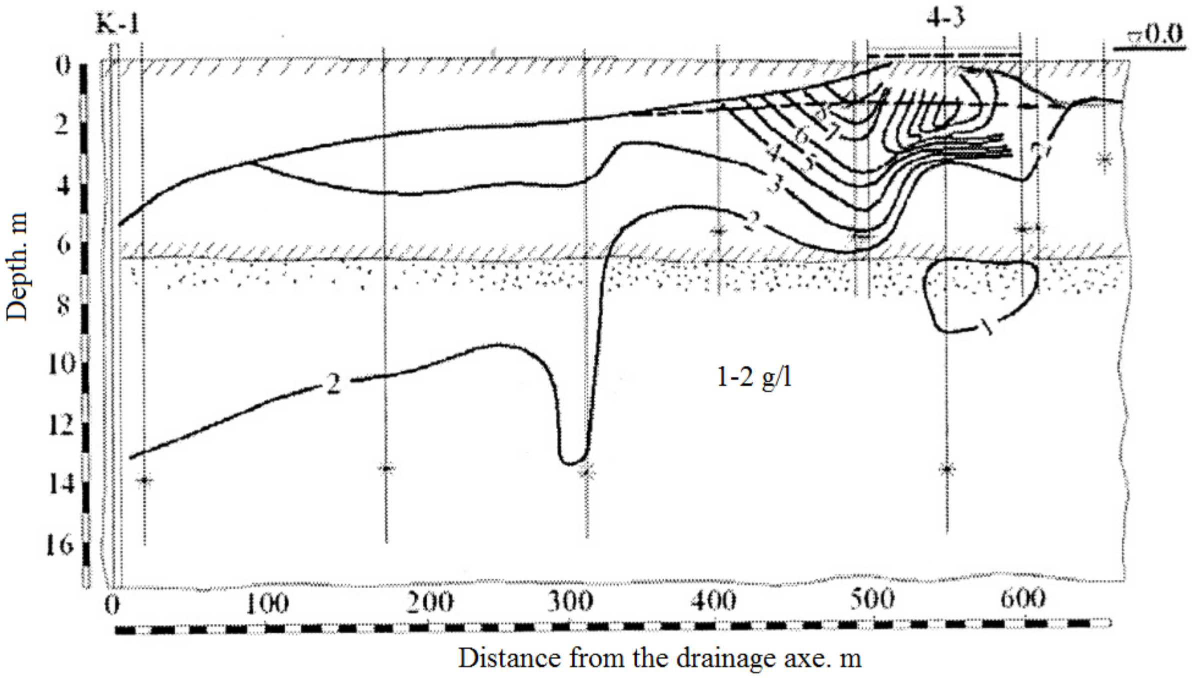

Figure 2. Isolines of groundwater mineralization according to the depth 3 during the oxidation process

Chemical reclamation experience of Ararat valley saline soil (with 0,8-1,2% sulfuric acid solution or with Fe_2SO_4) confirms that the portions of natural salts (from 0,2 to 0,7 percent) in the 0-1 m layer of the ground – increase by around 7 -10 times. It is conditioned by the acid volume (from 40-50 to 80-120 t/ha in case of 80-90 percent H_2SO_4) [4,8,10,11]. The current situation necessitates to implement thorough washing with irrigation water, the inevitable consequence of which becomes rising of groundwater level up to 0,3-0,5 m according to the ground surface. As a result to 2-3 week's intensive work of drainage, the artificial ,,pads" of 12-15 g/l mineralization are formed on the free surface of groundwater, (which is a result of a chemical ameliorant) and due to the intensive washing become smaller to 3-5 g/l. Desalination role of drainage is obvious: the initial mineralization of drainage are also reduced from 5-7 g/l to 1,5-1,8 g/l [4,5,8,13,15].With the aid of thorough washing in the first year of vertical drainage (Q d = 40-60 l / s capacity) removes from 3 to 2,5 thousand tons of salt, and in the next 2-3 years from 1 to 0,5 and after , 4-5 years 1-0,5, 0,5-0,2 thousand tones (Fig. 2,[4,13]).

It is obvious, that the upper layers of ground are being desalted, but its deeper masses and ground water detain impermissible quantities of salts for much longer period of time. A question arises ,,what kind of measures are important to be taken to desalinate the aeration zone and groundwater?''. This is a problem, and its solution requires regulation of drainage flow of water systems by correct choice of their work regime. Therefore, the issue of drain water regulation should include the saline balance in the region and all the processes of implementation.

Results of long-term investigations of Ararat hydromorphic salinized hollows allowed to draw an equation of drainage (Q_d) (Figure 1 [8]).

$$Q_d = Ir + Cop = Ir + H_d + H_g + H_{hd} + H_w, \qquad (4)$$

where Ir-is the irrigation water, Cop- «irrigation – (Ir) - aeration zone (A_z) - ground water (Gw) – drainage (Dr)» (W-A_z-G-D) the openness portion of system water-salt balance, Hd - drain norm [9], Hg-groundwater desalination norm, H_{hd} - hydrodynamic pressure norm, H_{iw}-irrigation washing regime norm.

Values of salt water budget equation (4) components of irrigation water-aeration zone-ground-drainage by the example of Ararat plain non-saline and weak and medium saline soils are tabulated below [8]. These data can also be used in case of ground subjected to chemical land reclamation and thorough wash up as non-saline.

Table 1

Portions of factors characterizing Ararat hydromorphic hollow soil-hydrogeological conditions

Soil- hydrogeological factors	Portions by soil type non saline soil	Weak and medium saline
Drain norm, according to the irrigation intake volume, Hd,%	5-6,4	22,4-26,2
Groundwater desalination norm, Hg, %	5,2-6,4	18,9-23,1
Removal norm of salts obtained from the hydrodynamic pressure, H_{hd}, %	(0,01-0,02)Qd	(0,02-0,05)Qd
Washing regime norm of irrigation, Hiw, %	-	1,25 M [1)]
Openness of salt-water balance, Cop, %	10,2-12,8	41,3 +49,4+0,25M
Irrigation water, I, %	89,8 – 87,2	(~58,7-50,6)-0,25M

1) M – Irrigation norm in non-saline soils.

Lowering of groundwater location through drainage systems of hydromorphic hollows is not the final solution to the problem, as for different crops groups (short, medium and long-root) it is necessary to have different depths [4,6]. In other words, for each group it is necessary to provide optimal groundwater depth, in which case we will have a stable and high yield.

By the results of Ararat Valley (1962-1989) and Gegharkunik Region (2005-2007) surveys have been developed optimal depths for different groups of crops(Hop), conditioned with their full root system(h_f) and aeration zone capillary water rim zone height from the groundwater [14].

$$Hop=1,1h_f+Kh_r \tag{2}$$

where, K - coefficient of capillary water rim, in the case of 1,2,3-short, medium, long root crops respectively (Table 2).

Table 2

Ground water location shall optimal depths for different groups of crops (medium and heavy, light and medium clay)

Crop group according to root length	Total length of root system, h_L, m	Coefficient of capillary water rim, K	Groundwater location length from hw, Kh_r, m	Optimal depth of ground water location, Hop, m
Short	0,5-0,6	1	0,40-0,45	0,95-1,05
Medium	0,6-0,9	2	0,80-0,90	1,6-1,80
Long	0,9-1,2	3	1,2-1,35	2,20-2,60

The results of long-term field surveys carried out in (Table 1 and 2) confirm that due to intensive drainage system activity it is possible to solve a number of problems related to hydromorphic saline hollow reclamation improvement, and usage of certain volume of drain water as well (equation, Table 1). The usage portions of water is conditioned by the degree of mineralization.

Conclusion

The main issue in improving reclamation conditions of a hydromorphic saline hollow is to regulate the ground water location depths. To solve this problem a compulsive necessity through drain flow to implement openness of "irrigation – aeration zone- groundwater and drainage water" system water-salt balance of circulation. The intensive activity of the system allowsto regulate groundwater location, preventing soil secondary salinization, providing aeration zone desalinization, normal development of crops, decreasing of groundwater mineralization and usage of certain volume of drainage for irrigation as well.

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ՀԻԴՐՈՄՈՐՖ ԱՂԱԿԱԼՎԱԾ ԳՈԳԱՀՈՎԻՏՆԵՐԻ ՄԵԼԻՈՐԱՏԻՎ ՎԻՃԱԿԻ ԲԱՐԵԼԱՎՄԱՆ ԽՆԴԻՐՆԵՐԸ ԵՎ ԼՈՒԾՈՒՄՆԵՐԸ

Ս.Մ.Մկրտչյան, Ս.Ն.Երոյան

Ակադեմիկոս Ի.Վ. Եղիազարովի անվան ջրային հիմնահարցերի և հիդրոտեխնիկայի ինստիտուտ

Հիդրոմորֆ աղակալված գոգահովիտների խնդիրների լուծումներն ուղղակիորեն առնչվում են «ոռոգման-աերացիայի գոտու-գրունտային-դրենաժային ջրեր» համակարգի աղաջրային հաշվեկշռի ոչ փակ շրջապտույտի իրականացմանը:

Դա հնարավոր է դրենաժային համակարգի աշխատանքի ռեժիմի կառավարման և պարամետրերի ճիշտ հաշվարկների միջոցով, որոնք թույլ կտան նաև դրենահոսքի որոշակի ծավալի օգտագործում ոռոգման նպատակով:

Բանալի բառեր. Հիդրոմորֆ, աղակալում, աղազերծում, դրենաժ, աղաջրային հաշվեկշիռ:

ЗАДАЧИ УЛУЧШЕНИЯ МЕЛИОРАТИВНОГО СОСТОЯНИЯ ЗАСОЛЕННЫХ ГИДРОМОРНЫХ КОТЛОВИН И ИХ РЕШЕНИЯ

С.М. Мкртчян, С.Н. Ероян
Институт водных проблем и гидротехники им.Академика И.В. Егиазарова

Решение задач засоленных гидриморфных котловин связывается непосредственно с осуществлением незамкнутого цикла водно-солевого баланса системы «оросительные-зоны аерации грунтовые-дренажные воды». Это возможно путем управления режимом работы дренажных систем и правильного определения параметров дренажа, что также предоставит возможность использовать определенный обьем дренажного стока с целью орошения.

Ключевые слова: гидроморфный, засоление, рассоление, дренаж, водно-солевой баланс.