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SALINE AND SWAMPY (WATERLOGGED) SOILS OF KAZAKHSTAN AND WAYS TO IMPROVE THEM

Abstract

The article describes the patterns of distribution of saline and swampy soils across the soil and climatic zones of Kazakhstan, describes the features of salt accumulation processes depending on geological development and identifies soil-halogeochemical provinces. Reclamation measures for their development are recommended. The most effective method of reclamation of hydromorphic meadow solonchaks of the chloride-sulfate type of salinization is leaching against the background of open deep horizontal drainage. Leaching of meadow solonchaks of the foothill plain of the Ili Alatau with a water norm of 5000 m^3/ha provides desalination of the soil and soil thickness with a capacity of 0-80 cm. During soda salinization of solonetzic meadow-chestnut soils, the application of 2.1 and 4.2 t/ha of 1% sulfuric acid solution ensures the transformation of the ionic composition of the pore solution from soda to sulfate, which is subsequently removed by leaching. On swampy (waterlogged) soils, the most rational is the creation of highly productive meadow agrocenoses and the preservation of meadow biocenoses.

Key words: arid landscape, salt accumulation, soil-halogeochemical provinces, salinization processes, soda salinization.

Introduction

President of the Republic of Kazakhstan Kassym-Jomart Kemelevich Tokayev in his state of the Nation Address dated September 01, 2022 "A just state. A united nation. A prosperous society", speaking about the problems of agricultural development, noted that there is currently no full-fledged information for the development of agriculture. All the disparate information about the state of agricultural lands, water resources, irrigation systems and transport accessibility will be combined on a single digital platform [1]. Therefore, a special place for the development of the agro-industrial complex of Kazakhstan in the future will be given to the digitalization of all agricultural lands, that is, the relevance of creating an information database of saline and wetlands of Kazakhstan in the framework of fulfilling the instructions of the Head of State K.Tokayev's initiative to introduce digital monitoring and control over the rational use of agricultural land is obvious. Also, in a message dated September 02, 2023, he noted that "Modern agriculture is a high–tech industry. Land and climate are no longer the determining factor for the success of farmers, innovative solutions have come to the fore. Without modern science, the situation in the industry will not just stagnate, but worsen. Measures should be taken to develop agricultural science and, most importantly, its practical application in agriculture" [2].

It is known that saline soils are a common component of arid landscapes. They are found all over the world in more than 100 countries. 900 million hectares of land in the world are subject to salinization to one degree or another, which is ~ 6% of all soils or about 20% of all developed territories [3]. According to Massoud estimates, 23% of arable land (7×109 hectares) is saline, and 37% is sodic [4]. Moreover, the trend of increasing soil salinity persists, especially in irrigated agricultural soils [5], where half of the area is subject to a high degree of salinity.

Saline soils are mainly distributed in Central Asia and Kazakhstan, they are also found in Western Siberia and Western China. Most of the saline soils are concentrated in Kazakhstan. Due to the physical and geographical features of our Republic, more than 80% of the saline soils of the former USSR are concentrated in it, which is more than 111.5 million hectares or 41% of the republic's area. It is located in the most saline part of the planet's land – Central Asia, which accounts for 1/5 or 191 million hectares of saline soils in the world (953 million hectares), which is equal to the area of similar soils in Africa and America combined [6]. Saline soils are widespread in the Republic of Kazakhstan. If solonetz and solonetzic soils reign in its northern and central parts, then solonchaks and solonchakous soils dominate in the southern, southwestern and southeastern parts.

A significant part of the intermountain depressions and foothill plains of the Almaty region are occupied (2.7 million hectares or 12.2%) by saline soils, where the proportions of weakly, medium, strongly and very strongly saline species, respectively, are 30, 20, 37, 13%. According to the chemistry of salinity, they belong to the soda-sulfate province. Their area, due to the global aridization of the planet, which began in the second half of the XIX century and continues in the coming century, tends to grow steadily, both in terms of the degree of salinity and the area of distribution. Data from the analysis of changes in the temperature of the surface air layer of the foothill plain of the Northern Tien Shan in 1935-1995 showed an increase in its average annual value by 1.4 ° C, by 1 ° C during the growing season and by 2 ° C for the months of October-March, i.e. summer became hotter and winter warmer [7]. The main factors contributing to the almost ubiquitous spread of saline soils in the Ili depression are the low hydrothermal coefficient (0.5-0.7), showing a high level of its dryness, a high sum of active temperatures ($\sum t > 10$ °C 3500) and weak drainage of the territory with a close occurrence (1.0-4.0m) of groundwater.

The main method of reclamation of saline soils of the depression is leaching against the background of artificial drainage. However, this method is unacceptable for alkaline soda-saline soils, which is due to their extremely low water permeability and weak solubility of soda.

Soda-saline soils are found in all continents from the tropical to the polar zones, but they are most widespread in the Northern Hemisphere [8]. The area of soda-saline soils in the countries of the former USSR is 120 million. ha and its catastrophic growth puts the problem of reclamation of soda-saline soils on one of the first places in modern reclamation soil science [9]. The main areas of soda salinity, which include solonetz and solonetzic soils, tend to 55-48 ° c in the European part, and 52-58 ° c in the Asian part, spreading in solid massifs or separate foci [10]. In the Asian part, the largest arrays of soda salinity are confined to the forest-steppe zone of Western Siberia, the southwestern part of which is located within the territory of the Republic of Kazakhstan.

Within the republic, soda-saline soils have become focal among zonal (chernozem and chestnut) soils in the northern, northeastern and introzonal (hydromorphic and semi-hydromorphic) soils in the southern, southwestern and southeastern regions. The area of soda-saline soils in the latter is 7,095 million hectares [11], 18.6% of them were distributed in Almaty, 47.7% of Dzhambul, 27.3% of Turkestan and 21.7% of Kyzylorda regions, among which the proportion of soils with a pronounced saline horizon "B_1" is 19.0, 12.3, 100 and 70.5%, respectively. The importance of the problem of increasing the fertility of such soils increases due to their spread among the most fertile soils of the foothill plain of the Northern Tien Shan - meadow, meadow–gray and meadow-chestnut soils. Here, the shortage of crops due to soda salinity ranges from 15 to 45% [12]. This is due to the presence of spots among arable land with oppressed or deprived vegetation. Their area ranges from several tens of square meters to several hectares. Small and medium-sized spots are annually fully exposed to all types of agricultural practices, from plowing to harvesting, i.e. significant material, monetary and labor resources are spent on them and, accordingly, devalued. Larger plots, as a rule, are not involved in arable land. The above circumstances indicate the urgent need for reclamation of soda-saline soils located in the zone of irrigated agriculture.

As is known, reclamation of any soil, including saline, requires studying not only the composition and properties of the soil, i.e. determining its soil-reclamation state, but also the genesis. Therefore, ignorance of the origin of soda soils can greatly complicate their reclamation. Since the foci of soda salinization are concentrated in the northeast and southeast of the republic and are far apart from each other, and accordingly the factors contributing to their formation are in various combinations, argiogi should be expected that they are heterogeneous in origin and require a differentiated approach in determining the methods of their reclamation.

The presence of a significant area of neutral and alkaline soda-saline soils in areas of intensive agriculture and focal distribution among zonal and intrazonal soils requires the determination of methods to increase their fertility.

Materials and methods

According to the report on the state and use of lands of the Republic of Kazakhstan for 2020, there are 35.8 million hectares of saline and 58.2 million hectares of saline soils in the Republic, which occupy 16.7 and 27.1% of the agricultural land area, respectively. Solonchaks account for a small proportion of the total area of saline soils in Kazakhstan. Their share in the structure of the soil cover increases slightly only in the southern half of the republic, which is a closed inland area that does not have free flow into open ocean basins. In turn, this area is divided into 3 extensive independent intracontinental depressions, with their closed drainage basins and large lake basins in the hypsometrically lowest parts. These are the Caspian lowland with the Caspian Sea, the Turan lowland with the Aral Sea and the Balkhash-Alakol and Ili depressions with the Balkhash lake. In all three depressions, as the runoff moves towards the final basin, its mineralization increases, the amount of saline soils increases, reaching a maximum on its coasts. The peculiarities of the geological development of Kazakhstan create the following prerequisites for the widespread spread of salt accumulation processes:

- formation of vast drainless plains with poor natural drainage;
- the predominance of loose rocks in sedimentary complexes with low filtration coefficients and weak water loss, gypsum carbonate with residual salinity;
- the formation of mountain ranges in the south-east, for which the plains of Kazakhstan serve as the basis for the accumulation of soluble products.

Long-term research allowed V. M. Borovsky (1982) to identify four soil-halogeochemical provinces on the territory of Kazakhstan [13]:

1. The basin of the Caspian Sea runoff with a predominance of sulfate-chloride and chloride salt accumulation;
2. The Aral Sea drainage basin with chloride-sulfate type of salt accumulation;
3. Lake drain pool. Balkhash with soda-sulfate salting;
4. The drainage basin of the Karsk Sea with a predominance of chloride-sulfate salt accumulation. The first three provinces belong to the closed reservoirs of the southern part of the republic, the fourth province communicates with the World Ocean through the Karsk Sea and covers northern, central and eastern Kazakhstan.

Waterlogged soils occupy 2.9 million hectares in the republic, of which 224.9 thousand hectares are in arable land. This group is mainly represented by hydromorphic and semi-hydromorphic soils. Floodplain lands amount to 1.1 million hectares, non–floodplain lands - 1.8 million hectares.

The most significant areas of soils of this group are in the Karaganda region – 0.6 million hectares. There are 0.2-0.3 million hectares of waterlogged lands in Kostanay, West Kazakhstan, Pavlodar, Aktobe, and Almaty regions.

The lands of this group are mainly represented by soils occupying floodplains and floodplain terraces of rivers, as well as non-floodplain depressions and depressions, including natural and artificial estuaries. The excess of meltwater and the duration of flooding negatively affect the timing of sowing, maturation and yield of crops. In this regard, it is more expedient to use the soils of this group as hayfields.

The area of wetlands is 1.1 million hectares, of which 23.9 thousand hectares are in arable land, of which 15.3 thousand hectares are in irrigated arable land.

 a  b

Figure 1. Saline soils (a), swampy soils (waterlogged) (b)

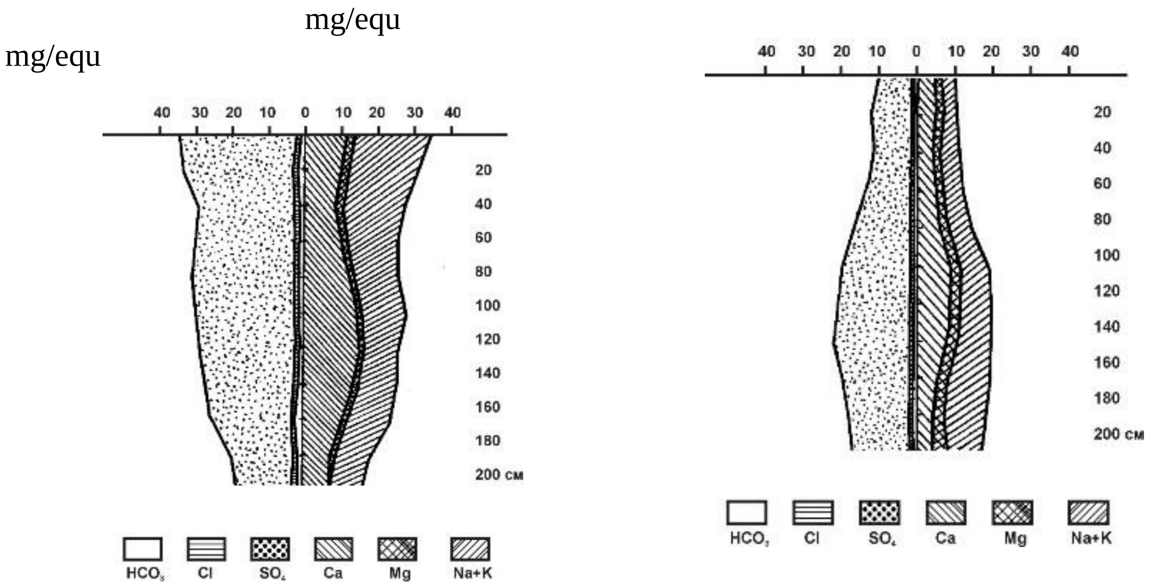
They were formed in conditions of excessive moisture and are mainly represented by boggy and meadow-boggy soils. They are distributed on the territory of all regions, except Mangystau, in small areas. In semi-desert and desert zones, boggy soils are found in depressions abundantly moistened by surface and groundwater: some of them dry out periodically (but the level of soil moisture usually does not fall below 0.5 m), while others are under water for a long time. They are divided into two subtypes: turf-boggy and silty-boggy and, depending on the amount of semi-decomposed plant residues, they have turf, turf-humus and humus-silty, in color from dark brown to bluish-gray, the upper organogenic horizon [14].

Meadow-boggy semi-desert and desert soils are common in deep depressions on flat plains and along river terraces in areas with groundwater at a depth of 0.5-1.5 m. They experience prolonged ground moisture and annual flooding. They have an unstable water regime, as a result of which, in dry periods, the falling swamp vegetation is replaced by meadow vegetation. In this case, there is a discrepancy between the profile of the soil and the nature of vegetation on its surface. They are characterized by a clear separation of the entire profile and the absence or low thickness (less than 20 cm) of the turf horizon, which distinguishes them from meadow and boggy turf soils. Boggy soils are found in the most depressed areas of the relief, occupying the bottoms of drying lakes and lowering the groundwater wedging zone on the removal cones. They are most often found in the form of small contours among meadow and meadow-boggy soils. A distinctive feature of these soils is the constant excessive moisture due to the close (within half a meter) occurrence of groundwater or due to periodic, varying duration of flooding. Groundwater (fresh and solonetzic) lies at a depth of 0.5-1 m in autumn, and in the winter-spring period partially merges with surface waters in summer. Excess moisture in the anaerobic conditions of soil formation leads to the accumulation of a significant amount of organic substances in the upper horizon and the gluing of the profile. The soil profile is usually moist, heavily peeled, and saturated with a large number of living and dilapidated plant remains [15].

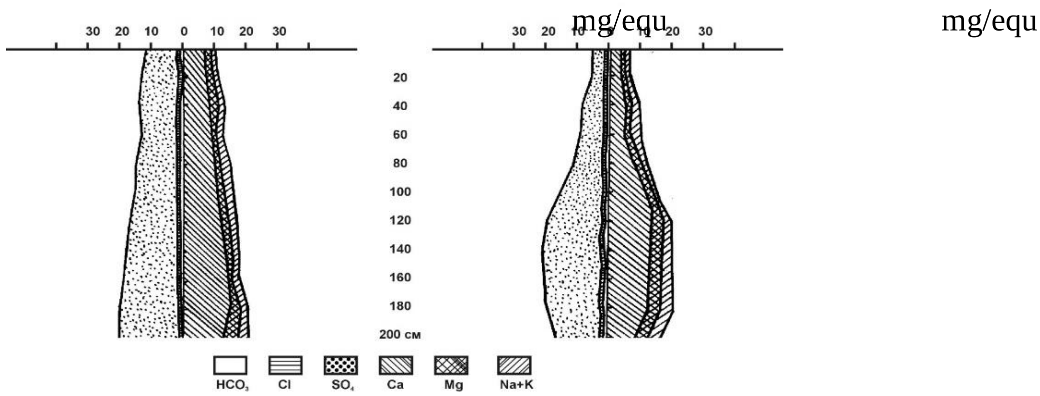
Research results and their discussion

For the development of hydromorphic meadow solonchaks of the chloride-sulfate type of the hydromorphic strip, it is necessary to lay a deep open horizontal drainage. Against this background, capital leaching, with a water norm of 5 thousand m3 / ha, leads to stratification of the upper 0-80 cm soil layer at a degree of 0.6-0.8%.

To ensure an irreversible process of salinization of meadow solonchaks, during the lighting period, a leaching irrigation regime with a humidity of 85% of the from lowest moisture capacity (LMC) is necessary (Figure 2). To prevent secondary salinization of the soil, preventive leaching should be carried out annually in early spring during the off-season period, with a norm of 1160 m3/ha of water. With an increase in the groundwater level during the non-vegetation period and the presence of ascending capillary moisture currents from the pressure groundwater, seasonal soil salinization is possible.



a) before leaching (1986) b) after leaching, the norm is 5000 m^3/ha (1987)



after 3 years of alfalfa cultivation:

c) variant 75% of LMC d) variant 85% of LMC

Figure 2. Changes in the salt profile of meadow solonchaks during reclamation

In the natural insufficiently drained territories of the foothill plains of the Ili Alatau, for soils of semi-hydromorphic and hydromorphic types of water regime, the most rational and economical method of combating salinization of irrigated lands is a deep (3.0-3.5 m) horizontal closed drainage, with an inter-wind distance of 200-300 m, which allows to keep the groundwater level below the critical depth., in seasonal, annual and multi-year cycles, and thereby prevent the process of secondary salinization of soils.

The cultivation of salt-resistant crops on weakly and medium surface-soda-saline solonetzic soils gives a completely satisfactory yield, which makes it possible to include these soils in arable land, however, they do not eliminate the soda content and, accordingly, the excessive alkalinity of the soil solution [16].

The 4-year standing of alfalfa increases the humus content of the arable layer by 0.29%, and barley and safflower reduce it by 0.95 and 1.18%, respectively.

The application of a 1% solution of sulfuric acid into slightly sodic-saline solonetzic meadow-chestnut soil at doses of 2.1 and 4.2 t/ha changes the type of salinity from soda to sulfate, without affecting the degree of salinity and productivity of spring barley (Table 1).

Table 1 - Effect of sulfuric acid on the composition of absorbed bases of soda-saline meadow-chestnut soil, mg-eq/ %

Experience variant	Depth, cm	Ca^{2+}	Mg^{2+}	Na^{+}	Amount, mg-eq per 100 g of soil
Control	0-20	9,6	8,8	1,85	20,25
		47,41	43,46	9,13	
	20-40	10,4	10,0	1,98	22,38
		46,47	44,68	8,89	
2,1 t/ha H_2SO_4	0-20	9,6	9,2	2,15	20,95
		45,82	43,91	10,26	
	20-40	10,4	8,8	2,50	21,70
		47,93	40,55	11,52	
4,2 t/ha H_2SO_4	0-10	11,6	9,2	2,08	22,88
		50,70	40,21	9,09	
	20-40	11,6	9,2	2,08	22,88
		50,70	40,21	9,09	

Drainage of waterlogged sloping soils has an important anti–erosion value, since the drainage system intercepts and removes excess moisture during wet periods, thereby reducing the intensity of surface runoff in spring - during the most active period of soil leaching. It should be noted that in drained areas with poorly permeable soils, the volume of surface runoff is 30-50% less, and soil losses are mainly 30% less than from non-drained ones.

On existing drained lands, as well as on lands of short–term humidification, the most effective methods of drainage should be widely used - closed horizontal drainage, as well as drainage by hollows.

To optimize the soil fertility of reclaimed territories, drainage is advisable based on the calculation of their use for meadow lands (drainage rate of 50-80 cm). This makes it possible to completely eliminate or reduce adverse changes in the drained soils.

An important problem is the elimination of soil compaction, which is created during the operation of heavy agricultural machinery, as a result of which weakly permeable layers are formed at a depth of 30-50 cm, leading to stagnation of water in the upper layers of the soil due to their low water permeability; this leads to the formation of surface runoff. Reducing compaction and improving soil permeability is achieved by periodic loosening (every two to five years) in certain areas to a depth of 40-60 cm at an angle of more than 30 to the direction of tillage. Agromeliorative measures to eliminate compaction should be applied at values of addition density on loams of more than 1.50-1.52 g / cm3, while non–capillary porosity should be less than 10%, pH values - 7-8; values of filtration coefficients-less than 0.3 m / day.

Currently, mowing, deep loosening, solid and striped are used. Strip loosening is performed in the form of separate strips. All activities are carried out with soil moisture in the loosening zone of 60-80% of the lowest moisture capacity.

To increase the duration of deep loosening, improve the water-physical and agrochemical properties of drained sloping slightly permeable mineral soils and their fertility in combination with loosening, chemical and biological reclamation of arable and sub-arable horizons should be used: the introduction of high doses of phosphogypsum, chemical meliorants, mineral and organic fertilizers into the sub-arable layer, the cultivation of crops with an intensively developing root system. High dehumidification efficiency is achieved in combination with other measures, with crop rotations of perennial grasses.

All land reclamation measures should be aimed at creating sustainable and productive agricultural landscapes that meet the requirements of not only economic, but also environmental efficiency.

The specifics of the functioning of swampy and waterlogged soils during techno- and agrogenesis will determine the need to create our highly productive seeded meadows. The creation of meadow agrocenoses on these soils most fully meets the principles of rational use and soil protection.

Drainage of swampy soils improves aeration of the root zone, which allows soils to warm up more quickly, and also leads to an overall improvement in the upper layer, i.e. those horizons that are susceptible to cultivation.

Gley strongly swampy soils (surface-gley and ground-gley) are characterized by a sharply unfavorable water regime that inhibits the development of cultivated plants. Gley soils on heavy rocks should also be attributed to this group. The improvement of soils in this group should be based on their reclamation with the installation of a drainage system.

The development of the lands of the Tash-Utkul massif, located with a complex complex of land reclamation to regulate the water-salt regime of saline, waterlogged, swampy soils and groundwater.

For example, vertical drainage is most acceptable on the left bank according to hydrodynamic conditions [17]. To optimize the water-salt regime of the lands of the first stage of construction, drainage structures should have an average annual flow rate of 1086 l/sec (module 0.146 l/sec/ha), which can be provided with simultaneous operation of 67 vertical drainage wells. Each of them serves 112 hectares, and taking into account the impact on the associated non–irrigated areas - 150-170 hectares.

On the right bank, according to hydrodynamic conditions, closed horizontal drainage with a depth of 3.0-3.5 m is preferred. At the time of irrigation in the center of the drainage, the groundwater level rises to 2.04-2.20, after their termination it will decrease to 2.3 m. Here, drainage with a length of 18.5 meters per 1 hectare (average annual flow modulus 0.07–0.16 l/sec/ ha) is required to ensure a favorable water-salt regime. Optimization of the water-salt regime and the groundwater level of irrigated lands will have a beneficial effect on the adjacent non-irrigated territory: the reclamation situation will improve, the productivity of pastures and hayfields will increase.

Meadow-type soils (waterlogged, boggy) are associated primarily with river valleys, various depressions and depressions of non-valley spaces, but unlike saline soils, the majority are occupied by non-negative elements of microrelief, and larger negative landforms.

These soils are typical for many regions of Kazakhstan, especially for the West Siberian, Caspian, Turanian regions and river valleys. There are more than 7 thousand large and small rivers in Kazakhstan -Irtysh, Ural, Tobol, Ishim, Syrdarya, Chu, Ili, Karatal, etc.

Most of these rivers have developed valleys, the width and development of river valleys very often does not depend on the size of the river itself, the width of its bed and the power of the water flow.

According to the generally accepted position in river valleys, or floodplains, three parts are distinguished: the riverine, central and near-coastal floodplains. Meadow soils (waterlogged wetlands) are formed in river valleys, along estuaries and smaller depressions. Any floodplain is a valuable agricultural land suitable for all-round use. First of all, these are hayfields, where with the help of simple measures - the destruction of low-value non-edible shrubs, the sowing of grasses and other crops of improvers, a significant amount of feed can be obtained, i.e. used as pastures [18].

Conclusions

The area of saline soils of the republic is 35,817.4 thousand hectares, the share as a percentage of the total area of agricultural land (214,348.8 thousand hectares) is 16.7%, and the area of wetlands is 1083.4 thousand hectares (0.5% of the total area of farmland).

According to long-term research, four soil-halogeochemical provinces are distinguished on the territory of Kazakhstan.

The area of wetlands in Kazakhstan is 1.1 million hectares, of which 23.9 thousand hectares are in arable land, of which 15.3 thousand hectares are in irrigated arable land, and waterlogged soils occupy 2.9 million hectares, of which 224.9 thousand hectares are in arable land. This group is mainly represented by hydromorphic and semi-hydromorphic soils. Floodplain lands amount to 1.1 million hectares, non–floodplain lands - 1.8 million hectares.

For the development of hydromorphic meadow solonchaks of the chloride-sulfate type of the hydromorphic strip, it is necessary to lay a deep open horizontal drainage. Against this background, capital leaching, with a water norm of 5 thousand m3 / ha, leads to salinization of the upper 0-80 cm of the soil layer at a degree of 0.6-0.8%. To ensure an irreversible process of salinization of meadow solonchaks, during the development period, a leaching irrigation regime with a humidity of 85% of the soil moisture content is necessary. To prevent secondary salinization of the soil, preventive leaching should be carried out annually in early spring during the off-season period, with a norm of 1160 m3/ha of water.

The cultivation of salt-resistant crops on weakly and medium surface-soda-saline solonetzic soils gives a completely satisfactory yield, which makes it possible to include these soils in arable land, however, they do not eliminate the soda content and, accordingly, the excessive alkalinity of the soil solution. The application of a 1% solution of sulfuric acid into slightly sodic-saline solonetzic meadow-chestnut soil at doses of 2.1 and 4.2 t/ha changes the type of salinity from soda to sulfate, without affecting the degree of salinity and productivity of spring barley.

In river valleys, or floodplains, there are three parts: the riverine, central and near-coastal floodplains. Meadow soils (waterlogged wetlands) are formed in river valleys, along estuaries and smaller depressions. In these soils, according to hydrodynamic conditions, closed horizontal drainage with a depth of 3.0-3.5 m is preferable. Any floodplain is a valuable agricultural land suitable for all-round use. First of all, these are hayfields, where with the help of simple measures - the destruction of low-value non-edible shrubs, the sowing of grasses and other crops of improvers, a significant amount of feed can be obtained, i.e. used as pastures.

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ЗАСОЛЕННЫЕ И ЗАБОЛОЧЕННЫЕ (ПЕРЕУВЛАЖНЕННЫЕ) ПОЧВЫ КАЗАХСТАНА И ПУТИ ИХ УЛУЧШЕНИЯ

Аннотация
В статье изложены закономерности распространения засоленных и заболоченных почв по почвенно-климатическим зонам Казахстана, приведены особенности процессов соленакопления в зависимости от геологического развития и выделены почвенно-галогеохимические провинции. Рекомендованы мелиоративные мероприятия по их освоению. Наиболее эффективном приемом мелиорации сазовых гидроморфных луговых солончаков хлоридно-сульфатного типа засоления является промывка на фоне открытого глубокого горизонтального дренажа. Промывка луговых солончаков предгорной равнины Илийского Алатау нормой воды 5 тыс.$м^3$ /га обеспечивает рассоление почвенно-грунтовой толщи мощностью 0-80 см. При содовом засолении солонцеватых лугово-каштановых почв внесение 2,1 и 4,2 т/га 1%-го раствора серной кислоты обеспечивает трансформацию ионного состава порового раствора от содового в сторону сульфатного, которое в последующем удаляется промывкой. На заболоченных (переувлажненных) почвах наиболее рациональным является создание высокопродуктивных луговых агроценозов и сохранение луговых биоценозов.
Ключевые слова: аридный ландшафт, соленакопление, почвенно-галогеохимические провинции, процессы рассоления, содовое засоление.

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ҚАЗАҚСТАННЫҢ ТҰЗДАНҒАН ЖӘНЕ БАТПАҚТАНҒАН (АРТЫҚ ЫЛҒАЛДАНҒАН) ТОПЫРАҚТАРЫ ЖӘНЕ ОЛАРДЫ ЖАҚСАРТУ ЖОЛДАРЫ

Аңдатпа
Мақалада Қазақстанның топырақ-климаттық аймақтары бойынша тұзданған және батпақтанған топырақтардың таралу заңдылықтары баяндалған, геологиялық дамуына байланысты тұздардың жинақталу үрдістерінің ерекшеліктері келтірілген және топырақ-галогеохимиялық өңірлері бөлінген. Оларды игеру бойынша мелиоративтік іс-шаралар

ұсынылады. Хлоридті-сульфатты түрде тұзданған сазды гидроморфты шалғынды сортаңдарды мелиорациялаудың ең тиімді әдісі ашық терең көлденең дренаж аясында шаю болып табылады. Іле Алатауы бөктеріндегі жазықтықтағы шалғынды сортаңдарды 5000 $м^3$ /га су нормасымен шаю, 0-80 см топырақ қалыңдығының тұзсыздануын қамтамасыз етеді. Кебірленген шалғынды-қоңыр топырақтардың содалы тұздануы кезінде күкірт қышқылының 1% ерітіндісін 2,1 және 4,2 т/га мөлшерде енгізу түтікше ерітіндісінің иондық құрамын содалыдан сульфаттыға қарай трансформациялауды қамтамасыз етеді, соңғысы шаю арқылы жойылады. Батпақты (артық ылғалданған) топырақтарда жоғары өнімді шалғынды агроценоздарды қалыптастыру және шалғынды биоценоздарды сақтау ең ұтымды әдіс болып табылады.

Кілт сөздер: құрғақ ландшафт, тұз жинақталу, топырақ - галогеохимиялық өңірлер, тұзсыздандыру үрдістері, содалы тұздану.