Volume 3, Issue 3, March - 2025
ISSN (E): 2938-3781

Web of Agriculture: Journal of Agriculture and Biological Sciences
webofjournals.com/index.php/8

MODELS OF THE MIGRATION PROCESS OF FORMATION OF DRAINAGE WATER MINERALIZATION

Khudaykulov S. I.
Abdullaev B. Kh.
Odiljonov O. M.
O. G‘. G‘ulomov
B. S. Tuxliyev
G‘. Omonov
N. Xalilov
N. Saidova

Abstract
The article presents a calculation scheme of meliorative drainage with an uneven field of filtration rates in the cover layer. Various intensities of settlement and the influence on the formation of mineralization of drainage waters are studied. Theoretical and experimental studies of the field of filtration rates during desalination of gray soils of the arid zone, part of the Fergana Valley zone, where 3 zones with a characteristic range of filtration rates can be distinguished in the cover layer, are analyzed. The boundaries of the filtration rate zones are given.

Introduction

Statement of the question. The migration process of drainage waters and their use in irrigation is an urgent task for the whole world. Therefore, the study of the patterns of the migration process of the formation of drainage water mineralization allows us to note some features of the urgent task. First of all, it seems possible to distinguish three main periods in the formation of the "output" curve: an increase in mineralization, a period of relative stabilization, and a subsequent decrease. They reflect a non-stationary migration process. The duration of characteristic periods is determined by the structural features of the migration area and the operating mode of the systems. The task of predictive assessment of mineralization of waters discharged by vertical drainage, as applied to the conditions of the arid zone, is especially relevant. The peculiarity of the considered task is that the lower layer is desalinated under the influence of the filtration flow from the cover layer. Depending on the type of drainage used - melioration or preventive - the process of formation of mineralization of drainage waters will be different.

Volume 3, Issue 3, March - 2025
ISSN (E): 2938-3781

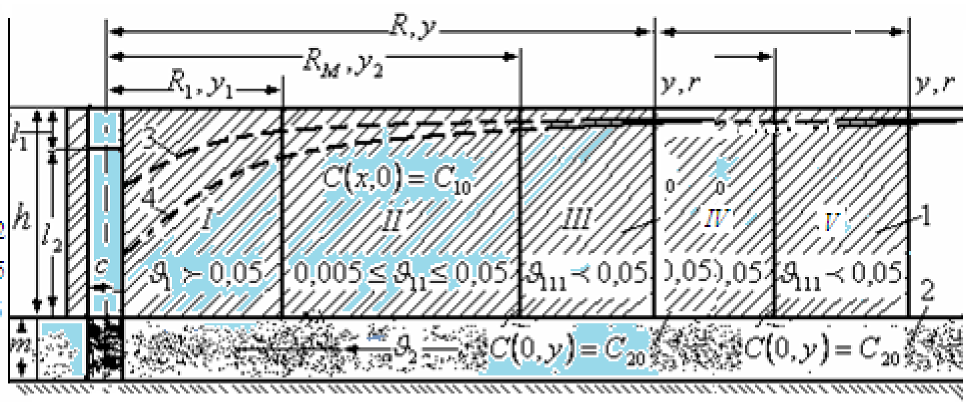

Fig. 1. Scheme of dynamics of groundwater mineralization stabilization. Fergana valley. 1-clay; 2-sand, groundwater level, 4 piezometric level, l and m are depth of cover layer and the aquifer

A distinctive feature of the calculation scheme for meliorative drainage (with flushing and flushing irrigation mode) is the unevenness of the filtration velocity field in the cover layer (Fig. 1), which predetermines different intensities of settlement and affects the formation of mineralization of drainage waters. Theoretical and experimental studies of the filtration velocity field during desalination of gray soils in the arid zone, part of the Fergana Valley zone, make it possible to distinguish 3 zones in the cover layer with a characteristic range of filtration rates:

I zone $\vartheta_1 \succ 0.05$ m/day (convective transfer of salts predominates);

II zone $0.005\vartheta_{11} \le 0.05$ m/day (convective transfer of salts and convective diffusion processes are comparable);

III zone $\vartheta_{111} \prec 0.005$ m/day (convective diffusion processes predominate).

Unlike the works of the above-mentioned authors, this work presents a more extensive study, the purpose of which is to identify in the cover layer 5 zones with a characteristic range of filtration rates, which we will designate as stabilization zones:

For an approximate predictive assessment of the dynamics of mineralization of drainage runoff, the following Soifer relationship can be used:

$$C_2(t)=C_{20}+C_{10}\bar{\varpi}_1\bar{t}_1\exp\left(-\frac{\vartheta_1 t}{n_э L}\right)+C_{10}\bar{\varpi}_{11}\bar{t}_{11}\exp\left(-\frac{0.1\vartheta_{11}h\bar{t}_{11}}{D}\right), \quad (1)$$

Where $C_2(t)$ – concentration of mineralization of drainage waters, g/l; C_{10}, C_{20} - initial mineralization of groundwater in the cover layer and formation, g/l; $\bar{\varpi}_1, \bar{\varpi}_{11}$ – the ratio of the cross-sectional area I and II zones, respectively, to the area of hydrodynamic influence of the well; $n_э$ – effective porosity;

D– convective diffusion coefficient, m2/day; and*h*– thickness of the cover layer, m; $\vartheta_1, \vartheta_{11}$ – filtration rate in zones I and II, m/day;

$$t_1 = \frac{t}{t_k}, t_k = 7n_э \frac{h}{\vartheta_1}, t_{11} = \frac{t}{t_c}; t_c = t_1 + 2t_2 + 2\sqrt{t_1 t_2 + t_2^2}, t_1 = \frac{h}{\vartheta_{11}}, t_2 = \frac{4D}{\vartheta_{11}^2},$$

Where $t_к, t_c$ – the duration of desalination of the cover deposits of zones I and II (to a value of approximately $0.1 - 0.2\, C_{10}$).

Dependence (1) can be used for an approximate assessment of the duration of the formation of characteristic periods, for example, the period of occurrence of the maximum value of the concentration of drainage waters for assessing the possibility of using them for irrigation. This dependence does not take into account the unevenness of the initial salinization, the heterogeneity of the structure of the environment, which affect the formation of mineralization of drainage waters in the initial period.

It is advisable to develop further studies of the dynamics of drainage water mineralization in three main directions:

– setting up long-term field experiments and observations at operating facilities;

– schematization of natural conditions and construction of calculation schemes;

– theoretical studies of salt transfer and substantiation of the mathematical model.

Let us consider the dynamics of the regularity of the migration process of formation of mineralization of drainage waters in the model of movement of a dispersed mixture in a fractured-porous medium consisting of porous blocks separated by cracks during operation of an imperfect well in a heterogeneous formation. The dispersed mixture consists of a mineralized liquid medium, the density of which is equal to $\rho_{см} = \rho_1 + \rho_2$, Where ρ_1 – the reduced density of water, equal to $\rho_1 = \rho_{1i} f_1$; ρ_2 – the density of the mineralized environment, equal to $\rho_2 = \rho_{2i} f_2$ [1].

Here ρ_{1i}, ρ_{2i} – true densities; f_1, f_2 – volumetric concentrations of water and mineralized environment.

It is assumed that the volume concentrations of water and mineralized medium are constant during the movement of both phases and phase transformations are absent. The cracks are uniform, and during the migration of the mixture there are no deformations, formation, or development of new cracks.

The layer is horizontal, of infinite length and finite thickness. h. The roof and base of the formation are impermeable. The formation is cut by a well with a radius c ,which is permeable not along its entire length, but in the interval $l = l_2 - l_1 \prec h$. The space around the well is mineralized and a cylindrical bottomhole zone of radius R is formed (see Fig. 1), the permeability of which is lower than in the rest of the formation. Putting $\beta_{j0} = \beta_{cj} + m_j \beta$, Where β_{cj} – coefficient of compressibility of layers; m_j – porosity of layers; β_{j0} – the compressibility coefficient of a mixture of mineralized liquid; the coefficient of piezoconductivity with the dimension $[\chi_j] = \frac{м^2}{c}$, equal $\chi_j = \frac{k_j}{\mu \beta_{j0}}$, and $j = 1$corresponds to the bottomhole zone; $j = 2$ – the outer part of the layer; k_j – permeability of cracks. The movement occurs axisymmetrically in two environments and is described by equations in cylindrical coordinates [2,3]:

$$\frac{\partial p_j}{\partial t} - \eta_j \frac{\partial \Delta p_j}{\partial t} = \chi_j \Delta p_j,\ (j = 1,2), \tag{2}$$

Where η_j – characteristics of the fractured porous medium, in m2; p_j – liquid pressure in the blocks.

$$\Delta p = \frac{\partial^2 p}{\partial r^2} + \frac{1}{r}\frac{\partial p}{\partial r} + \frac{\partial^2 p}{\partial z^2}.$$

Before the well starts operating, the pressure in the entire formation is constant and equal p_0 . The well operates at a flow rate Q Q. The initial and boundary conditions are as follows: $p_j = p_0 + qP_j$, Where $q = Q\mu_{см}/2\pi dk$; $\mu_{см}$ – dynamic viscosity of mineralized liquid; $\mu_{см} = \nu_{см}\rho_{см}$; , $\nu_{см}$ – kinematic viscosity of mineralized liquid; $\rho_{см}\bar{V}_{см} = \rho_1\bar{V}_1 + \rho_2\bar{V}_2$; $\bar{V}_1, \bar{V}_2$ – velocity vectors of each phase of the mixture, salt and water.

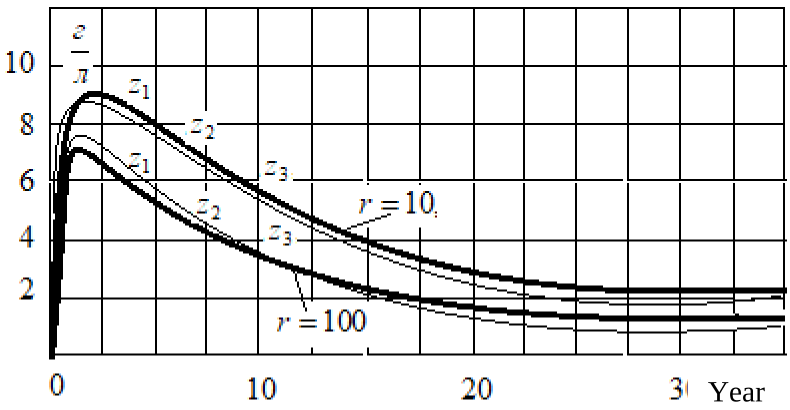

Fig. 3. Mineralization distribution graph

In the initial period of salt migration, the concentration does not change, the pressure is constant and for the function P_j , which determines the change in mineralization of the mixture, equations (2) retain their form. Then the initial conditions become zero:

$$\left.\frac{\partial P_j}{\partial z}\right|_{\substack{z=0\\ z=h}} = 0,\quad P_2(\infty, z, t) = 0. \tag{3}$$

The heterogeneity of the structure of the environment affects the formation of mineralization of drainage waters and during the period of the onset of the maximum value of the concentration of drainage waters increases, while the function P_j , which determines the formation of mineralization of the mixture, has the following boundary values:

Volume 3, Issue 3, March - 2025
ISSN (E): 2938-3781

$$\left(r\frac{\partial P_1}{\partial z}\right)=\begin{cases}\left[1-\exp\left(-\frac{\chi_1}{\eta_1}\right)\right](z\in[l_1,l_2]);\\ 0 \qquad (z\notin[l_1,l_2]).\end{cases} \tag{4}$$

During the period of the onset of the maximum value, the formation of mineralization of the mixture of drainage waters increases and at the boundary of zone II, equalities in the formation of mineralization of the mixture for both layers and equality of flows are fulfilled [4]:

$$P_1(R,z,t)=P_2(R,z,t),$$

$$\left(\frac{k_1}{\mu}\frac{\partial P_1}{\partial r}+\eta_1\beta_{10}\frac{\partial^2 P_1}{\partial t\partial r}\right)_{r=R-0}=\left(\frac{k_2}{\varpi}\frac{\partial P_2}{\partial r}+\eta_2\beta_{20}\frac{\partial^2 P_2}{\partial t\partial r}\right)_{r=R+0}. \tag{5}$$

To the functions of changes in the mineralization of the mixture $P_j(r,z,t)$ apply the Laplace transform to the variable t . Then, as in works [1,3], for the image function $f_j(r,z,t)$ formation of mineralization of the mixture we obtain the equation

$$\Delta f_j-\frac{s}{\chi_j+\eta_j s}f_j=0 \tag{6}$$

with borderscondition, as in work [3]. The resulting equation allows for the separation of variable functions of the mixture mineralization images, for which we set

$$f_j(r,z,s)=Z_j(z)R_j(r,s).$$

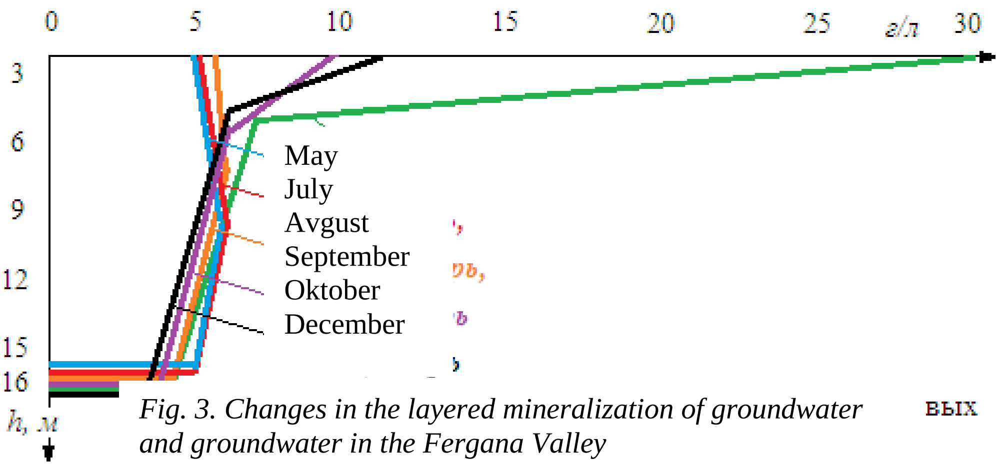

Fig. 3. Changes in the layered mineralization of groundwater and groundwater in the Fergana Valley

Then equations (2) and boundary conditions (4) yield the following two equations. The differential equation for vertical changes in mineralization Zj(z):

Web of Agriculture: Journal of Agriculture and Biological Sciences
webofjournals.com/index.php/8

$$\frac{d^2 Z_j}{\partial z^2}+\lambda^2 Z_j=0\,,\ \frac{dZ_j}{\partial z}\bigg|_{\substack{z=0\\z=h}}=0\ (j=1,2); \qquad (7)$$

differential equation for the radius of action of mineralization Rj(r, s):

$$\frac{d^2 R_j}{\partial r^2}+\frac{1}{r}\frac{dR_j}{dr}-\left(\frac{s}{\chi_j+\eta_j s}+\lambda^2\right)R_j=0\,,(j=1,2), \qquad (8)$$

$$R_2(\infty,0)=0\,.$$

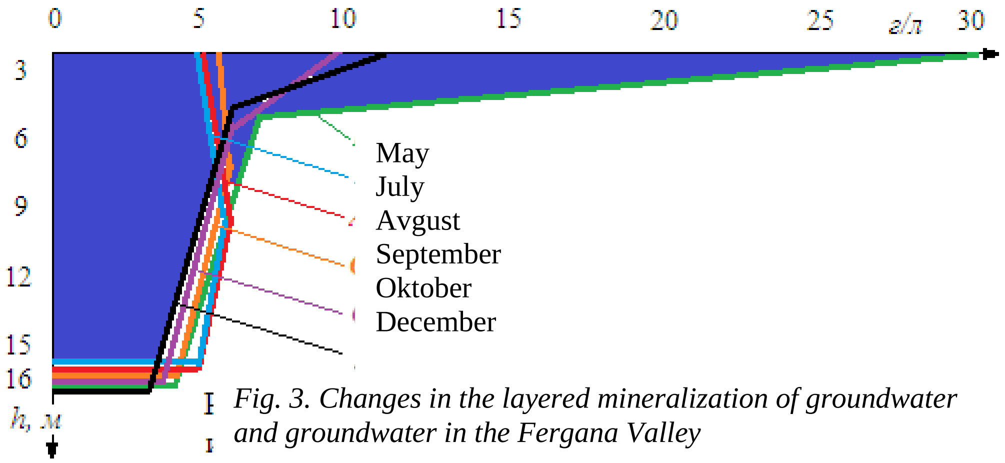

Fig. 3. Changes in the layered mineralization of groundwater and groundwater in the Fergana Valley

As is known from works [2, 3], differential equation (7) has eigenfunctions

$$Z_{jn}=C_{jn}\cos\lambda_n z\,,$$

Where $\lambda_n = n\pi/h$ – eigenvalues, and the corresponding eigenfunctions, the problems (8) of which we take for the radius of action of the filtration flow with salt, have the form [5]

$$R_{1n}=A_{1n}I_0(r\nu_n)+B_{1n}K_0(r\nu_n),\ R_{2n}=B_{2n}K_0(r\delta_n),$$

Where $\nu_n^2=\frac{s}{\chi_1+\eta_1 s}+\lambda_n^2\,;\ \delta_n^2=\frac{s}{\chi_2+\eta_2 s}+\lambda_n^2\,;\ I_m$ And K_m - McDonald functions m -goorder.
Definitions of constants A_{1n}, B_{1n}, C_{1n} is carried out as in works [3,5]. Then we obtain the solution to the problem (2), (3) – (8) of mineralization distribution in filtered water. Fig. 2 shows the graphs of mineralization formation of drainage waters for the case $c=0$ at $Q=500\frac{см^3}{сек}\,;h=12м\,;l=6м$
.

Volume 3, Issue 3, March - 2025
ISSN (E): 2938-3781

Conclusions

1. The curves show the distribution of salts depending on time and distance from the well. $r = 10м$ And $r = 100м$ at levels $z_1 = 0$, $z_2 = 3м$, $z_3 = 6м$ Fig.2.

2. The most unfavourable melioration situation is formed in zone III, characterized by an unstable salt regime and the manifestation of secondary salinization processes under a hydromorphic regime.

3. Analysis of the filtration velocity field at the drainage design stage will allow, in each specific case, to outline the optimal operating mode of the system in order to exclude the formation of zone III.

REFERENCES

1. Veksler A.V. Basic equations of a one-dimensional channel suspension-carrying flow // Siltation of reservoirs and its control. Moscow: Kolos, 1970. – 156 p.
2. Voynich-Syanozhentsky T.G., Lomtatidze V.G., Tavartkiladze N.E. On the turbulent flow of a two-phase water-air stream with variable flow rate along the path // Izvestiya TNISGEI. 1960. No. 12 (46). P. 134 – 138.
3. Kiselev P.G. Movement of fluid with variable mass // Questions of hydraulic engineering. Collection of works of MISI. 1955. No. 5. P. 43 – 55.
4. Knoroz B.S. Gravity hydraulic transport and its calculation // Izvestiya VNIIG. 1951. Pp. 56 – 61.
5. Khamidov A.A., Khudaykulov S.I. Theory of jets of multiphase viscous liquid. Tashkent: Fan, 2003. – 140 p.