

Change of Physical and Water-Physical Properties of the Reclamation Pratal Saline Lands of Submountain Plains of Ili Alatau

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Abstract—The resalinization of irrigable earth brings an enormous damage to agriculture. Worsening of the water-salt mode of soil results to the decline of the productivity of irrigable earth and fall of part of irrigable plough-land from an agricultural turn. Researches were conducted on the before reclaimed pratal saline lands in the natural conditions and under the lucerne (in the submountain plains of Ili Alatau, in the farm of Teskensu, of the Almaty region). Were investigated such parameters as volume weight, unit weight, porosity of soils, maximal hygroscopicity, wilting moisture, the minimum moisture-capacity.

Keywords—the reclaimed pratal saline land, volume mass, porosity of soils, maximal hygroscopicity.

I. INTRODUCTION

ALMOST all territory of Republic of Kazakhstan belongs to the internal-drainage area of dry land, where because of its physic-geographic features the large areas of salt soils of the CIS are concentrated and it is one of the saltiest parts of Central Asia. This territory in all geological epochs was the zone of intensive salt reserve (at the average 1,6 tons/km² per year) and its modern level (20-40 tons/km² per year) is one of the highest one [1].

The resalinization of irrigable earth brings an enormous damage to agriculture. Principal reason of this harmful phenomenon is an absence of engineering collector-drainage network in the conditions of weak natural outflow of subsoil waters. Worsening of the water-salt mode of soil results to the decline of the productivity of irrigable earth and fall of part of irrigable plough-land from an agricultural turn.

II. MATERIALS AND METHODS

As we know, physical and water properties of soils, being the function of past processes of soil formation, by turn makes big influence on its direction and rate of further soil formation process. The use of this position allows to estimate correctly the genetic features of soils and on their basis to work out most acceptable agrotechnical and reclamative measures for optimization their fertility [2, 3].

Therefore the study of physical and water properties of the investigated soils gives an opportunity to define their changes and efficiency during land-reclamation.

Researches were conducted on the before reclaimed pratal

saline lands in the natural conditions and under the lucerne (in the submountain plains of Ili Alatau, in the farm of Teskensu, of the Almaty region). Were investigated such parameters as volume weight, unit weight, porosity of soils, maximal hygroscopicity, wilting moisture, the minimum moisture-capacity.

III. THE RESULTS OF RESEARCHES AND DISCUSSION

The volume weight. A density of constitution of soil is very dynamic property in superficial horizons of soil and is in difficult dependence on mechanical composition, structural state, maintenance of organic substance, easily soluble salts, root-inhabited systems of plants. It suffers a considerable change at irrigation and especially by mechanic tooling of soils.

It was determined by data of scientists, that optimal for development of cultural plants is a density of arable layer within the limits of 1,10-1,35 g/cm³. At the density of constitution of soil under below or higher than this limit the water-air, thermal and food modes of soils get worse, the growth, development of plants and harvest of agricultural cultures go down.

As the data of the investigated soils showed, before washing of the lowest quantity of volume weight was characterized at the top horizon 0-40 cm (1,19-1,26), where the maximal amount of salts and organic substances are concentrated. Here the sodium sulfate prevails in the content of salts, and, as is generally known, it is characterized with middle solubility, hygroscopicity and is found in such two forms as mirabilite Na₂SO₄*10 H₂O and thenardite Na₂SO₄*H₂O. The mellowing on soil mass has influence on the transition of them from one form to another.

Downward on the profile of soil - deeper at 40 cm happened sharp increase of volume weight to 1,62 g/cm³ and its composition by the Kachinskiy scale estimated as strongly compressed [4].

The capital washing, rendering the saline operating on the zone of aeration of soils and lands, causes the change of quantitative and quality composition of salts, and consequently to the volume weight of soils on all profile [5]. Compression of overhead horizons of soils, as a result, of its salinization made it possible to explain the shrinkage of soils, related to alteration of soil mass.

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TABLE I. Change of volume weight of the pratal saline lands under the post reclamation methods, g/cm³

Depth, cm	Before washing (1986)	After washing (1987)	After the three years of cultivation of lucerne (1989)		The post reclamation period (2015)
			75% from MMC	85% from MMC	
0-20	1,19	1,35	1,36	1,31	1,39
20-40	1,26	1,39	1,38	1,35	1,40
40-60	1,53	1,47	1,42	1,43	1,44
60-80	1,56	1,53	1,50	1,49	1,50
80-100	1,60	1,58	1,56	1,53	1,52

The cultivation of lucerne, on the preliminary desalinated soils, in three years, with the mode of irrigation 75% from MMC, did not have influence on the quantity of volume weight. And on the variant of 85% from MMC, where the higher washing water mode was supported, this index went down to 1,31-1,35 g/cm³. The decline of volume weight happened in lower horizons too, as compared with the initial state.

The substantial change of density of addition of pratal saline lands happened, as a result, of the capital washing and cultivation on the desalinated soil of culture of lucerne. Structureless mellow soil in overhead 0-40 cm layer, and strongly compressed below 40 cm layer soil purchased a normal structure and good enough constitution.

After the continuous post-reclamative period (2015), in the conditions of the productive sowing some compressions of overhead horizons were occurred. The volume weight in a layer 0-100 cm was 1,39-1,52 g/cm³.

The unit weight. Unit weight of hard phase of soils, as is generally known, depends on mineralogical composition, maintenance in it of organic substance and salts. As the data of table 2 shows, unit weight of hard phase of overhead horizons of pratal saline lands before washing (1986) was 2,63-2,66, with an increase the depth to 2,70-2,75 g/cm³.

TABLE 2. Change of unit weight of the pratal saline lands under the reclamation methods, g/cm³.

Depth, cm	Before washing (1986)	After washing (1987)	After the three years of cultivation of lucerne (1989)		The post reclamation period (2015)
			75 % from MMC	85 % from MMC	
0-20	2,63	2,69	2,69	2,59	2,61
20-40	2,66	2,71	2,72	2,61	2,66
40-60	2,70	2,72	2,73	2,68	2,70
60-80	2,75	2,73	2,71	2,71	2,72
80-100	2,72	2,73	2,71	2,73	2,74

Under influence of washings and tilled lucerne there is change: after washing the increase is marked in overhead horizons (2,69-2,71 g/cm³), that, maybe, it is related to making of mechanical composition and compression of profile of soil heavier after washing.

In a cultivation period (under the lucerne of the 3rd of life) in overhead horizons (on a variant 85% MMC) there is reduction of unit weight of soil to 2,59-2,61 g/cm³.

Some reduction of unit weight after realization of washings takes place in a cultivation period under an lucerne and mainly in overhead, more humus horizons due to the increase of the yellowed bits and pieces and root mass of lucerne.

Determination of unit weight of soil after the continuous post-reclamative period showed, that its further reduction is in a layer 0-40 cm to 2,57-2,59 g/cm³. Apparently, it is explained by the increase of amount of organic substances (humus - 2,98 %) and yellowed bits and pieces of agricultural cultures.

Porosity of soils. Porosity determines many properties of soil such as moisture-capacity, capillary getting up and evaporation of moisture, motion of moisture, nourishing elements and salts in soil, availability of moisture to the plants, maintenance of air in soil, effective volume of development of rootage of plants and vital functions of microorganisms.

The detailed study of porosity of different types of soils is conducted by N. Kachinskiy, M. Polskiy; A. Doyarenko, A. Rode, A. Sukhachev, D. Manukyan and etc. [4, 6, 7].

According to the quantity of volume weight and unit weight the total porosity of soil before washing (1986) in a layer 0-40 cm was 54,8-52,6% (table 3), in low layers it goes down to 43,4-41,2% and estimated as unsatisfactory.

TABLE 3. Change of total porosity of the pratal saline lands under the reclamation methods, g/cm³.

Depth, cm	Before washing (1986)	After washing (1987)	After the three years of cultivation of lucerne (1989)		The post reclamation period (2015)
			75 % from MMC	85 % from MMC	
0-20	54,8	49,8	49,5	49,6	46,7
20-40	52,6	48,7	49,3	48,3	47,3
40-60	43,4	46,0	48,0	46,7	46,6
60-80	43,3	44,0	44,7	45,1	44,8
80-100	41,2	42,2	42,5	44,0	44,5

After realization of washings and cultivation of lucerne - in cultivation period (1989), and also after the continuous post-reclamative period (2015) in the conditions of the productive sowing of agricultural cultures there is some decline of total porosity in a meter layer - 47,3 - 44,5 %, that correlates with the increase of by volume weight of soil.

Maximal hygroscopicity (MH). Soil moisture in a state of maximal hygroscopicity is firmly constrained and it moves as steam, and that is why does not dissolve salt, quite inaccessible to the plants and is a "dead supply".

The quantity of MH in a soil profile before washing (1986) fluctuated within the limits of 7,25-4,96%. Some increase of MH in overhead horizons as compared with low layers is explained by higher maintenance in soil of humus and water-soluble salts. Stocked moisture, corresponding MH, before washing in a meter layer was 838,3 m³/ha, after washing (1987) its size was 6,37-4,73 %, with the supply of moisture in the meter layer of 785,2 m³/ha. It is necessary to suppose washing reduces a value MH of soils, because of washing easily soluble hygroscopic salts. So, according to data of M.Umarov [8], increasing of degree of salinization to 1 and

more percentage on a dense remain increases MH in 2 times against its indexes in the soils washed from salts.

In a cultivation period - under the lucerne of 3rd of life there is some reduction of quantity of MH, thus on a variant 85% from MMC is more noticeable, than on a variant 75% from MMC (in a layer 0-20 cm - 5,20 and 5,65 %, respectively), and in a post-reclamative period - 5,01

Quite inaccessible for plants supply of moisture, i.e. its dead supply, in the meter layer of soil was 646,5 and 709,5 m³/ha, and after the continuous post-reclamative period - 641,10 m³/ha.

Wilting moisture (WM). Wilting moisture of plants depends on genetic properties of soils, type of plants and phases of their development. On availability for plants, soil moisture of category of WM behaves to difficult of access, that is composed from maximal maintenance of firmly linked and partly mellow constrained moisture [9].

A quantity of WM is a border between accessible and inaccessible for plants soil moisture. At reduction of soil moisture to the quantity of WM the physiological and biochemical processes of plants are broken, their height stops, wilting and even death comes.

Before washing (1986) the quantity of WM of plants in a meter layer fluctuated within the limits of 9,71-6,64%, that corresponds to the supply of inaccessible for plants moisture as 1141,8 m³/ha.

After washing (1987) the index of WM went down a little bit till 8,53-6,34% in an overhead meter layer, that in a count on a supply is equal to 1051,7 m³/ha. Under the lucerne of 3rd of cultivation (1989) the quantity of WM of plants in connection with some salinization of soil profile notably went down and in the overhead meter layer fluctuated on a variant of 75% from MMC within the limits of 7,57-5,96, and on a variant 85% from MMC - 6,97-5,53%, with corresponding supplies in a meter layer 950,6 and 865,8 m³/ha, and in the post-reclamative period - 859,2 m³/ha.

Thus, during the washing of salts from a soil profile in a cultivation period there is a decline of quantity of WM and inaccessible moisture, the interval of accessible for plants moisture increases.

The minimum moisture-capacity. As is generally known, the minimum moisture-capacity (MMC) characterizes the maximal amount of moisture, which soil can retain in itself in the suspended and equilibrium state after its abundant moistening and free flowing down of gravitational moisture. It is the most essential agronomical and soil-hydrogeological constant, on the basis of that all calculations of supplies of soil moisture, including accessible parts for the plants, washing norms, mode of irrigation and other, are conducted.

The quantity of MMC, on classification of A. Rode [10], behaves to the form of the free suspended moisture, and on availability for plants - to the category easily accessible. The minimum moisture-capacity consists of sum of firmly linked, mellow linked and capillary-suspended moisture.

After scientists' work, it was found that the quantity of MMC depends on granulometric composition, maintenance of humus, density of composition, salinization, micro and macrostructure, character of porosity of soil etc.

In the investigated soils the quantity of MMC before washing (1986) fluctuated in a meter layer within the limits of 23,53-22,56% from the weight of soil.

After washing there is some increase to 26,50-24,10%, and after the 3rd of cultivation of lucerne its quantity appears more higher - 27,25-25,30%, and in a post-reclamative period (2015) in a meter layer - 27,04 - 25,91 (table - 4).

In conversion on a supply of easily accessible for the plants of MMC in a meter layer was: before washing - 3300,5, after washing - 3684,1 m³/ha; after the 3rd of cultivation of lucerne - on a variant with the irrigation 75% from MMC was equal to 3741,8 on a variant 85% from MMC was equal to 3737,0 m³/ha. After the continuous post-reclamative period reserved moistures were 3799,8 m³/ha.

TABLE 4. Change of water property of the pratal saline lands and moisture reserves of various category under the reclamation methods, %/m³/ha, respectively.

Depth, cm	Before washing (1986)			After washing (1987)			After the three years of cultivation of lucerne (1989)						The post reclamation period (2015)		
	MH	WM	MMC	MH	WM	MMC	75 % from MMC			85 % from MMC			MH	WM	MMC
							MH	WM	MMC	MH	WM	MMC			
0-20	7,25 172,5	9,71 231,1	23,29 554,3	6,37 171,9	8,53 230,3	26,50 715,5	5,65 153,6	7,57 205,9	26,77 728,1	5,20 136,2	6,99 182,6	27,25 713,9	5,01 137,25	6,72 184,09	27,04 740,92
20-40	6,35 160,0	8,51 214,4	22,74 573,0	5,46 151,8	7,31 203,2	25,60 711,7	5,24 144,6	7,02 193,7	26,30 725,8	4,83 130,4	6,47 174,6	26,80 723,6	5,03 137,74	6,74 184,64	27,02 740,18
40-60	5,89 180,2	7,89 260,4	22,56 690,3	5,33 156,7	7,14 209,9	24,77 728,2	4,59 130,3	6,15 174,6	25,91 735,8	4,22 120,6	5,65 161,5	26,07 745,6	3,95 108,35	5,30 145,24	27,10 743,48
60-80	5,35 166,9	7,16 223,4	23,53 734,1	5,08 155,4	6,80 208,0	24,10 737,4	4,74 142,2	6,35 190,5	25,30 759,0	4,46 132,9	5,97 177,9	25,90 771,8	4,42 130,12	5,93 174,47	26,56 781,23
80-100	4,96 158,7	6,64 212,5	23,40 748,8	4,73 149,4	6,34 200,3	25,06 791,9	4,45 138,8	5,96 185,9	25,48 793,1	4,13 126,4	5,53 169,2	25,56 782,1	4,19 128,95	5,60 172,54	25,91 794,30
0-100	838,3	1141,8	3300,5	785,2	1051,7	3684,7	709,5	950,6	3741,8	646,5	865,8	3737,0	641,10	859,2	3799,8

Thus, as data shows, salinization of pratal saline lands favorably affected on the quantity of freely-accessible moisture, namely the provision of agricultural plants with accessible moisture, improves, because during the cultivation a quantity of maximal hygroscopicity reduces and MMC of soil increases and on the estimated scale of N. Kachinskiy [4] passes from unsatisfactory to satisfactory state.

IV. CONCLUSION

After the continuous post-reclamative period (2015), in the conditions of the productive sowing some compressions of overhead horizons were occurred. The volume weight in a layer 0-100 cm was 1,39-1,52 g/cm³.

Determination of unit weight of soil after the continuous post-reclamative period showed.

After realization of washings and cultivation of lucerne - in cultivation period (1989), and also after the continuous post-reclamative period (2015) in the conditions of the productive sowing of agricultural cultures there is some decline of total porosity.

In a cultivation period - under the lucerne of 3rd of life there is some reduction of quantity of MH.

During the washing of salts from a soil profile in a cultivation period there is a decline of quantity of WM and inaccessible moisture, the interval of accessible for plants moisture increases.

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