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RESEARCH OF THE PHYSICAL AND CHEMICAL PROPERTIES OF THE AUTOMORPHIC CHERNOZEM SOLONETZS ON THE TERRITORY OF THE REPUBLIC OF MOLDOVA

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Abstract

In condition of the Republic of Moldova activities for improvement of the automorphic chernozem solonetzs and secondary solonetzized soils by irrigation meet severe difficulties related to the lack of gypsum in the republic. In such a situation, there appeared a need to use and test new amendments obtained basing on industrial waste which contains components of calcium and acid pH. Automorphic chernozem solonetzs and complexes of soils with different degree of solonetization are spread in all soil provinces of the Republic of Moldova, but the most important areas are located in Ciuluc Hills steppe, on the periphery of Codri Plateau as well as in Southern Moldova Plain. Automorphic chernozem solonetzs subtype was formed and has evolved on deposits of salty Neogene clay which contain 1-2% of soluble salts with sodium sulfate predomination. It is important to note that parental rocks of automorphic solonetz are situated at a shallow depth of 50-100 cm. Halogenesis processes from the soil of the republic are caused not only by natural factors such as soil formation rocks with high content of soluble salt or highly mineralized groundwater. With the beginning of chernozems irrigation process, soils salinization and more frequently, secondary solonetization of zonal soils was recorded. Zonal soil alkalization is highly intensified as a result of irrigation with water from local sources such as inland rivers, ponds and reservoirs. These are characterized by high degree of mineralization, alkaline pH and unfavorable chemical composition. Sodium compounds predominate in soluble salts composition.

Key words: *automorphic chernozem solonetzs, Codri Plateau, irrigation, secondary solonetzized soils.*

INTRODUCTION

Automorphic chernozem solonetzs subtype was formed and has evolved on deposits of salty Neogene clay which contain 1-2% of soluble salts with sodium sulfate predomination. It is important to note that parental rocks of automorphic solonetz are situated at a shallow depth of 50-100 cm.

In the geomorphological and, especially, lithological conditions of the republic, the spatial distribution of the automorphic alkaline soils has a diffuse, insular character, with formation of well-defined areas within the zonal soils, predominantly chernozems and greyzems. In areas with high share of solonetzs, crop productivity decreases by 40-60%.

Halogenesis processes from the soil of the republic are caused not only by natural factors such as soil formation rocks with high content of soluble salt or highly mineralized groundwater. With the beginning of chernozems irrigation process, soils salinization and more frequently, secondary solonetization of zonal soils was recorded. Zonal soil alkalization is highly intensified as a result of irrigation with water from local sources such as inland rivers, ponds and reservoirs. These are characterized by high degree of mineralization, alkaline pH and unfavorable chemical composition. Sodium compounds predominate in soluble salts composition.

In condition of the Republic of Moldova activities for improvement of the automorphic chernozem solonetzs and secondary solonetzized soils by irrigation meet severe difficulties related to the lack of gypsum in the republic. In such a situation, there appeared a need to use and test new amendments obtained basing on industrial waste which contains components of calcium and acid pH.

MATERIALS AND METHODS

The research started with the assessment of natural conditions and delimitation of soil units borders. For mapping the comparative-geographical method of V.V. Dokuchaev was used, which allows establishing the natural links between soils and soil formation factors (Составление и использование почвенных карт, 1987). Utilization of geographic information system (GIS) and mapping modern equipment during research activities were carried out within the territory of the pilot areas. The researches were conducted in 2016-2017 by the working team.

For study development, there were used the following materials: maps of territorial organization of communes from the pilot areas at scale of 1:10000; soil maps at 1:10000; topographic plans at 1:10000; digital map of soil cover of Moldova at 1:10000; remote sensing materials "ortophoto" at 1:5000 of Land Relations and Cadastre Agency (LRCA); "Digital Elevation Model (DTM)" of LRCA.

Mentioned materials were connected to the national reference system MoldRef-99. Subsequently thematic layers ("Hydro", "Terrain", "Settlements", "Soil", etc.) as well as structure of the database parameters were formed. Next step consisted in digitization of soil and territories with vineyards and orchards plantations polygons that can be used in irrigation. A digital model of the elevation was developed at a scale of 1:1000 and attributive information for each area was introduced. There were performed field research activities for actualization of soil, infrastructure and land degradation polygons which were estimated digitally in the office from geospatial remote sensing materials. The works were made in the MapInfo (2D) and ArcGIS (3D) software and in accordance with "Instructions on soil survey to attribute of land for state and public needs" approved in 1991 (Instrucţiunile privind …, 1994) "Regulation on the content of general Land Cadastre documentation" approved by the Republic of Moldova Government Decision no. 24 of 11.01.1995 (Regulamentului cu privire la ... 1995).

RESULTS AND DISCUSSIONS

For assessment of automorphic solonetzs amendments and fertilization efficiency, field experience was established which included following variants: 1. Reference (control) soil (no amended and no fertilized soil); 2. Defecation sludge; 3. Defecation sludge + manure; 4. Defecation sludge + manure + NPK; 5. Defecation sludge + NPK. Organic fertilizers were administered with a dose of 60 t/ha. The applied amount of chemical fertilizer (NPK) was equivalent to the nutrient content of 30 t of manure. In the mixed fertilizers version, the organic fertilizer dose was 30 t/ha. Some of the main criteria for solonetzs quality assessment during improvement period are the content and composition of the soluble salts. The experimental field soil is of sulphate salinization. The soil profile is clearly distinguished by the total content of soluble salts. Thus, the superficial horizon is characterized by a low degree of salinization, the central part of the profile is included in moderate salinization values class, and the parental material is moderately to strongly salinize. Analysis of obtained material of chemical composition and soluble salt content demonstrates that the predominant component is sodium sulphate. In soil upper horizons Na_2SO_4 is about 49%, and in the underlying and the parental material this component accounts up to 85% of the total amount of salts. Regarding the impact of amendment and ameliorative fertilization on the soluble salt composition, an increasing content of calcium bicarbonate and calcium sulphate, which are harmless to agricultural plants, is observed. The calculations show that in the horizon treated with defecation sludge and fertilizers, the sum of toxic salts is 59-76% of the soluble salt total content, and in the reference (control) soils this index reaches values of 85-90%. The soil in the variants treated with calcium waste and fertilizers is determined as slightly solonetzized (6-9% Na^+), and the one from the unfertilized variant is included in the moderately solonetzized category (11% Na^+). Exchangeable Ca^{2+} content has increased in comparison with reference (control) soil with 4-6 me/g soil, which is equivalent to 72-78% of bases sum. They show that the coarse and medium sand total content is insignificant and makes 0.02-0.18%. A higher percentage is characteristic for fine sand. There statistically significant difference in the silt fraction content. Thus, coarse silt prevails with a share of 23-30%, followed by fine (17-24%) and medium silt (8-11%). A high content of fine clay is characteristic for automorphic chernozem solonetz texture. In distribution of particles with a diameter of less than 0.001 mm within the soil profile, there was recorded an increase of 6-13% in the 30-50 cm layer which includes in its composition the biggest part of sodium clay-illuvial horizon (Btna). The character of physical clay distribution is identical to that of fine clay, but in this case it is observed only an increasing trend of the fractions with a diameter of less than 0.01 mm in the Btna horizon. According to the content of this fraction and Kacinski classification, the granulometric composition of automorphic chernozem solonetz is finely clay (Ursu, 2011).

Characteristics of soil layer. According to pedo-geographical regionalization, study area is included in First pedo-geographical Zone of Hilly Silvosteppe of Northen Moldavian Plateau, district II of chernic and leached chernozems of Northen Plain Steppe, rayon III of Steppe of Balti Plateau, subrayon III a of Steppe of Ciuluc Hills with chernic and solonetized chernozems (Instrucţiunile privind cercetările pedologice …, 1987; Урсу, 1980).

For the study area, soil cover map at 1:10000 scale was developed in digital format. In the limit of the area there were found 135 polygons covering an area of 2576.44 ha. The structure of the soil cover is formed by about 64% chernozems where the calcic prevails with 28.4%, widespread at altitudes of 67-257 m and the average slope of 6.07º. Ordinary chernozem with a share of 28.1% are located within altitudes of 63-224 m with an average slope of 4.4º. Chernic chernozem can be found between altitudes of 78 m to 252 m, with the average slope degree of 4.58º and with area 7.8% of total soils area (Tables 1 and 2).

On the second place solonetzs and saline soils are situated (14.8%). Chernozem-like soils occupy about 11%. Share of alluvial soils is 7.8%, landslides constitute 2.1%. Weighted average bonitet (system of land fertility appraisal) is 62 points.

Types of soil degradation are very different in the catchment area. Approximately 32.6% (841.07 ha) of land are subject to halomorphic processes (Table 3). Water erosion extends on about 25% of the total area. Chernic, ordinary and calcic chernozems are eroded at 55.7%, 41.7% and 23.8%, respectively.

Leached chernozem-like soils are eroded at about 87%. The total area of soils with different erosion degrees is 643.68 ha.

Slightly eroded soils prevail with a share of 59% formed at an average altitude of 116 m, with average slope degree of 5.75º. Moderately eroded soils with a share of 37% are located at an average altitude of 137 m, with average slope degree of 7.85º. A strongly eroded soil occupies only 3.6% and spread at an average elevation of 171 m and slope degree of 9.44º. Soils subject to hydromorphic processes occupies 31.15 ha or 1.21% of area.

Within the catchment are at here are highlighted 590.93 ha (22.94%) of soils formed on Neogene salty parental rocks which generates formation and developments of solonetzs and salty soils (Sandu, 1994).

Total area of different types of degraded soils makes up 1459.05 ha of the total area equal to 2576.44 hectares, which constitute 56.6%.

Table 1. Geomorphometric characterization of soils

Soil name	Area, ha	Elevation, m			Slope, degree			Aspect
		min.	max.	average	min.	max.	average	
Chernic chernozem	200.80	77.77	252.23	108.20	0.00	24.57	4.58	South
Ordinary chernozem	724.50	63.49	224.27	120.82	0.00	21.54	4.41	South-East
Calcic chernozem	730.58	67.34	257.04	136.91	0.00	33.33	6.07	South
Typical moor soil	5.02	160.03	209.41	186.70	5.14	11.29	8.16	South-West
Leached chernozem-like soil	62.57	94.32	235.00	139.24	0.64	25.15	9.18	East
Chernic chernozem-like soil	220.22	65.76	233.08	110.95	0.00	22.47	4.02	South
Solonetz molic	369.50	68.46	207.49	128.56	0.00	28.02	5.75	South
Gleic solonetz	0.27	64.94	70.61	67.89	1.00	5.67	4.47	South-West
Gleic solonceak	10.31	94.89	113.35	102.39	0.02	7.66	3.02	South
Mollic alluvial soil	41.81	86.01	123.48	99.67	0.00	16.84	2.10	South-East
Alluvial stratified soil	142.44	65.84	174.49	88.73	0.00	14.87	2.86	South
Gleic alluvial soil	15.54	59.22	70.03	62.93	0.01	11.31	1.86	South
Active landslides	52.87	94.80	244.29	174.95	0.05	35.67	11.89	South-West
TOTAL	**2576.45**							

Table 2. General characteristics of soils

Soil name	Number of polygons	Area, ha	% of total area	Subtype bonitet	Calculated bonitet
Chernic chernozem	8	200.80	7.79	100	89
Ordinary chernozem	39	724.51	28.12	82	69
Calcic chernozem	32	730.58	28.36	71	58
Typical moor soil	1	5.03	0.20	25	25
Leached chernozem-like soil	3	62.57	2.43	85	62
Chernic chernozem-like soil	17	220.21	8.55	85	84
Solonetz molic	24	369.50	14.34	34	34
Gleic solonetz	1	0.27	0.01	34	34
Gleic solonceak	2	10.31	0.40	10	10
Mollic alluvial soil	2	41.81	1.62	85	85
Alluvial stratified soil	1	142.43	5.53	80	80
Gleic alluvial soil	2	15.54	0.60	25	22
Active landslides	3	52.87	2.05	5	5
TOTAL	**135**	**2576.44**	**100**	**-**	**62**

Table 3. Soil degradation types

Soil name	Total	Soil area, ha							
		Eroded				Hydro-morphic	Halo-morphic	Neogene rocks	Degraded
		slightly	moderately	strongly	sum				
Chernic chernozem	200.80	105.54	6.39	-	111.93	-	-	-	111.93
Ordinary chernozem	724.51	149.74	15.23	7.45	172.43	-	208.50	124.71	364.29
Calcic chernozem	730.58	125.44	163.86	15.65	304.95	-	184.42	129.53	468.98
Typical moor soil	5.03	-	-	-	-	5.03	-	-	5.03
Leached chernozem-like soil	62.57	-	54.37	-	54.37	-	54.37	54.37	54.37
Chernic chernozem-like soil	220.21	-	-	-	-	-	6.65	6.65	6.65
Solonetz molic	369.50	-	-	-	-	-	369.50	268.46	369.50
Gleic solonetz	0.27	-	-	-	-	0.27	0.27	-	0.27
Gleic solonceak	10.31	-	-	-	-	10.31	10.31	7.21	10.31
Mollic alluvial soil	41.81	-	-	-	-	-	-	-	-
Alluvial stratified soil	142.43	-	-	-	-	-	-	-	-
Gleic alluvial soil	15.54	-	-	-	-	15.54	7.05	-	15.54
Active landslides	52.87	-	-	-	-	-	-	-	52.87
TOTAL	**2576.44**	**380.72**	**239.86**	**23.10**	**643.68**	**31.15**	**841.07**	**590.93**	**1459.05**
% of total		**59.15**	**37.26**	**3.59**	**24.98**	**1.21**	**32.64**	**22.94**	**56.6**

According to texture composition, clayey loam soil predominates with a share of 50.6%. On the second place loamy clay soils are situated with 45.7%, followed by fine and average clays with about 3.7% (Table 4).

Eluvial-delluvial clayey loam (with 40.59% prevails in parental rock structure. Neogene clay deposits of (Na) ranks on second place with 22.94%, followed by eluvial-colluvial clays with 18.66% (Table 5). Alluvial-delluvial sediments (Ad) for 7.9% and alluvial - 7.75%. Complex of sands and clay under landslide is 2.05%. Structural distribution of parental material is reflected in Figure 1.

Intrazonal subtype of (steppe) chernozem-like automorphic solonetzs and zonal soils complexes with different degrees of alkalinity, in general chernozems, are widespread in all pedogeographic provinces of Moldova. It should be mentioned that spatial distribution of these soils is very scattered and is determined by lithological and geomorphologic conditions. An important role in formation, development and spatial distribution of chernozem-like automorphic solonetzs is played by soil formation rocks (Andrieş, 2007).

Table 4. Soil texture

Soil name	Soil area, ha			
	Total	texture		
		clay	loamy clay	clayey loam
Chernic chernozem	200.80	-	9.54	191.26
Ordinary chernozem	724.51	18.58	310.34	395.59
Calcic chernozem	730.58	57.80	213.96	458.82
Typical moor soil	5.03	-	5.03	-
Leached chernozem-like soil	62.57	8.20	54.37	-
Chernic chernozem-like soil	220.21	-	131.66	88.56
Solonetz molic	369.50	4.66	357.19	7.66
Gleic solonetz	0.27	-	0.27	-
Gleic solonceak	10.31	7.21	3.09	-
Mollic alluvial soil	41.81	-	22.91	18.91
Alluvial stratified soil	142.43	-	-	142.43
Gleic alluvial soil	15.54	-	15.54	-
Active landslides	52.87	-	52.87	-
TOTAL	**2576.44**	**96.45**	**1176.77**	**1303.22**
%		**3.74**	**45.67**	**50.58**

Table 5. Soils formed on different parental rocks

Soil name	Soil cover surface, ha						
	Total surface	Parental rocks					
		Na	eda	edtc	Ad	Al	At
Chernic chernozem	200.80		9.54	191.26	-	-	-
Ordinary chernozem	724.51	124.71	204.22	395.59	-	-	-
Calcic chernozem	730.58	129.53	142.23	458.82	-	-	-
Typical moor soil	5.03	-	5.03	-	-	-	-
Leachedchernozem-like soil	62.57	54.37	8.20	-	-	-	-
Chernic chernozem-like soil	220.21	6.65	9.95	-	203.61	-	-
Solonetzmolic	369.50	268.46	101.05	-	-	-	-
Gleicsolonetz	0.27	-	0.27	-	-	-	-
Gleicsolonceak	10.31	7.21	3.09	-	-	-	-
Mollic alluvial soil	41.81	-	-	-	-	41.81	-
Alluvial stratified soil	142.43	-	-	-	-	142.43	-
Gleic alluvial soil	15.54	-	-	-	-	15.54	-
Active landslides	52.87	-	-	-	-	-	52.87
TOTAL	**2576.44**	**590.93**	**483.58**	**1045.67**	**203.61**	**199.78**	**52.87**
%		**22.94**	**18.77**	**40.59**	**7.90**	**7.75**	**2.05**

The largest areas of automorphic solonetzs and the largest participation in the composition of the soil cover, is recorded in Ciuluc-Soloneţ Hillsand Central Moldavian Plateau. These soils are widespread in the Codri borders, in Southern Moldavian Plain and the Tigheci Hills.

According to soil survey study results, total area of chernozem-like automorphic solonetzsis 26.9 thousand hectares. In most cases these soils are located on the territories of eluvial and trans acumulative (transition) landscapes. It is widely accepted that in mentioned landscapes, predominantly located in interfluves and related hillsides with gently undulating slopes, a regime of slowed migration of several elements and substances in the soil, including soluble salts is installed.

Chernozem-like automorphic solonetzs is formed and evolved in these types of landscape only in conditions when the soil formation rocks were presented by salty clay deposits, generally of Neogen, located in small depth of 0.5-1.0 m. These clays contain considerable amounts of soluble salts (1.5-2.5%), sulfate prevailing in their composition; they are characterized by fine texture with predomination of clay with a share of 40-47%in its composition.

On watersheds, there can be often meet solonetzs with crust or columns at the top of the surface. Solonetzs with medium depth columns occupy slopes with south, southwest and west aspect. Automorphic solonetzs with great depth columns are located on gently undulating slopes of northern, northeastern and eastern aspect. In trans accumulative landscapes automorphic solonetzs often form complexes with semi-hydromorphic solonetzs.

Main peculiarity of chernozem-like automorphic solonetzs distribution consists of formation of small island areas, distinctively outlined. These soils, diffused in the highly productive terrains, substantially increase the complexity of soil cover and reduce their productive capacity by 40-60%. A significant participation of automorphic solonetzs both as number of contours as well as surface share (5-8% of arable land) is recorded in the districts located in the Ciuluc-Solonetz Hills. The largest share of solonetzs is located in Singerei district, this constituting 8.49% or 4634 ha.

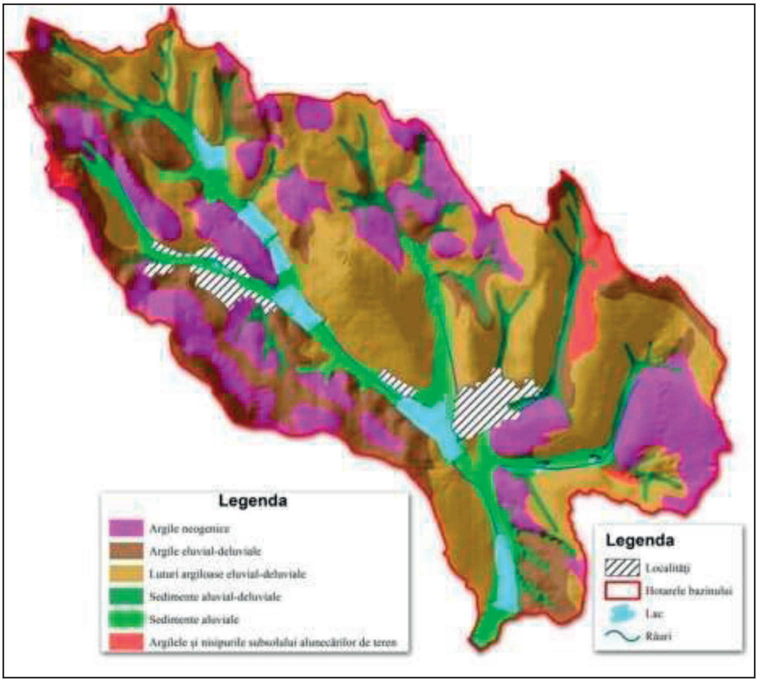

Figure 1. Parental material

For assessment of ameliorative state of salty soil in terms of application of agropedoameliorative works soil profiles were placed on chernozem-like automorphic solonetzs from where samples for chemical and physical analysis were taken. Within field and laboratory work, physical hydrological, physico-chemical and physico-mechanical properties of soil were determined. Soil profile morphology and morphometry are characterized below.

Description ofchernozem-like automorphic solonetzs profile:

Ah (0-30 cm) - arable humic layer, low solonitized, darc-grey, compact, masive structure, fine pores, cracks, plant debris, horizons clearly distinguished.

Btna (30-50 cm) - sodium clay-iluvial horizon, dark-gray with brown hues, massive structure with prismatic slitizate (vertic) formations, very compact, fine pores, semi-decomposed small roots, fine clay, and horizons clearly distinguished.

Bkz (50-70 cm) - transitional horizon, yellow with brown hues, nonhomogeneous, humus tongues, unstructured, compact, fine pores, veins and crystals of gypsum with carbonate, fine clay, gradual transition.

BCkz (70-100 cm) - horizon of transition to soil formation rock, yellow with humus accumulation through the cracks, unstructured, compact, weak gleyzation, stagnant, rare beloglasca, fine pores, spots of carbonates and gypsum crystals, fine clay.

Table 6. Chemical proprieties of chernozem-like automorphic solonetzs

Horizon	Depth, cm	Hygroscopic water	Humus	$CaCO_3$	$N\text{-}NO_3$	P_2O_5	K_2O
		%			mg/100 g soil		
Ah	0 -30	4.95	4.79	-	0.57	2.04	57.1
Btna	30 - 50	5.50	3.26	0.5	0.39	0.76	38.0
Bkz	50 - 70	4.79	1.51	4.5	0.31	0.67	35.9
Bckz	70 - 100	4.10	0.90	7.1	0.25	0.57	33.2

Performed researches showed that the experimental field soil is characterized by "great" share (4.79%) of organic matter on 0-30 cm depth. Sodium clay-iluvial horizon (Btna) contains 3.26% of humus and falls in the "middle" class. The underlying horizons amount of humus is "low" to "very low" (Table 6).

Table 7. Salt content, pH and ionic composition of water content of chernozem-like automorphic solonetzs

Horizon	Depth, cm	Dry residue, %	pH	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	Toxic salts, %
			me/100 g soil							
Ah	0-30	1.170	7.90	0.32	0.02	2.02	0.32	0.08	1.96	5.2
Btha	30 - 50	0.248	8.1	0.35	0.03	3.10	0.32	0.20	2.96	6.5
Bkz	50 - 70	0.464	8.25	0.72	0.10	5.76	0.49	0.74	6.05	12.3
Bckz	70 - 100	0.763	8.75	0.42	0.17	10.28	1.90	0.75	8.22	29.7

Distribution of organic matter within soil profile is characteristic for given subtype of soil and is manifested by a sudden reduction of its content from the upper to deeper horizon. Thus, the difference in humus content in the topsoil and subsoil constitutes 1.53%.

In automorphic solonetzs improvement practice content of $CaCO_3$ and maximum accumulation depth play an important role. From presented data it can be seen that amount of calcium carbonate is insignificant in the first 50 cm. In the subsoil and parental material $CaCO_3$ content increases significantly (7.1%) and is included in the "middle" class. Great depth location of carbonic acid salts excludes the possibility of agro-biologicum provement which consider involving calcium compounds reserves in Btna horizon through soil improvement works.

The content of nitrate nitrogen is reduced, the maximum concentration of $N\text{-}NO_3$ in the soil profile (0.57 mg/100 g soil) was found on surface (Table 6). Chernozem-like automorphic solonetzs has a "moderate" content of phosphorus. P_2O_5 content at the surface is 2.04 mg/100 g soil. In underlying layer it is reduced to 0.76 mg/100 g soil. Republic soils, including the alkali ones, are well supplied with exchangeable potassium, whose content is determined by the mineralogical composition peculiarities. The degree of assurance of chernozem-like automorphic solonetzs with K_2O is "very high". Arable layer contains 57.1 mg/100 g soil K_2O. Profile distribution of exchangeable potassium shows a sharp differentiation (Table 6).

Some of the main criteria for assessment of solonetzs quality state in terms of their improvement is the content and composition of soluble salts. Experimental field soil is of sulphate class of salinization with ratio Cl: SO_4 between 0.01:1 and 0.02:1. Top horizon is characterized by a low degree of salinity, the central part of the profile consists of values of moderately saline class, and parental matter is moderate to highly salinized. From data presented in Table 7, there can be observed increased levels of dry residue in depth from 0.170% to 0.763%. The anionic composition of water content is dominated by sulfate with participation of 2.02 to 10.28 me/100 g soil, and the cation one by sodium content of 1.96 to 8.22 me/100 g soil. HCO_3^- and Cl^- anions and divalent cations Ca^{2+} and Mg^{2+} occupy subordinate positions. Value of pH in top horizon is 7.90 reaching in depth 8.75 units.

Table 8. Composition of soluble salts in chernozem-like automorphic solonetzs

Horizon	Depth, cm	$Ca(HCO_3)_2$	$Ma(HCO_3)_2$	$CaSO_4$	$MgSO_4$	Na_2SO_4	$MgCl_2$	Toxic salts, %
		me/100 g sol						
Ah	0-30	0.32	-	-	0.06	1.96	0.02	85
Btha	30-50	0.32	0.03	-	0.14	2.96	0.03	60
Bkz	50-70	0.72	-	0.07	0.64	5.05	0.10	86
Bckz	70-100	0.42	-	1.48	0.58	8.22	0.17	82

Table 9. Composition of exchangeable cations in chernozem-like automorphic solonetzs

Horizon	Depth, cm	Ca^{2+}	Mg^{2+}	Na^{+}	Suma	Ca^{2+}	Mg^{2+}	Na^{+}
		me/100 g sol				% from sum		
Ah	0-30	22.00	13.00	7.74	42.74	52	30	18
Btha	30-50	16.00	14.01	8.70	38.71	41	36	23
Bkz	50-70	15.06	15.32	8.96	39.34	38	39	23
Bckz	70-100	14.44	15.00	9.52	38.96	37	39	24

The composition of the soluble salts is shown in Table 8. Analysis of the obtained material shows that the predominant component is sulphate sodium. In the upper layers of soil Na_2SO_4 constitutes about 49% and the underlying horizons and parental material this compound is up to 85% of the total salts sum.

For emphasize the value of alkali soils it is necessary to know the content and ratio of exchange cations. The obtained results show a differentiated distribution of alkali and alkaline-earth bases on solonetz profile. Thus, the superficial soil horizons contains 22.00 me/100 g calcium soil; in underlying horizons and parental material this element does not exceed 16.00 to 14.44. A reverse distribution of adsorbed of sodium is recorded within soil profile. Contents of exchangeable Na^{+} increases from 18% in eluvial horizon to up to 24% in soil formation rock. Character of cation Mg distribution is more uniform (Table 9).

Granulometric (textural) composition is one of the intrinsic soil properties, practically unchanged by anthropogenic intervention and also by improvement activities. Decisively, texture determines water and air regime as well as physical, chemical and mechanic properties. In Table 10 there are showed the results of estimation of study area soils textural composition. They show that the content of coarse and medium sand is insignificant and is less than 0.2%. A higher percentage is characteristic for fine sand. From presented data, a statistically significant difference in content of silt fractions can be seen. Thus, coarse silt predominates with a share of 27-30%, followed by fine (17-24%) and middle silt (8-11%).

A high content of fine clay is characteristic for chernozem-like automorphic solonetzs texture. In distribution of particle with diameter ≤ 0.001 mm in the soil profile, there was recorded an increase up to 13% in clay-iluvial sodium horizon. Distribution of physical clay (silt and clay) is identical to fine clay, but in this case there was identified a growing trend of fractions with a diameter less than 0.01 mm in Btna horizon.

Considering this fraction content, and according to Kacinski classification, textural composition of chernozem-like automorphic solonetzs is fine clay.

The content of peptized fine clay in 0-30 cm layer makes up 10.5%, increasing to 14.0% in the underlying layer (Table 11). Dispersion factor in the surface layer makes up 15 to 16%. High salt content in the Bkz salt horizon and soil formation rock lead to suspension clotting, making it impossible to determine the micro-aggregate composition.

Table 10. Textural composition of chernozem-like automorphic solonetzs

Horizon	Depth, cm	Content of fractions (%) with diameters (mm)						
		> 0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	<0.01
Ah	0-30	0.2	4.5	29.6	11.5	22.1	32.1	65.1
Btna	30-50	-	3.0	27.1	7.5	17.0	45.4	69.9
Bkz	50-70	-	3.4	28.0	9.4	18.0	41.2	68.6
BCkz	70-100	-	0.9	28.5	10.0	20.0	36.6	66.6

Table 11. Micro-aggregate composition of chernozem-like automorphic solonetzs

Horizon	Depth, cm	Content of fractions (%) with diameters (mm):							Fd, %
		>0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	<0.01	
Ah	0-30	0.3	8.8	44.2	14.5	21.7	10.5	46.7	33
Btna	30-50	0.2	7.0	40.3	15.8	22.5	14.0	52.3	31

Table 12. Physical proprieties and hydro-physical indicators of chernozem-like automorphic solonetzs

Horizon	Depth, cm	D	DA	PT	PD	PU	PI	CH	CO	CC	CU
		g/cm^3		% v/v			%				
Ah	0-30	2.61	1.24	52	19	13	20	11.5	16.54	26.8	10.4
Btna	30-50	2.65	1.45	45	11	9	24	11.9	16.9	23.4	6.5
Bkz	50-70	2.69	1.53	43	8	10	24	11.2	15.9	22.7	6.8
BCkz	70-100	2.71	1.58	42	11	5	26	11.4	16.2	19.5	3.3

Basic physical proprieties which determine the state of soil alignment are shown in Table 12. The results show that the soil solid phase density is characterized by homogeneity with insignificant increase from 2.61 g/cm^{3}in surface layer to 2.71 g/cm^3 the soil formation rock and due to decrease of humus content by 3.84%.

The apparent density in the arable layer is 1.24 g/cm^3, growing in depth, being in soil formation rock up to 1.58 g/cm^3. The total porosity is a function of solid phase density and the soil bulk density. Arable layer has an average PT of 52%, which decrease to 42% in the parent rock, creating restrictions to aeration process. Aeration porosity indicates free pore volume at soil moisture equal to field capacity. It is the "average" (19%) at the surface and sharply decreases with depth up to 8-11%, indicating deficient aeration propriety of soil. Studied soil is characterized by high values of inactive porosity (20-26%).

Hygroscopic coefficient is between 11.2 to 11.9% and closely correlates with fine clay content. Wilting coefficient represents the lower level of plant available water. According CO data in automorphic solonetzs it is 15.9-16.9%, falling within class values "high" to "very high".

One of main hydro-physical indicators is the field capacity. CC is the upper level of plant available water. In terms of hydro-physics, chernozem-like automorphic solonetzs profile is distinctly differentiated. Its upper layer is characterized by "high" values of CC (26.8%), the transition horizons have an "average" field capacity (22.7 to 23.4%) and in parental material CC is "low" (19.5%).

Water capacity corresponds to useful water reserve that the soil can yield plants. Those measurements show that the shallow soil horizon is "low" (10.4%). The soil and rock underlying horizons have with "very small" (3.3-6.8%).

Wilting capacity (Plant available water) corresponds to water resources that soil can yield to plants. The measurements show that in surface layer of soil horizon CU is "low" (10.4%). Underlying horizons and soil formation rock have CU "very low" (3.3-6.8%).

It is known that alkali soils are characterized by a defective structure. In the unchanged alignment, automorphic solonetzs structure is strictly differentiated in genetic horizons. Eluvial horizon has lamellar structure with reduced hydrostability. Structure of clay-iluvial sodium horizon (Btna) is prismatic-column. Structural aggregates have an extremely compact alignment, and their porosity is low and fine. The underlying soil horizons, soil is nonstructural with massive clod formations.

CONCLUSIONS

Studying automorphic solonetzs and secondary solonetized chernozems through irrigation was performed in subdistrict of Ciuluc Hills, respectively Southern Bessarabian Steppe district.

There were characterized in detail the natural conditions of the study areas, in particular climate, topography, soil formation rocks, soils and hydrographic network.

In field and laboratory conditions there were determined morphological and morphometric parameters, studied the physical, chemical and hydric proprieties of automorphic solonetzs. A particular attention was given to saline indicators required for argumentation of improvement works.

There were determined and assessed the state of deep-plowing ordinary chernozem quality irrigated with water from local sources. Also there were determined the chemical composition and quality indicators of water used in irrigation. Basing on performed research there will be calculated the need for amendments to restore degraded chernozem fertility.

Using remote sensing material there were developed maps of irrigation fund at 1:1000 scale of Lebedenco commune. The works were done in MapInfo (2D) and Arc GIS (3D) software.

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