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Satbayev University

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ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Satbayev University

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IMPROVEMENT OF ENVIRONMENTALLY SAFE RINSING OF SALTED LANDS TECHNOLOGY

Abstract. The theoretical justification of the environmentally friendly saline leaching technology is based on a model of the evolutionary hydrogeochemical process of the natural system, which describes mass transfer in sedimentary formations during geological time, where it occurs via the molecular diffusion mechanism through the aqueous phase, namely, a portion of the dissolved salts is removed from the soil layer proportional to the amount of their solid phase enclosed within this layer.

To implement the developed flushing method, saline soil flushing technologies are proposed in practice, where the water supply to the check with a furrow is regulated by feeding it to the checks in pressure mode until it is completely moistened, and then the water supply is reduced to work in a non-pressure mode, i.e. water flow rate the check is reduced until it is equal to the filtration coefficient of the soil.

Moreover, the developed technology for washing saline soils based on the «soft» control of the hydrogeochemical process, which is based on the concept of the laws of natural evolutionary soil processes in the interpretation described above: the soil as an open system has stability, self-regulation and is in translational dynamic equilibrium.

To implement in practice the developed methods and technology for flushing saline lands, the proposed methodology for determining the parameters of flushing technology with irrigation technique using furrows from two opposite outlet furrows of row crops, which allow to determine the irrigation time and predict the regime of soil moisture with high reliability and reliability.

Key words: soil, salinization, rinsing, leaching, management, waste-free, safe, technology, process, soil formation, intensity, water permeability.

Introduction. Washings of saline lands cause global disturbances in the natural balances of the flows of substances and energy, significantly redistribute surface and underground drains, involving centuries-old reserves of readily soluble soil salts in the modern geological cycle. Therefore, at present, there are different approaches to determining the rinsing standards and the rinsing technology for saline lands, which leach salts to the toxicity threshold for crops using experimental results and theoretical developments on the basis of applying the achievement of fundamental sciences to solve the problem of land reclamation.

The principles for substantiating the conditions for washing saline lands are built on two essentially different positions: empirical, based on a generalization of a large amount of factual material from experimental studies, and theoretical, based on the use of the law of physicochemical processes based on the theory of salt transfer and salt exchange in a natural system. To a large extent, this situation is due to the fact that salinization and desalinization of irrigated lands are a multifactorial process, the theoretical description of which is still far from perfect. At the same time, an understanding of these processes, precisely because of their multifactorial nature, can be achieved only on the basis of theoretical concepts based on the principles of exact sciences and taking fully into account environmental conditions. Therefore, the main attention in the study of salt transfer during leaching is given to substantiating the theoretical positions of the analysis of the processes occurring in this process, striving to identify the role of various factors.

As an example, to assess the environmental safety of flushing saline lands on the basis of the law of nature, in order to reduce the risk of environmentally undesirable consequences and to establish the direction and intensity of the natural process, a modeling method is used, which is currently important from both theoretical and practical points of view. Therefore, when developing a "model" of saline soil leaching, it is necessary to verify the correctness and accuracy of the formulation of the task and determine their reliability to solve the problems posed by leaching saline soils.

Purpose of the study – based on the laws of nature and natural hydrogeochemical processes, to develop methods and technologies for ecologically safe rinsing of saline lands and its methodological supports, ensuring the construction of highly productive hydro-landscape systems.

Materials and research methods. The theoretical basis for the environmentally sound saline leaching technology is based on a model of the evolutionary hydrogeochemical process of the natural system, which describes mass transfer in sedimentary formations over geological time and occurs by the mechanism of molecular diffusion through the aqueous phase, i.e. $dS = -\alpha \cdot S \cdot dg$, namely, with a certain portion of infiltrating water (dg), a part of the dissolved salts (dS)proportional to the amount of their solid phase enclosed within this layer (where is the salinity coefficient): $S_i = S \cdot \exp(-\alpha \cdot g)$ [1]

In carrying out leaching of saline soils, the technical effect tends to turn into permanent and increasingly intensifying, up to the complete replacement of the self-regulation of natural systems by technogenic regulation. These natural processes occur under conditions: inconsistencies in the intensity of water supply during leaching of saline soils (V_t^n): $V_t^n = N/t$, with the intensity of absorption of water into the soil ($V_t^в$): $V_t^в = (V_O - K_ф) \cdot exp(-K_в \cdot t) - K_ф$, i.e. $V_t^n >> V_t^в$, and in the time scale will constantly increase (where N – estimated rinsing rate; t - rinsing duration; $K_ф$- filtration coefficient; V_O- absorption rate at the end of the first hour; $K_в$ - proportionality coefficient, which depends on soil properties) [2].

Therefore, from an ecological point of view, saline soils must be washed on the basis of "soft" management of natural systems. Unlike "hard" management, "soft" management is based on improving the former natural productivity of ecological systems or increasing soil fertility through a focused and based on the use of objective laws of Nature [3].

Research results. Based on the laws of nature and natural hydrogeochemical processes, a method for washing saline soils has been developed, including the preparation of temporary irrigation and drainage networks and checks, deep reclamation loosening of soils across the drains with alternating loosened and not loosened strips of the same width, followed by the flow of water into the checks in pressure mode to complete humidification, and then the water supply to work in a non-pressure mode, characterized in that temporary irrigation networks from the opposite side are cut in checks with zero marks the check and the furrow with a depression in the direction of the center of the check, while the flushing rate is supplied with the help of the furrow at the same time with oncoming jets at the same flow rate until they collide with each other in the center of the check, with the subsequent alignment of the water layer in the furrow along the water supply front (figure 1) [4].

To implement the developed flushing method, saline soil flushing technologies are proposed in practice, where the water supply to the check with a furrow is regulated by feeding it to the checks in pressure mode until it is completely moistened, and then the water supply is reduced to work in a non-pressure mode, i.e. water flow rate the check is reduced until it is equal to the filtration coefficient of the soil [5].

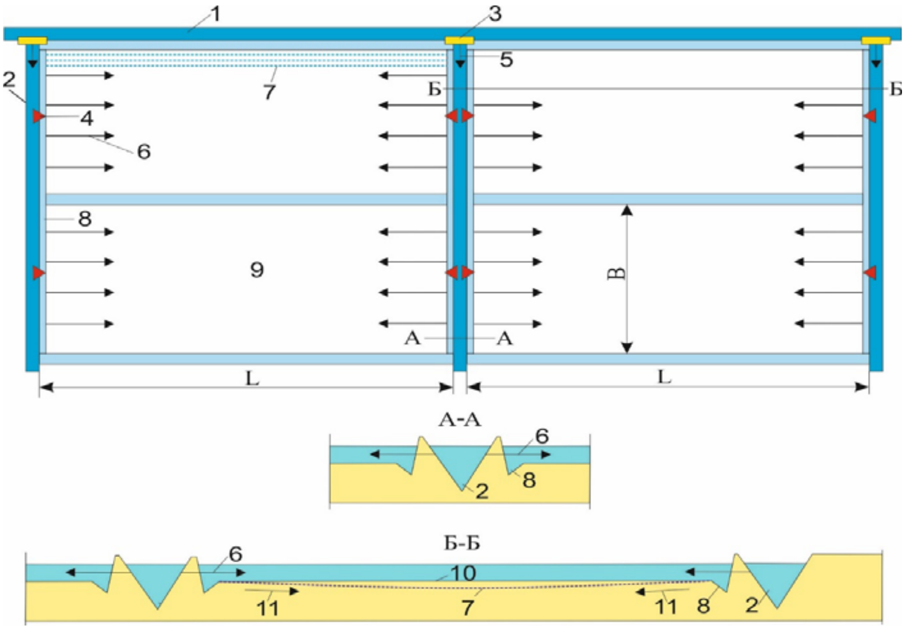

Figure 1 – Technological scheme of washing the soil layer of saline lands (1- distribution channel; 2- temporary irrigation; 3- water outlet in the distribution channel; 4- water outlet in the temporary irrigation; 5- direction of water flow in temporary irrigators; 6- direction of irrigation along the furrows ; 7- irrigation furrows; 8- output furrows; 9 –washed (watered) check; 10- land surface in watered checks; 11- direction of the slope of the bottom of the furrow)

The length of the washed check (L) depending on the horizontal slope of the earth's surface, is taken within 100-200 meters, and the width of the check (B) is determined taking into account the distances between rows of crops ($b_б$), cultivated after washing: $B = b_б \cdot n_б$ (where $n_б$ – the number of planned irrigation furrows along the width of the check), then the area of the washed check (F_a) will be equal: $F_a = B \cdot L$.

The horizontal slope of the bottom of the furrow is directed to the middle of the washed check and the depth of the cut furrow at the beginning of the furrow should be 10 cm, in the middle of 20 cm and for water loss simultaneously by opposing jets with each other along the furrows using the outlet furrows located opposite to the side inside the check.

The flow rate of water in the outlet furrows is determined based on the specific flow rate of the irrigated furrow ($q_б$) and the number of furrows ($n_б$), located inside the washed check: $Q_{oa} = q_б \cdot n_б$, here $q_б$ – specific consumption of irrigated furrow, l / s.

The water flow rate in temporary sprinklers (Q_b) is determined on the basis of the water flow rate of the outlet furrow (Q_{oa}) taking into account the number of simultaneously working outlet furrows (n_{oa}), i.e. $Q_b = Q_{oa} \cdot n_{oa}$.

The duration of the output furrows (t_{np}), that is, the water supply of the washed check is determined from the following systems of equations:

$$t_{np} = N_{iэ} \cdot F_n / 3.6 \cdot Q_b ;\ t_{np} = N_{iэ} \cdot F_n / 3.6 \cdot Q_{oa} ;\ t_{np} = N_{iэ} \cdot F_n / 3.6 \cdot q_б \cdot n_б ,$$

where $N_{iэ}$ – flushing rate in i – saline leaching stage, m^3/ha.

The leaching rate of saline soils can be determined by the formula Zh. S. Mustafayev, allowing to establish the sizes of flushing norms, taking into account the dynamics of hydraulic processes in soil [6]:

$$N = (\alpha / \beta) \lg(S / S_i) ,$$

where β - solubility rate of a solid during a chemical reaction between solid and liquid substances: $\beta = 2.02 \cdot \exp(-9.57 \cdot V_t)$, here V_t - water absorption rate in the soil (figure 2).

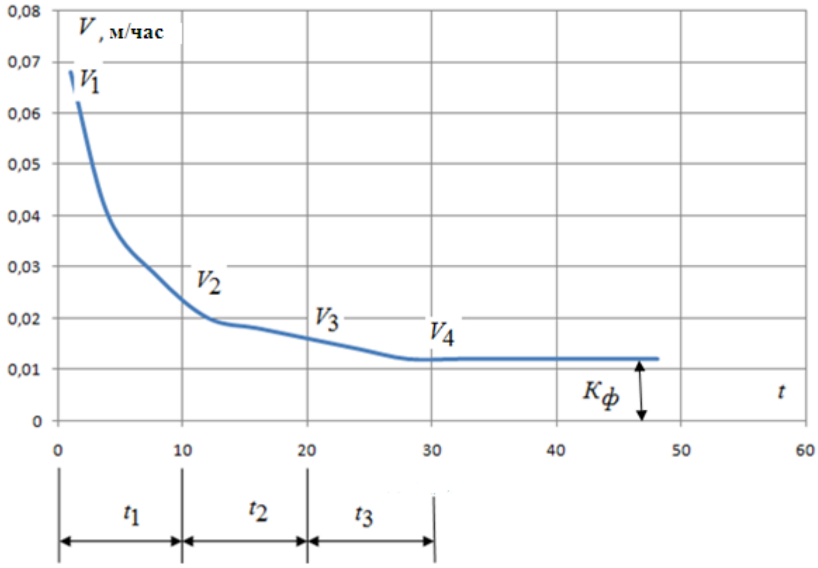

Figure 2 – The rate of absorption of water into the soil

Thus, at the initial stage, the absorption rate will be quite large, and after saturation of the soil with moisture, the absorption rate is equal to the filtration rate, which makes it possible to develop them into several sub-steps (n) taking into account the soil water absorption rate (V_t). For each sub-step, the average rate of water absorption into the soil ($V_{tcp} = (V_{ti} + V_{ti+1})/2$) is determined and multiplying them by the duration of the sub-steps (t_i) we determine the amount of flushing norms (N_{ti}), which are carried out in pressure mode: ($N_{ti} = V_{tcp} \cdot t_i$).

In general, the standards for flushing saline lands (N_{tH}), which are carried out in pressure mode, are determined by the formula: $N_{tH} = \sum_{i=1}^{n} N_{ti}$.

Rinsing standards for saline soils ($N_{tбб}$), which are flushed in a non-pressure mode, are determined by the following formula: $N_{tбб} = N - N_{tH}$.

The duration of leaching of saline soils in pressure-free mode ($t_{\partial o}$)is determined by the formula: $t_{\partial o} = (N - N_{tбб}) / K_{ф}$, where $K_{ф}$ - filtration coefficient.

In this case, leaching of saline soils is carried out when the average daily air temperature is more than + 5 ° C, that is, in early spring, then, firstly, the soil moisture will be close to the maximum permissible humidity, and secondly, the salts in the soil layer are in a state more dissolved, which allow using the leaching rate additionally falling on the soil surface, it is easy to displace salts in the lower layers of the soil.

When rinsing the soils of saline lands and after cultivating more salt-tolerant crops, it is necessary to maintain the same irrigation technology for furrows, that is, the regime of oncoming jets with the same costs.

The advancement of the flow along the furrows is described by the equation [7]:

$$l = a \cdot t^{\beta} ,$$

where l - flow path over time t ; a - proportionality coefficient; β - coefficient characterizing the attenuation of the speed of the flow along the furrow.

The average rate of seepage of water into the soil varies over time according to the equation of A.N. Kostyakova [8]:

$$V_t = V_o / t^{\alpha} ,$$

where V_o - absorbed water layer for the first unit of time; α - coefficient characterizing the attenuation of the absorption rate.

Denoting the specific intensity of the water supply to the furrow q, average depth of water in a furrow h, total feed time T, furrow length l, and the current time and length, t and l_t respectively, we write the differential equation of the water balance in the furrow:

$$q \cdot dt = \frac{V_o}{(T-t)^{\alpha}}(T-t)\frac{\alpha \cdot \beta}{t^{1-\beta}}dt + h\frac{\alpha \cdot \beta}{t^{1-\beta}}dt,$$

deciding which, we get: $$q \cdot T = (2 \cdot \beta - \beta^2)(\frac{V_o \cdot T^{1-\alpha}}{2-\alpha}) + h)l_T,$$

where, we find l_t, q, T and m_T.

The value m_T can be represented by the equation:

$$m_T = m(1 - \frac{l}{2 \cdot l_q}),$$

where m - average irrigation rate; l_q - flow length after turning off the water supply.

The maximum possible costs with non-washing speed of the jet in the furrow are determined by the formula:

$$q_{\max} = W \cdot V_{\partial on},$$

where $q_{\max}$ - the maximum possible flow rate into the furrow. l / s; W - live section area of the furrow, m2; $V_{\partial on}$ - the maximum permissible speed of water in the furrow, depending on the mechanical composition of the soil, m / s.

The speed of water in the furrow can be determined by the formula: $V = C\sqrt{R \cdot J}$, where C - speed coefficient according to N.N. Pavlovsky: $C = (1/n)R^y = (1/n)R^{1/3}$, where n - roughness coefficient; R - hydraulic radius, m.

The wetted perimeter of the irrigation furrow is determined by the formula of V. F. Nosenko: $\alpha = q^{2/3}/i^{1/6}$, where q - flow rate ,m^3/hour; i - furrow slope. The live section area of the furrow is determined by the formula of V.F. Nosenko: $\omega = 0{,}00147(q^{2/3}/i^{1/3})$, m^2. The hydraulic radius of the irrigation furrow is determined by the formula: $R = w/a$, m.

Estimated Net Irrigation Rate ($m_{нт}$) in m^3/ha count on a layer of water $h_{нт}$ in m taking into account the estimated width of absorption of water ($в$), i.e. $h_{нт} = m_{нт}/1000$, and if the wetted perimeter is taken as the estimated absorption width (α), then $h_{нт} = m_{нт} \cdot в/10000 \cdot \alpha$, m.

Using a given coefficient of uniformity of moisture (K_p)we determine the maximum moisture that is observed at the beginning of the furrow:

$$h_н = h_{нт}/K_p = h_к/K_p.$$

With a straight plot of furrow hydration with a uniformity coefficient (K_p)the average irrigation norm along the furrow length is expressed by the equation: $h_{cp} = (h_н + h_{нт})/2 = (h_{нт}/2)[(1/K_p)+1]$.

Losses of water below the root layer for deep discharge caused by uneven moisture along the furrow length will be equal: $h_{cб} = (h_н - h_{нт})/2 = (h_{нт}/2)[(1/K_p)-1]$.

After applying the irrigation norm during counter irrigation along the furrows, the water layer in the furrow is aligned along the entire length and its values can be determined taking into account the absorbing water during irrigation, that is, according to the following formula:

$$h_{cв} = h_{нт} - \frac{V_o}{1-\alpha} \cdot t^{1-\alpha},$$

where V_o - absorption rate at the end of the first hour; α - indicator depending on soil properties and initial moisture; t - watering duration.

The duration of water absorption after (t_O)watering is determined by the formula:

$$t_O = 1 - \alpha \sqrt{\frac{h_{cв}(1-\alpha)}{V_O}}\ .$$

Thus, the proposed methodology for determining the parameters of flushing technology with irrigation technique for furrows from two opposite outlet furrows of row crops, allows you to determine the irrigation time and predict the mode of soil moisture with high reliability.

Conclusions. At the same time, the developed technology for rinsing saline soils on the basis of "soft" control of the hydrogeochemical process, which is based on the concept of the laws of natural evolutionary soil processes in the interpretation described above: the soil as an open system, has stability, self-regulation and is in translational dynamic equilibrium. At the same time, the principle of environmentally friendly technology for washing saline soils is based on reasonable dosing and regulation of technogenic loads on the natural system. Dosing - regulation of the flushing rate on a temporary scale is possible with a deep understanding of the laws of natural processes that determine the essence of the geological cycle of water and chemicals and the environmental restrictions that nature poses to our activities.

It should be noted that the hydrobiological and ecological development of saline and restoration of technologically disturbed soils of natural systems with a focus on high-tech, resource-saving, waste-free technologies in the long term determine the strategy of environmental reconstruction as a human environment at the stage of a deep ecological crisis. However, with balanced nature management it cannot be achieved only by reconstructing the natural system, but first of all, reconstructing the thinking and activities of all mankind is required.

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ТҰЗДАНҒАН ЖЕРДІ ШАЮДЫҢ ЭКОЛОГИЯЛЫҚ ТҰРҒЫДА ҚАУІПСІЗ ТЕХНОЛОГИЯСЫН ЖЕТІЛДІРУ

Аннотация. Табиғат заңдылықтары және табиғи гидрогеохимиялық үдерістер қағидасы негізінде жоғарғы өнімді гидроагроландшафттық жүйені құруды қамтамасыз ететін және топырақтың даму үдерісін сақтауға мүмкіндік беретін тұзданған жерді шаюдың экологиялық тұрғыда қауіпсіз технологиясы мен әдісі әзірленді.

Тұзданған жерді шаюдың экологиялық тұрғыда қауіпсіз технологиясын теориялық тұрғыда негіздеу, геологиялық уақыт ішінде үгінді қалдығындағы салмақ алмасуды білдіретін, яғни топырақ ерітінді құрамындағы молекулярлық деффузияның механикалық үдерісі арқылы жүретін, атап айтқанда, топырақ қабатынан сүзілетін судың белгілі бір көлемі пропорционал қатты қалдықтардан еріген тұзды бөлігін алып кетеді деген табиғи жүйедегі гидрогеохимиялық үдерістердің эволюциялық үлгісіне бейімделген.

Сонымен тұзданған жерді шаю жағдайын негіздеу екі түрлі қағидаға негізделген, яғни эмперикалық-тәжірбелік зерттеулер нәтижесінде қол жеткізген мол мәліметтерді талдауға, ал теориялық негіздеу – табиғи жүйедегі тұз алмасу және тасымалдау теориясына негізделген, физикалық-химиялық үдерістердің заңдылықтарына бейімделген.

Тұзданған жердегі топырақ шаю мөлшерін және шаюдың жоғарғы қысыммен және қысымсыз жағдайдағы судың топырақ қабатына сіңу тәртібін ескере отырып, уақытша арық, кәріз тізбектерін және атыз дайындаумен қатар, қопсыту қондырғысының еніне сәйкес келетін ені бірдей жолақтың бірі қопсытылған және екіншісі қопсытылмаған, кәрізге қиғаш топырақты терең мелиоративті қопсыту жұмыстары жүргізілген соң, атыздағы жүйектерге қарама-қарсы бағытта бірдей мөлшерде су беріледі және олар бір-бірімен түйіскенде, кері қарай шегініс болады да, атызға бір түрлі су жіберуге болады. Іс жүзінде ұсынылған шаю әдісін іске асыру үшін шаю технологиясы ұсынылған, яғни атызға берілетін су ағынын реттеу арқылы топырақ қабатын сумен толық қандырғанша топыраққа судың сіңуі жоғарғы қысымда жүреді, ал содан соң атызға суды беру шамасы біртіндеп азайтылады және шаю қарқыны да төмендеп, топырақтағы судың сүзілу жылдамдығының шамасымен теңеседі, яғни шаю танаптағы топырақ қабатындағы судың сүзілу жылдамдығына сай су беріліп отырады және судың топыраққа сіңіуі қысымсыз жағдайда жүзеге асырылады.

Сонымен ұсынылып отырған тұзданған жерді шаю технологиясы гидрогеохимиялық үдерісті «жеңіл» басқаруға негізделген, яғни топырақ үдерісінің табиғи эволюциялық заңдылығын тану жағдайына негізделіп, топырақ ашық жүйе ретінде орнығатын және өзін-өзі реттеу жағдайы динамикалық тепе-теңдікте болатыны ескерілген.

Тұзданған топырақты шаю, ауаның орташа тәуліктік жылулығы +5°С болғанда жүргізілуі керек, яғни көктем мезгілінің бас кезінде, ал ол кезде біріншіден топырақ қабатының ылғалдығы, оның ылғал сыйымдылығының шектелген-мүмкіншілік шамасына жақын болады, екіншіден топырақ қабатындағы тұз ертінді түрінде болғандықтан, топырақ бетіне берілетін қосымша су арқылы топырақ қабатынан жылдам ығыстырып шығаруға болады.

Тұзданған жерді шаю технологиясын және әдісін өндірісте іске асыру үшін ауылшаруашылық дақылын, атыздың екі жағына орналасқан оқ арықтар арқылы суару техникасының өлшемдік көрсеткіштерін анықтаудың әдістемесі ұсынылған, ал ол жоғарғы дәрежедегі нақтылықпен топырақтың ылғалдану дәрежесін бағдарлауға және суару уақытын анықтауға мүмкіндік береді.

Түйін сөздер: топырақ, тұздану, шаю, басқару, қалдықсыз, қауіпсіз, технология, үдеріс, топырақ дамуы, қарқын, судың сүзілуі.

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СОВЕРШЕНСТВОВАНИЕ ТЕХНОЛОГИИ ЭКОЛОГИЧЕСКИ БЕЗОПАСНОЙ ПРОМЫВКИ ЗАСОЛЕННЫХ ЗЕМЕЛЬ

Аннотация. На основе законов природы и природных гидрогеохимических процессов разработаны способы и технологии экологически безопасной промывки засоленных земель и его методологическое обеспечение, обеспечивающих конструирования высокопродуктивных гидроагроландшафтных системы и позволяющее сохранить естественные почвообразовательные процессы.

Теоретическое обоснование экологически безопасной технологии промывки засоленных почв базируется на модели эволюционного гидрогеохимического процесса природной системы, описывающая массоперенос в осадочных формациях в течение геологического времени, где происходит по механизму молекулярной диффузии через водную фазу, а именно определенной порцией инфильтрирующихся вод из почвенного слоя выносится часть растворенных солей пропорциональная количеству их твердой фазы, заключенных в пределах этого слоя.

При этом принципы обоснования условий промывок засоленных земель строятся на двух существенно различных позициях: эмпирической, основанной на обобщении большого фактического материала экспериментальных исследований, и теоретической, основанной на использовании закона физико-химических процессов, базирующихся на теории солепереноса и солеобмена в природной системе.

Способ промывки засоленных почв, включающий подготовку временных оросительных и дренажных сетей и чеков, глубокое мелиоративное рыхление почв поперек дрен с чередованием рыхленных и нерыхленных полос одинаковой ширины, с последующей подачей воды в чеки в напорном режиме до полного увлажнения, а затем подачу воды до работы в безнапорном режиме, отличающийся тем, что в чеках с нулевыми отметками нарезают временные оросительные сети с противоположенной стороны чека и борозды с углублением в сторону центра чека, при этом подачу промывной нормы с помощью борозды проводят одновременно встречными струями с одинаковыми расходами, до столкновения друг с другом в центре чека, с последующим выравниванием слоя воды в борозде по фронту подачи воды.

Для реализации разработанных способов промывки на практике предложены технологии промывки засоленных почвы, где подачу воды в чек с помощью борозды регулируют, подавая ее в чеки в напорном режиме до полного увлажнения, а затем подачу воды уменьшают до работы в безнапорном режиме, то есть подачу расхода воды в чек уменьшают до тех пор, пока она не будет равной коэффициенту фильтрации данной почвы.

При этом разработанная технология промывки засоленных почв на основе «мягкого» управления гидрогеохимического процесса, где в основу положено понятие закономерности природных эволюционных почвенных процессов в той интерпретации, какая была изложена выше: почва как открытая система, обладает устойчивостью, саморегулированием и находится в поступательном динамическом равновесии.

Промывки засоленных почв проводятся, когда среднесуточная температура воздуха будет больше +5°С, то есть в начале весны, тогда, во-первых, влажность почвы будет близка к предельно-допустимой влажности, во-вторых, соли в почвенном слое находятся в состоянии более растворенными, которые позволяют с помощью промывной нормы дополнительно падаваемой на поверхности почвы, легко вытеснить соли в нижние слои почвы.

Для реализации в практике разработанных способов и технологии промывок засоленных земель предложенная методика определения параметров технологии промывки с техникой полива по бороздам из двух противоположенных выводных борозд пропашных сельскохозяйственных культур, которые позволяют определить время полива и прогнозировать режим увлажнения почвы с высокой достоверностью и надежностью.

Ключевые слова: почва, засоление, промывка, управление, безотходная, безопасная, технология, процесс, почвообразование, интенсивность, водопроницаемость.

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