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Satbayev University

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ИЗВЕСТИЯ

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RESEARCH OF HYDROGEOLOGICAL CONDITIONS AND ENERGY PARAMETERS OF ZONAL IRRIGATED SOILS WHEN OPTIMIZING ENERGY-EFFICIENT RECLAMATION TECHNOLOGIES IN THE REPUBLIC OF KAZAKHSTAN

Abstract. The article presents the results of studies of hydrogeological conditions of the geological structure of soils and issues of optimization of energy-efficient reclamation technologies in the Republic of Kazakhstan.

From a geological point of view, the study area belongs to the complex of modern alluvial-proluvial deposits, which contributes to their complex relationship in size and area, and lithological differences. The main zonal soils, such as serozem, chestnut and chernozem, have different hydrogeological conditions and require different energy costs when carrying out reclamation measures to ensure maximum yields of cultivated crops. For the territory of Kazakhstan, the values of the components of the energy balance increase from northern to southern latitudes, from the zone of chernozem soils to gray soils.

The results of the research showed that the energy intensity of the use of ameliorative measures varies from 3780.0 to 8400.0 MJ/ha, depending on the type of ameliorant. In the structure of the total costs for land reclamation works, accordingly, it changes from 1703.85 to 4815.81 MJ/ha. The largest share of costs (58-60%) is fuel and electricity, 24-25% - the operation of agricultural machinery and tractor equipment, the labor of workers and maintenance personnel - 6-8%.

Key words: hydrogeological conditions, groundwater, melioration, irrigated lands, energy parameters, energy efficiency, energy intensity.

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ҚАЗАҚСТАН РЕСПУБЛИКАСЫНДА ЭНЕРГИЯЛЫҚ ТИІМДІ МЕЛИОРАТИВТІК ТЕХНОЛОГИЯЛАРДЫ ОҢТАЙЛАНДЫРУ КЕЗІНДЕ АЙМАҚТЫҚ СУАРМАЛЫ ТОПЫРАҚТЫҢ ЭНЕРГЕТИКАЛЫҚ ПАРАМЕТРЛЕРІ МЕН ГИДРОГЕОЛОГИЯЛЫҚ ЖАҒДАЙЛАРЫН ЗЕРТТЕУ

Аннотация: Мақалада топырақтың геологиялық құрылымының гидрогеологиялық жағдайларын зерттеу нәтижелері және Қазақстан Республикасындағы энергия тиімді мелиоративтік технологияларды оңтайландыру мәселелері берілген.

Геологиялық тұрғыдан зерттелетін аумақ қазіргі аллювийлік-пролювийлік шөгінділер кешеніне жатады, бұл олардың көлемі мен ауданы бойынша күрделі байланысына, литологиялық айырмашылықтарына ықпал етеді. Серозем, каштан және қара топырақ сияқты негізгі аймақтық топырақтардың гидрогеологиялық жағдайлары әртүрлі және мәдени дақылдардың максималды өнімін қамтамасыз ету үшін мелиоративтік шараларды жүргізу кезінде әртүрлі энергия шығындарын қажет етеді. Қазақстан территориясы үшін энергетикалық баланстың құрамдас бөліктерінің мәндері солтүстіктен оңтүстік ендікке, қара топырақ аймағынан боз топыраққа дейін артады.

Зерттеу нәтижелері көрсеткендей, мелиорациялық шараларды қолданудың энергия сыйымдылығы мелиорант түріне байланысты 3780,0-ден 8400,0 МДж/га дейін өзгереді. Мелиорациялық жұмыстарға жалпы шығындар құрылымында сәйкесінше 1703,85-тен 4815,81 МДж/га-ға дейін өзгереді. Шығындардың ең үлкен үлесін (58-60%) отын мен электр энергиясы, 24-25% - ауыл шаруашылығы машиналары мен трактор техникасын пайдалану, жұмысшылар мен техникалық қызмет көрсету персоналының еңбегі - 6-8% құрайды.

Түйін сөздер: гидрогеологиялық жағдайлар, жер асты сулары, мелиорация, суармалы жерлер, энергетикалық параметрлер, энергия тиімділігі, энергия сыйымдылығы.

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ИССЛЕДОВАНИЕ ГИДРОГЕОЛОГИЧЕСКИХ УСЛОВИЙ И ЭНЕРГЕТИЧЕСКИХ ПАРАМЕТРОВ ЗОНАЛЬНЫХ ОРОШАЕМЫХ ПОЧВ ПРИ ОПТИМИЗАЦИИ ЭНЕРГОЭФФЕКТИВНЫХ МЕЛИОРАТИВНЫХ ТЕХНОЛОГИЙ В РЕСПУБЛИКЕ КАЗАХСТАН

Аннотация. В статье приведены результаты исследований гидрогеологических условий геологической структуры почвогрунтов и вопросы оптимизации энергоэффективных мелиоративных технологий в Республике Казахстан.

С геологической точки зрения район исследований относится к комплексу современных аллювиально – пролювиальных отложений, способствует их сложной взаимосвязи по размерам и площади, литологическим различиям. Основные зональные почвы, такие как сероземные, каштановые и черноземные имеют различные гидрогеологические условия и требуют различных энергетических затрат при проведении мелиоративных мероприятий, обеспечивающих получение максимальных урожаев возделываемых сельскохозяйственных культур. Для территории Казахстана значения составляющих энергетического баланса повышаются от северных широт к южным, от зоны черноземных почв к сероземам.

Результаты исследований показали, что энергоемкость применения мелиоративных мероприятий изменяется от 3780,0 до 8400,0 МДж/га в зависимости от вида мелиоранта. В структуре совокупных затрат на проведение мелиоративных работ соответственно изменяется от 1703,85 до 4815,81 МДж/га. Наибольшую долю затрат (58-60 %) составляет топливо и электроэнергия, 24-25 % - эксплуатация сельскохозяйственных машин и автотракторная техника, труд работников и обслуживающего персонала – 6-8 %.

Ключевые слова: гидрогеологические условия, геология, грунтовые воды, мелиорация, орошаемые земли, энергетические параметры, энергоэффективность, энергоемкость.

Introduction.

In the upper hydrogeological layer of the Asa interfluve massif, from a geological point of view, the complex of modern alluvial-proluvial deposits contributes to their complex relationship in size and area, and lithological differences. The geological structure of the upper tier of the hydrogeological massif at the Asa site includes complex alluvial deposits of the proluvial age of the Middle Quaternary - modern age with a very complex relationship with lithological differences in size and in context (Geologıa SSSR. M., 1921).

The study area belongs to low-carbonate gray soils of the periphery of semi-deserts in the foothills of the Northern Tien Shan. The basis of the irrigated bark of agriculture is gray soils. In the valley of the Asa River, hydromorphic soils are developed, subject to the influence of shallow mineralized groundwater. The soil cover of desert areas consists of loose gray soil. Bare soil is typical for areas with deep relief. Soils with poor water permeability, when wet, harden, and when dried, turn into a solid mass (Howard Mooers et all, 2009). In the valley of the Asa river basin, sands cover 10-20% of the total land area and are distributed over the territory in small areas(Bezruk V.M., 1984).

At present, for the development of the economy of the Republic of Kazakhstan, in particular the agro-industrial complex, the main task is the effective use of water and land, material and labor, and other resources. To do this, it is necessary to ensure the use of energy-efficient technologies aimed at increasing productivity and reducing costs in the production process (Krygin, 2021). Energy costs in agricultural production exceed the standards and are several times higher than in developed foreign countries (Faizov et all, 2007). Therefore, studies to establish the energy efficiency of the applied reclamation measures will make it possible to identify and optimize energy-consuming methods for specific hydrogeological and soil conditions of irrigated areas, up to individual farms and fields. In the problem of energy saving and energy efficiency improvement of land reclamation in agriculture underline the relevance and importance of solving this issue (Balgabaev et all, 2020).

The soil cover of the Republic of Kazakhstan differs from the soils of other countries in its low resistance to anthropogenic pressures and is subject to degradation and desertification processes (Laiskhanov et all, 2016). More than 75% of the total territory is subject to these processes to varying degrees, of which 14% of pastures are severe (Baishanova et al., 2016).

In Kazakhstan, 86% of the territory is occupied by plains, on which the following types of soils are distinguished: chernozems (up to 52 ° N), chestnut (between 52 and 48 ° N), and brown, gray-brown, and gray soil (south of 48 ° NL). Agro-resource and ecological-genetic properties of zonal soils of the Republic of Kazakhstan are shown in Table 1 (Saparov et all, 2006).

Table 1 - Agro-resource and ecological-genetic properties of zonal soils of the Republic of Kazakhstan

Soil genetic indicators	Chernozem ordinary	Southern Chernozems	Dark chestnut	Chestnut	Light chestnut	Sero-zems
Thickness of the humus horizon, cm	60-80	50-70	40-60	35-45	30-40	25-30
Humus, %	6-9	5,0-6,0	3,4-4,6	2,3-3,5	1,5-2,5	1,5-2,2
$C_{гк}C_{фк}$	1,5-2,5	1,2-2,0	1,0-1,5	1,0-1,3	0,9-1,1	0,6-0,8
C:N	10-12	9,5-10,5	9-10	9,5-10,5	8-9	7,5-8,5
Nitrogen, %	0,3-0,6	0,2-0,3	0,15-0,3	0,12-0,25	0,10-0,20	0,09-0,10
P_2O_5, %	0,15-0,25	0,12-0,20	0,12-0,25	0,12-0,20	0,10-0,05	-
K_2O, %	1,8-2,5	2,0-2,5	1,5-2,0	1,5-2,0	1,0-1,5	-
The sum of absorbed bases, mg/eq·100 g of soil	45-55	35-40	25-30	20-25	15-20	10-15
pH of aqueous suspension	6,5-7,0	6,5-7,5	7,0-7,8	7,5-7,9	7,6-8,0	8,1-8,8
Depth occurrence of soluble salts, cm	130-180	125-175	120-145	100-125	80-100	70-90

Research Materials and methods. The objects of research are zonal soils (sierozems, chestnut, and chernozems) on irrigated agricultural landscapes of the Republic of Kazakhstan. Experimental plots (with zonal soils) and agroformations operating on them in different soil and climatic conditions were selected:

- Sierozems zone (pilot plot № 1 (PP-1), experimental production site "Besagash" KazSRIWE (Kazakh Scientific Research Institute of Water Economy), Zhambyl district of Zhambyl region) (Zhaparkulova et all, 2021);
- Chestnut zone (pilot plot № 2 (PP-2), farm "Sergey", Evgenievka village, Aksu district, Pavlodar region);
- Chernozems zone (pilot plot № 3 (PP-3), Omarov farm, Kenesary village, Burabay district, Akmola region).

The study area of PP № 1 belongs to low-carbonate gray soils of the periphery of semi-deserts in the foothills of the Northern Tien Shan. The hydrogeological conditions of the soils of this study area well studied in the works, which indicate that the main soils are gray earth, hydromorphic soils affected by shallow mineralized groundwater (Veselov et all, 2004). In this layer, humus reserves amounted to 1.44%. To reduce the harmful effects of magnesium solonetzization and increase soil fertility reclamation measures are required to introduce calcium-containing chemical ameliorants (phosphogypsum, gypsum, etc.), organic substances (manure, humus, bio humus, etc.) to increase humus reserves in the soil and periodic loosening of the soil horizon to a depth of 40-50 cm.

Zhambyl agricultural experimental station at the Besagash site. Meadow-serozem irrigated loamy sandy soils. The soil-forming rock is sandy loam, the bedding is sand.

A - 0-33 cm Gray, sandy loam, effervesces from the surface, slightly compacted, radicular, transition is clear in color, lumpy-dusty

B - 33-50 cm Grayish-yellow, lumpy-dusty structure, sandy loam, dry, ridged, gradual transition.

BC - 50-67 cm Lighter, loamy (sandy), fresh, compacted, effervescent, gradual transition

C - 67-105 cm Yellowish-yellow, sandy loam, sand towards the end of the profile, moist, structureless, effervescent, compacted.

The study area of PP № 2 belongs to the chestnut soils of the Irtysh depression (Veselov et all, 2004). According to the qualitative composition, irrigation water from the main canal named after K. Satpaev fresh, non-salty (0.835 g/l). According to the chemical composition is - bicarbonate-sodium with a high content of sulfate. According to the classification of water quality, differentiated by chemical composition (ratio Cl^-/SO_4^{2}) belongs to group II, satisfactory (indicators 0.10 g/l). According to the chemical composition is - bicarbonate-sodium with a high content of sulfate (Satpaev, 1965).

The study area of PP № 3 in terms of soils belongs to ordinary chernozems. Groundwater is formed as fissure and fissure-karst, in fissured and karst limestone's, which usually occur at a depth of up to 40 m (Kulagin et all, 2019). Well flow rates are up to 2560 m^3/day (29 l/s), more often 520-688 m^3/day (6-8 l/s), mineralization is low - up to 1 g/l, less often 1.5-2 g/l.

The depth of manifestation of carbonate content is 35-40 cm, gypsum found from a depth of 140-160 cm. In this regard, reclamation measures are required to increase the phosphorus content by applying phosphorus-containing fertilizers (Mueller et all, 2014).

Results and discussion. Since the irrigated agro landscapes of Kazakhstan are located in different natural and climatic zones, and the conditions for these zones were taken into account when assigning various parameters and limits for regulating the water-salt and food regimes in the root layer of soils (Table 2). This application made it possible to substantiate various reclamation measures to manage the soil potential to increase the productivity of irrigated agro landscapes (Vyshpolsky et all, 2010).

Table 2 - Limits of regulation of ecological and reclamation regimes of the root zone of soils for optimizing energy-efficient reclamation technologies for managing the soil potential of zonal soils of the Republic of Kazakhstan

Indicators	Toxicity threshold by soil zones		
	Chernozem	Chestnut	Serozems
Mineralization of irrigation water (Ciw), g/l	0,4 – 0,6	0,4 – 0,6	0,5 – 2,2
Fluching water mineralization (Cwm), g/l	0,4 – 0,8 Cwm≤Csc	0,5 – 1,0 Cwm≤Csc	0,5 – 5,0 Cwm≤Csc
Soil solution concentration (Csc), g/l	Csc≤LPC	Csc≤LPC	Csc≤LPC
Mineralization of groundwater (Cg) used for subirrigation, g/l	0,6 – 0,8	0,6 – 1,5	1,0 – 3,0
Groundwater level, m: at Cg = 0.5 -1.0 g/l at Cg = 1 – 3 g/l at Cg = 3 – 5 g/l	1,0 – 1,5 1,5 – 2,0 1,8 – 2,3	1,0 – 1,2 1,5 – 1,8 2,0 – 2,5	0,8 – 1,0 1,2-1,5 2,3 – 3,0
Salinity chemistry	soda-sulfate, sulfate	sulfate, soda-sulfate, chloride-sulfate	chloride-sulfate, soda-sulfate, sulfate
Toxicity threshold	LPC*	LPC	LPC
Absorption capacity, mg-eq/100 g of soil	32-40	23-30	10-15
Na+ content in soil-absorbing complex (SAC), %	≤5-10	≤5-7	≤3-5
Content of Mg2+ in SAC, %	≤30	≤30	≤15-30
Hydrogen indicator (pH)	7-7,5	7,3-7,8	7,8-8,2
Regulation of the water regime of soils, in fractions of the lowest moisture capacity (LMC**)	0,75 - 0,90	0,70 – 8,5	0,65-0,80

*- the limit Permissible Coefficient
**- lowest moisture capacity

The reproduction of soil fertility requires a certain amount of energy resources, depending on the type of soil (Kireycheva et all, 2008). For chernozems, it averages about 1000 GJ/ha, chestnut soils - 700 GJ/ha, gray soils - 330 GJ/ha (Volobuev, 1974). Chernozems and chestnut soils, due to their most complex structural organization, require increased resources to ensure effective fertility.

The methodology for assessing the energy potential of soils is based on taking into account the solar energy coming to the Earth's surface and its expendable part: for water consumption (evaporation and transpiration) of cultivated crops, photosynthetic activity of plants, physical and chemical processes in the soil, including during humus formation (Bulatkin, 1986). Its action is aimed at increasing the efficiency of soil potential, achieving environmentally sound productivity of irrigated lands in various soil and climatic zones (Nerpin et all, 1975).

The most important parameters of the ratios in this system are total radiation, radiation balance, albedo, effective radiation, sunshine duration, cloudiness and other indicators of the value, which are given in according to actinometrical measurements at meteorological stations in Kazakhstan (Table 3) (Gitay et all, 2002).

Table 3 - Characteristics of the sunshine duration according to weather stations of the Republic of Kazakhstan

Admini-strative areas	Name of weather stations	Average annual values of sunshine characteristics			
		duration, h	standard deviation, h	average duration per day with sun, h	number of days without sun, days
Akmola	Shchuchinsk	2452	177	7,7	47
Pavlodar	Aksu	2459	171	7,7	46
Zhambyl	Zhambyl	2982	92	9,0	33

For the conditions of Kazakhstan, the values of the radiation balance were calculated for four zones - from the plain (R=200-219 kJ/cm^2) and foothill-plain (R=148-200 kJ/cm^2) to the foothill (R=148-200 kJ/cm^2) and mountain (R=88-100.5 kJ/cm^2). In our studies, indicators were used both instrumentally measured at meteorological stations (Q, S, R, D, etc.). The energy supplied to irrigated fields is accumulated in its two main objects: in green plants and soil organic matter, which ensures an increase in productivity and plant growth and humus content in the soil. The additional amount of energy that is necessary for the full realization of the production potential is 22.1-24.5 kJ/ha.

The energy of soil formation is spent on three main components: trapspiration and evaporation - 95-99.5%, biological processes - 0.5-4.0% and erosion (washout, weathering) about 1% (Vyshpolsky et all, 2005). The energy accumulated in biomass production is the energy costs for photosynthesis and humus formation, which, according to V.R. Volobuev - 1% of the incoming energies and is estimated through the bioenergetic potential of BEP (Volobuev, 1974). It includes the energy accumulated in BEP_{hum} soil humus and in BEP_{plant} plant phytomass production (Adilbektegi et all, 2019). The BEP indicator allows you to assess the amount of energy needed to create a production potential (Kireycheva et all, 2006).

The analysis and generalization of the above data made it possible to establish the values of the elements of the energy balance in relation to various types of soils (Table 4).

Table 4 - Values of energy parameters of zonal soils of Kazakhstan

Name of soil types	Values of energy balance components, kJ/cm^2			
	Radiation balance, R	Soil formation energy, Qp	Bioenergetic potential, BEP	Turbulent energy return, J
Chernozems	191,0	114,6	1,9	74,5
Chestnuts	203,0	125,9	2,0	75,1
Sierozems	238,0	157,2	2,3	78,5

Radiation balance R is from 191 to 238 kJ/cm^2, the soil formation energy is, on is from 114.6 to 157.2 kJ/cm^2, the turbulent energy return J is from 74.5 to 78.5 kJ/cm^2. These values for chestnut soils have intermediate values - 203.0, respectively; 125.9 and 75.1 kJ/cm^2.

The value of turbulent energy return J, which affects the increase in land productivity, is the smallest in the zone of chernozems (about 74.5 kJ/cm^2) - the most fertile soils and do not require relatively large volumes of reclamation compared to the zone of distribution of gray soils (J = 78.5 kJ/cm^2). Under conditions prior to reclamation measures, this value averages about 100.0 kJ/cm^2 for chernozems, 135 kJ/cm^2 for chestnut soils, and 185 kJ/cm^2 for gray soils. Consequently, the most significant decrease in the value of this indicator can be achieved as a result of certain reclamations in the zone of gray soils - by 106.5 kJ/cm^2, the smallest (by 25.5 kJ/cm^2) - on chernozems, and on chestnut soils - by 59.9 kJ/cm^2, increasing their productivity according to these values (Budyko, 1956).

Based on the above data on the bioenergetics potential of various types of soils, we estimated the production potential of reclaimed lands with chernozems, chestnut, and gray soils. It reflects the maximum possible accumulation of photosynthesis energy by plants of cultivated crops, which makes it possible to ensure the accumulation of the main products in the total biomass up to 12-16 thousand fodder units per irrigated hectare (Bulatkin, 1986). The results obtained correlate well with the data on the potential (maximum) and actually achieved yields of the leading agricultural crops on the irrigated lands of Kazakhstan and its border regions (Table 5).

Table 5 - Achieved maximum and real prospective levels of crops yields on irrigated lands

Irrigated crop	Achieved maximum yield		Real perspective yield	
	t/ha	thousand feed units per 1 ha	t/ha	thousand feed units per 1 ha
Wheat (for grain)	5,5-8,7	6,6-10,4	4,5-5,0	5,4-6,0
Corn (for grain)	8,0-12,5	10,7-16,8	6,5-9,0	8,7-12,1
Cotton (raw)	4,5-5,5	5,4-6,6	3,5-4,0	4,2-4,8
Corn (for silage)	65,0-75,0	10,4-12,0	45,0-60,0	7,2-9,6
Alfalfa (for hay)	14,0-21,9	6,9-10,7	9,0-10,0	4,4-4,9

Potential, actually possible and other levels of productivity of a plant community or crop yields achieved by applying yield-programming technology. It based on the arrival of photo synthetically active radiation (PAR) and the efficiency of photosynthesis. This is that part of the total solar radiation with wavelengths of 380-710 nm, which absorbed by plants in the process to create organic matter. To calculate the income, dependence (1) is used (Kayumov, 1989):

$$Q_{PAR}=0,43S+0,57D, \text{ kJ/cm}^2, \quad (1)$$

where: Q_{PAR} - photo synthetically active radiation (PAR);

S - Direct solar radiation to a horizontal surface;

D - Scattered solar radiation.

The annual course of the PAR is similar to the annual course of the total radiation, which depends on the geographic latitude of the territory (Berlyand, 1960). If it is necessary to find the value of the PAR arrival with latitudes between the indicated degrees, it determined by interpolation.

To determine the energy intensity of land reclamation measures, energy characteristics used, including specific indirect and direct costs (Table 6) (Prishchepa et all, 1989).

Table 6 - Energy intensity of land reclamation activities depending on the type of ameliorant

Name of reclamation measures	Unit composition		Number of attendants	Labor costs, pers. hour/ha	Energy costs, MJ/ha				Total costs, MJ/ha
					Indirect		straight		
	tractor brand	agricultural mashine			mashine exploitation	agricultural mashine	fuel, electricity	maintenance workforce	
Application of organic amelio-rant (manure, bio humus), 20 t/ha, including:			3	2,33	577,39	521,87	3574,88	141,67	4815,81
- loading of fertilizers	MTZ-82	PF-0,75	1	0,67	54,87	33,77	378,18	40,74	507,56
- transportation	MTZ-82	2PTS-6	1	0,3	109,35	14,82	169,34	18,24	311,75
- fertilizer spreading	K-701	PRT-16	1	1,36	413,17	473,28	3027,36	82,69	3996,17
- energy equivalent									8400,00
Application of mineral chemicals (gypsum, phosphogypsum), 15 t/ha, including:			3	1,135	369,67	509,84	2682,57	106,40	3668,48
- loading ameliorant	MTZ-82	PF-0,75	1	0,50	40,95	25,2	282,23	30,40	378,78
- transportation	MTZ-82	2PTS-6	1	0,23	18,84	11,36	129,82	13,98	174,00
- scattering ameliorant	K-701	PRT-16	1	1,02	309,88	473,28	2270,52	62,02	3115,70
- energy equivalent									3780,00
Application of liquid chemical ameliorants (liquid ammonia) 100 kg/ha, including:			12	36,24	12,86	-	477,0	1213,99	1703,85

- loading	Manually	-	3	3,0	-	-		300,0	300,00
- transportation	GAZ-53Б		1	0,24	12,86	-	477,0	14,59	504,45
- unloading	Manually	-	3	3,0	-	-	-	300,0	300,00
- solution preparation	Manually	-	2	2,0	-	-	-	133,20	133,20
- application of the solution	Special device	-	2	7,0	-	-	-	466,20	466,20
- energy equivalent									7118,00
Note - the energy equivalent of 1 kg of physical mass of manure is 0.42 MJ, phosphogypsum - 0.252 MJ, ammonia - 71.18 MJ.									

The largest share of costs (58-60%) is fuel and electricity, 24-25 % - the operation of agricultural machinery and tractor equipment, the labor of workers and maintenance personnel - 6-8%. In general, in order to obtain potential productivity during reclamation, it is necessary to invest much less energy resources (almost on all types of soils) than to ensure accelerated reproduction of soil fertility.

One of the important indicators that require taking into account the processes that lead to the loss of energy (fertility) of the soil is the soil energy resource coefficient (SERC) (Kiryushin et all, 1993). It makes it possible to judge changes in the energy state of the soil during reclamation activities. Under natural conditions (before reclamation), the values of the coefficient for southern chernozems are 0.50-0.55, chestnut soils 0.30-0.35 and gray soils 0.12-0.15 (Korinets, 1992).

In our studies, in the implementation of various types and complex of reclamation, the following indicators were obtained (Table 7).

Table 7 - The value of the coefficient of energy resource of various types of soils (SERC) when carrying out individual types and a complex of reclamation

Soil type	The use of certain types and a complex of reclamation				Complex of events
	water (for irrigation)	chemical (phosphogypsum)	biological (manure application)	agrotechnical (deep loosening)	
Chernozems (Akmola region)	0,81	0,86	0,84	0,83	0,89
Chestnut (Pavlodar region)	0,63	0,72	0,68	0,67	0,79
Sierozems (Zhambyl region)	0,58	0,66	0,62	0,61	0,73

Conclusion. The results of the study of hydrogeological and soil features of zonal soils in the study areas showed that: Sierozems soils, hydromorphic soils, subject to the influence of shallow mineralized groundwater. Analysis of the cationic composition of the SAC shows that the dominant cation is calcium, which ranges from 57.5 to 62.1% of the total salts. Magnesium reserves vary within 37.1-41.7% of the total SAC, which indicates magnesium solonetzization of soils.

Chestnut soils, humus horizon of medium thickness (0-40 cm), the content of mobile forms of nutrients (NO_3, P_2O_5, K_20) in the root layer are low. High content of magnesium and sodium cations is in the soil-absorbing complex. According to the qualitative composition, groundwater is slightly mineralized, slightly brackish (1.674 g/l). By chemical composition is - bicarbonate-sodium with a high content of sulfate (Kupriyanov V. N., 2020).

Chernozems soils, non-saline, rich in humus, the thickness of the humus horizon is 45 cm on average, there is a deep manifestation of carbonate content. The amount of exchangeable sodium along the profile does not exceed 1%, which indicates the absence of solonetzization. They are poor in phosphorus; their total content in the soil is about 0.1%.

For all studied zonal soils, in order to obtain maximum yields, it is necessary to carry out reclamation measures that increase the bioenergetics potential of soils and plants. To determine the energy intensity of land reclamation measures, energy characteristics were used, including specific indirect and direct costs. Energy intensity indicators were divided into 2 groups: by types of costs and by reclamation effect. The energy intensity of the application of ameliorative measures varies from 3780.0 to 8400.0 MJ/ha, depending on the type of ameliorant. In the structure of the total costs for land reclamation works, accordingly, it changes from 1703.85 to 4815.81 MJ/ha.

The largest share of costs (58-60%) is fuel and electricity, 24-25 - the operation of agricultural machinery and tractor equipment, the labor of workers and maintenance personnel - 6-8%. In general, in order to obtain potential productivity during reclamation, it is necessary to invest much less energy resources (almost on all types of soils) than to ensure accelerated reproduction of soil fertility.

One of the important indicators that require taking into account the processes leading to the loss of energy (fertility) of the soil is the coefficient of the energy resource of the soil. Because of the ongoing complex reclamation measures on sierozems, chestnut and chernozems soils, the energy resource coefficient can be increased, respectively, to 0.73; 0.79 and 0.89.

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