Scientific Papers. Series A. Agronomy, Vol. LV-2012
ISSN Online 2285-5793; ISSN-L 2285-5785

STATE QUALITY MONITORING OF THE GREY SOILS FROM WARM MODERATELY NORTH ZONE OF THE REPUBLIC MOLDOVA

Tamara LEAH

Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo", str. Ialoveni 100, 2070, Chisinau, Republic of Moldova, Phone: (+373-22) 28-48-61, Fax: (+373-22) 28-48-55, E-mail: tamaraleah09@gmail.com

Corresponding author e-mail: tamaraleah09@gmail.com

Abstract

In result of quality monitoring of zonal soils has been found that arable Grey soils from moderately warm semi- humid zone of North part of Moldova, compared with fallow Grey soils, are characterized by moderate degradation of soil properties as a result of dehumification, destruction and considerable decrease of humus and nutrients content. Eluvial horizons of virgin and arable Grey soils have unfavorable physical and chemical properties – excessive compaction, acid reaction, low content of humus and nutrients. The presence of eluvial compact horizons in profile of Grey soils leads to decrease the water permeability, which are regularly influenced by temporarily excess of humidity, have a low stability for erosion processes and low fertility. In the arable Grey soils decreased acidity, leading to the stopping of eluvial processes. Using in continue the Grey soils without fertilizers application will lead to decreasing soil quality state. The necessary measures to maintain fertility of arable Grey soils are: increasing organic matter content by applying chemical and organic fertilizers, vegetal wastes and residues; implementation of zonal crop rotation; improvement the tillage system.

Key words*: degradation, evolution, Grey soils, monitoring, soil quality.*

INTRODUCTION

The main zonal soils area of agricultural land in Republic Moldova are Chernozems (1 mln 500 thousand ha or 77.8%) and Grey soils (123.7 thousand ha or 6.7% from the total surface). Grey soils from semihumid warm moderate zone of Moldova's north part occupy the Moldova's Northern Plateau. This geo-morphologic district is characterized by slow forms of relief, which makes manifestation of weakly erosion processes. Absolute altitudes are 250 - 300 m. Horizontal fragmentation in valleys - 1.5 to 2.0 km/km^2. In the west part the average vertical fragmentation is 50-100 m, in the fossil reefs chains - up to 150 m.

Grey soils were formed under deciduous forest vegetation in conditions of temperate climate (sum of temperatures >10°=2700-2800°, annual amount of precipitation - 550-650 mm, moisture coefficient, K=0.7-0.9). As a result of deforestation in different historical periods these soils were used in arable. The largest areas of deciduous forest have been cleared and restored to agricultural land in the last 100 years. Parental materials are loess, which are characterized by a clear difference of profile texture [1, 3].

MATERIAL AND METHOD

To determine changes in quality status of arable Grey soils from Northern zone of the Republic Moldova in comparison with the virgin Grey soils, was located two monitoring polygons: no.24 on the arable farmland and no.25 in the forest on the horizontal surface of a large heights [1].

RESULTS AND DISCUSSIONS

Polygon no. 24, profile of arable Grey soils

Destination of the polygon is to make periodic observations of changes in quality status of typical arable Grey soils under agriculture influence. The soil profile of polygon no.24 is located on the horizontal surface of a large peak on the North Plateau of Moldova (on the territory of Alexandreni commune, Edinet district). Absolute altitude - 234 m, mainly soil

profile coordinates: latitude - 48°08.517', longitude - 27°17.856'. Polygon date location (beginning observations) - 11.10.2007.
Northern Plateau of Moldova is a primary denudation area formed in Pliocene period. Surface rocks are composed of loam-clay loess wind provenance (thickness - 1-2 m), under which are located the Pliocene sandy-clayey deposits with large fragments of calcareous rocks. The polygon is located in the moderately warm semihumid climate zone. Solar periods (sunny days) - 280-290. Isolation duration - from 2000 to 2050 hours. Average annual temperature - 7-8°C. Amount of t°>10° - 2700-2800°. Annual amount of precipitation - about 600 mm. Evaporability potential – 650 – 700 mm. Hydrothermal coefficient by Ivanov-Vâsoţkii - 0.8 to 0.9. Vegetation period - 166-167 days [2,4].
The soil cover of arable land consists from arable Grey soils moderate humifer with semi profound humus profile, clay 0-35 cm and clay-loam 35-100 cm. Arable land is used in field crops (Photo 1).

Photo 1. Location of polygon no. 24 – large height on the low wave plateau of Northern Moldova with arable Grey soils

The natural degradation factors are: eluvial-alluvial soil textural differentiation, excessive compaction of alluvial underlying layer.
Anthropogenic factors of soil degradation are: dehumification, destruction of arable layer and compacting secondary post arable soil layer in result of irrational farming.
The investigated of arable Grey soils is characterized by profile type: Ahp1 - Ahp2 - Bhtw - Btw - BCtw - 1CRk. Soil profile has a depth of 120 cm. At the 100 cm of depth appears the underlying rock composed from yellowish unconsolidated sandy-clayey rock material with large fragments of sandstone (Photo 2).

Photo 2. Profile no.24 - grey soil, arable

After land deforestation and use on the arable, as a result of hydrothermal regime change and biological cycle of substances modification, the eluvial - alluvial processes in the profile of these soils has ceased [1,2]. Statistical average data on arable Grey soils on the polygon no. 24 are presented in tables 1-5.

Polygon no. 25, profile of virgin Grey soils
Polygon destination - the absolute standard for comparing and assessing properties changes of arable Grey soil in result of anthropogenic impact.
The polygon is located on the horizontal surface of a large peak of North Moldavian Plateau, in the primary forest in the south part of arable land that was located polygon no. 24 (Photo 3).

Photo 3. Location of monitoring polygon no. 25 – virgin Grey soil, deciduous forest on the plateau

Table 1.Texture of arable Grey soil with whole profile on the monitoring polygon no.24

Horizons and depth, cm	Limits of granulometric fractions, mm; content, % g/g						
	1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	<0.01
Ahp1 0-24	2.2	23.6	31.2	9.6	13.2	20.2	43.0
Ahp2 24-35	2.4	23.4	31.1	9.2	13.9	20.0	43.1
Bhtw 35-53	2.1	21.7	28.3	8.2	12.5	27.2	47.9
Btw 53-71	1.6	21.5	27.8	8.7	10.8	29.6	49.1
BCtw 71-80	2.4	22.2	26.3	8.4	10.9	29.8	49.1
BCtw 80-100	2.8	26.4	23.0	9.7	10.1	28.0	47.8
1CRk 100-120	9.7	63.7	9.2	5.1	5.3	7.0	17.4

Table 2. Average statistical parameters (X ± s) of structural composition on the genetic horizons of arable Grey soil

Depth, cm	The content of structural elements (size, mm) determined by dry sieving (numerator) and water stability aggregates (denominator), % w/w				Quality structure (dry sieve)	Hydrostability structure (wet sieve)
	>10	< 0.25	Sum 10 – 0.25	Sum >10 + < 0.25		
Ahp1 0-12	23.8±8.0 / -	8.5±5.6 / 64.6±3.5	67.7±3.9 / 35.4±3.5	32.3±3.9 / 64.6±3.5	good	low
Ahp1 12-25	39.6±1.6 / -	4.3±0.7 / 64.1±3.3	56.2±2.0 / 35.9±3.3	43.9±2.0 / 64.1±3.3	favorable	low
Ahp2 25-35	34.5±6.1 / -	3.5±2.2 / 69.4±4.7	62.3±7.5 / 30.6±4.7	38.0±7.5 / 69.4±4.7	good	low
Bhtw 35-53	22.3±5.3 / -	2.9±0.8 / 64.9±2.8	74.9±4.6 / 35.1±2.8	25.2±4.6 / 64.9±2.8	good	low

Table 3. Average statistical parameters (X ± s) of physical properties on genetic horizons of arable Grey soil

Horizons and depth, cm	Thickness of horizons, cm	Fractions, %g/g		Hygroscopicity	Hygroscopicity coefficient	Density	Apparent density	Total Porosity, % v/v	Compaction degree % v/v
		<0,001 mm	<0,01 mm	% g/g		g/cm^3			
Ahp1 0-12	12±1	20.2	43.0	4.1±0.6	5.2±0.6	2.60±0.02	1.30±0.02	49.9±0.9	0±2
Ahp1 12-25	13±1	20.2	43.0	4.1±0.6	5.2±0.6	2.60±0.02	1.45±0.03	44.4±1.1	11±2
Ahp2 25-35	10±1	20.0	43.1	3.8±0.7	4.9±0.7	2.62±0.01	1.52±0.05	41.2±0.7	17±2
Bhtw 3 5-53	18±1	27.2	47.9	3.5±0.5	4.6±0.8	2.66±0.01	1.61±0.02	39.5±0.6	22±1
Btw 53-71	18	29.6	49.1	3.6	5.5	2.68	1.61	39.9	22
BCtw 71-80	29	29.8	49.1	3.4	4.8	2.69	1.62	39.8	22
BCtw 80-100	29	28.0	47.8	3.0	4.3	2.69	1.61	40.1	21
1CRk 100-120	-	7.0	17.4	0.8	1.3	2.68	1.51	43.8	6

Table 4. Average statistical indexes of chemical properties on genetic horizons of arable Grey soil

Horizons and depth, cm	pH	$CaCO_3$	P_2O_5 total	Humus	N total	C : N	Mobile forms, g/100 g soil		Hydrolytic acidity, me/100g soil
		% g/g					P_2O_5	K_2O	
Ahp1 0-25	6.4±0.1	0	0.104±0.003	2.28±0.12	0.114±0.007	11.6±0.5	2.0±0.4	14±2	3.6±0.4
Ahp2 25-35	6.3±0.1	0	0.086±0.008	2.07±0.09	0.107±0.007	11.2±0.2	1.7±0.2	12±1	3.2±0.4
Bhtw 35-53	6.5±0.1	0	0.059±0.004	1.44±0.13	0.077±0.007	10.8±0.3	1.2±0.3	10±1	2.4±0.5
Btw 53-71	6.8	0	-	0.84	-	-	-	-	-
BCtw 71-80	7.0	0	-	0.43	-	-	-	-	-
BCtw 80-100	7.2	0	-	0.37	-	-	-	-	-
1CRk 100-120	8.0	9.7	-	0.17	-	-	-	-	-

Table 5. Average statistical parameters (X ± s) of exchangeable cation content of arable Grey soil

Horizons and depth, cm	Exchange cations, me/100g soil		
	Ca^{++}	Mg^{++}	Sum (Ca^{++} + Mg^{++})
Ahp1 0-25	22.6±2.0	3.3±0.2	25.9±1.7
Ahp2 25-35	21.3±1.5	3.2±0.3	24.5±1.7
Bhtw 35-53	22.1±1.0	3.2±0.3	25.3±1.1
Btw 53-71	22.6	3.0	25.6
BCtw 71-80	22.4	3.0	25.4
BCtw 80-100	21.8	3.0	24.8
1CRk 100-120	15.5	2.6	18.1

Absolute altitude - 239 m, mainly soil profile coordinates: latitude - 48° 08.283 ', longitude - 27°17.566'.

The climate and relief conditions, the surface and underlying rocks are similar to those of no.24 polygon. The soil cover consists by humifer virgin Grey soils, has a moderate humifer profile, clay 0-26 cm and clay – loamy 26-120 cm.

The profile of virgin Grey soil is characterized by profile type: Aht - AEh-BEhtw - Bhtw - Btw - BCtw - CRk (Photo 4).

Photo 4. Profile no. 25, virgin Grey soil

Profile in the primary forest is located vis-à-vis the profile no. 24, 100 m south of the northern limit of arable land. Effervescence - beginning at a depth of 120 cm. Carbonates at the depth of 120 appears as pseudomycelia and veined small and medium-sized fragments of sandstone [2, 4].

Comparative properties characteristic values of arable and virgin Grey soils on the depths and standards layers are presented in table 11. Larger information in this regard can be obtained in the comparison result of statistics parameters of average properties of these soils presented in tables 1 - 5 for arable Grey soils and tables 6 - 10 for virgin Grey soils.

The data of tables 1 - 11 confirms that the texture of virgin and arable Grey soils is practically analogical - loamy in the upper and loam-clay in the illuvial or illuviale-cambic profile horizons.

In the recent condition of structural state of these soils the loamy texture of arable layer can be considered as good in terms of soil tillage. Due of clay texture the arable layer is working easier; plowing is less cloggy, than in case of fine textured soils (clay-loam, loam-clay, clay), lumps are fragments comparatively easier.

Table 6. Texture of virgin Grey soil on the monitoring polygon no. 25

Horizons and depth, cm	Granulometric fraction limits, mm; content, % w/w						
	1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0,001	<0,01
Ahţ 0-9	1.1	23.3	32.9	11.0	12.4	19.3	42.7
AEh 9-26	0.7	22.9	32.8	10.8	12.0	20.8	43.6
BEhtw 26-37	0.9	22.4	30.2	10.2	11.3	25.0	46.5
Bhtw 37-54	1.0	22.7	28.9	9.9	10.0	27.5	47.4
Btw 54-72	0.8	22.8	27.4	9.9	10.9	28.2	49.0
BCtw 72- 100	1.1	28.1	23.7	9.5	9.9	27.7	47.1
BCtw 100-120	2.4	31.3	20.7	9.1	8.9	27.6	45.6
1CRk 120-140	1.5	55.2	18.5	5.7	6.3	12.8	24.8

Table 7. Average statistical parameters (X±s) of structural composition of virgin Grey soil on the polygon no. 25

Depth, cm	The content of structural elements (size, mm) determined by dry sieving (numerator) and the hydrostabile aggregate (denominator),% g/g				Quality structure (dry sieve)	Hydrostability structure (wet sieve)
	>10	< 0.25	Sum 10 – 0.25	Sum >10 + < 0.25		
Ahţ 0-9	7.2±1.1	9.3±1.8	83.5±2.0	16.5±2.0	very good	very high
	-	26.1±1.6	73.9±1.6	26.1±1.6		
AEh 9-24	9.5±2.4	5.2±1.8	85.2±2.2	14.7±2.2	very good	very high
	-	17.8±1.5	82.2±1.5	17.8±1.5		
BEhtw 24-35	31.0±2.6	3.6±0.6	65.4±2.1	34.6±2.1	good	high
	-	23.7±3.2	70.2±12.3	23.7±3.2		
Bhtw 35-53	46.1±11.4	4.7±3.3	49.2±11.8	50.8±11.8	moderate	high
	-	33.5±2.3	66.5±3.5	33.5±2.3		

Table 8. Average statistical parameters (X ± s) of the physical properties of virgin Grey soil on the polygon no. 25

Horizons and depth, cm	The thickness of horizons, cm	Fractions, %g/g		Hygrosc-opicity	Higros-copicity coefficient	Density	Apparent density	Porosity total, % v/v	Compaction degree % v/v
		<0.001 mm	<0.01 mm	% g/g		g/cm^3			
Aht 0-9	9±1	19.3	42.7	5.2±0.4	6.3±0.5	2.51±0.01	1.19±0.02	52.8±0.7	-6
AEh 9-24	15±2	20.8	43.6	4.2±0.3	5.3±0.3	2.59±0.04	1.27±0.01	51.1±0.6	-2
BEhtw 24-35	11±1	25.0	46.5	3.9±0.4	5.3±0.4	2.65±0.003	1.42±0.02	46.2±0.9	8
Bhtw 35-53	18±1	27.5	47.4	4.1±0.3	5.6±0.3	2.67±0.02	1.63±0.03	39.1±1.1	23
Btw 53-72	19	28.2	49.0	5.1	6.3	2.69	1.67	37.9	25
BCtw 72- 100	48	27.7	47.1	5.6	6.8	2.70	1.66	38.5	24
BCtw 100-120		27.6	45.6	5.3	6.5	2.70	1.62	40.0	21
1CRk 120-140	-	12.8	24.8	2.5	3.7	2.71	1.51	44.3	12

Table 9. Average statistical index of chemical properties of virgin Grey soil on monitoring polygon no. 25

Horizons and depth, cm	pH	$CaCO_3$	P_2O_5 total	Humus	N total	C : N	Mobile forms, mg/100g soil		Hydrolytic acidity me/100g soil
		% g/g					P_2O_5	K_2O	
Aht 0-9	6.4±0.4	0	0.147±0.011	6.16±0.72	0.272±0.22	12.9±0.4	7.6±2.6	39±4	2.4±1.3
AEh 9-24	5.6±0.5	0	0.095±0.017	3.14 ±0.22	0.153±0.004	12.2±0.2	3.1±0.4	17±3	6.3±1.7
BEhtw 24-35	5.5±0.4	0	0.075±0.013	2.12±0.23	0.112±0.012	11.5±0.3	2.1±0.2	14±3	5.4±1.1
Bhtw 35-53	5.6±0.2	0	0.057±0.005	1.25±0.11	0.067±0.006	10.9±0.4	2.2±0.2	12±1	3.9±1.0
Btw 53-72	5.6	0	-	0.75	-	-	-	-	-
BCtw 72- 100	5.6	0	-	0.37	-	-	-	-	-
BCtw 100-120	6.1	0	-	0.32	-	-	-	-	-
1CRk 120-140	7.5	4.5	-	0.15	-	-	-	-	-

Table 10. Average statistical parameters (X±s) of exchangeable cation content of virgin Grey soil, polygon no. 25

Horizons and depth, cm	Exchange cations, me/100g soil		
	Ca^{++}	Mg^{++}	Sum ($Ca^{++} + Mg^{++}$)
Aht 0-9	27.9±2.4	2.9±0.1	30.8±2.4
AEh 9-24	19.7±2.2	3.1±0.2	22.8±2.0
BEhtw 24-35	18.8±1.7	3.2±0.2	22.0±1.7
Bhtw 35-53	19.1±1.2	3.3±0.3	22.4±1.4
Btw 53-72	19.3	4.0	23.3
BCtw 72-100	20.8	4.0	24.8
BCtw 100-120	20.0	4.0	24.0
1CRk 120-140	16.0	3.0	19.0

The texture of illuvial horizons (illuvial - cambic) Bhtw and Btw is loam-clay. The medium-fine texture and monolithic structure led to excessive compaction of these horizons and forming in them an unfavorable quality physical status [2]. Arable layer structure of Grey soils is moderate qualitative, and aggregates water stability - is small. So, a favorable state of physical quality for the arable layer can be created only by regular soil works over the entire life growing crop plants.

The upper horizons Aht, AEh, BEhtw of virgin soil are characterized with very good structure of formed by water stability aggregates. Therefore, use on the arable has destroyed the initial favorable structure of virgin Grey soils. Structural destroyed processes essential lowered the resistance to compaction of this layer. Towards the end of the vegetation period the apparent density of the arable layer reach values 1.4 to 1.5 g/cm^2, and the underlying layer post arable - more than 1.5g/cm^2, which creates unfavorable conditions for plant growth. The illuvial horizons Bhtw şi Btw of arable and virgin Grey soils are similar and are characterized by an almost monolithic structure, apparent density (1.61 to 1.66 g/cm^3) and high degree of compaction (20-24). Some remedy of physical quality status of illuvial horizon can perform only working under 40-70 cm of depth. The humus content of arable soil layer of 0-30 cm (2.23%), compared to the humus content in the same layer of virgin soil (3.84%), and decreased by 1.6%. Arable soils have lost up to 42% of the initial content of humus.

Table 11. Average statistic weighted parameters of the main characteristics of virgin and arable Grey soils on the standards depths (layers) important in terms of agronomic

Standard layers, cm	Fractions <0.001 mm	Fractions <0.01mm	CH*	D	AD	PT	CD	Humus, %	$CaCO_3$	pH	HA
Polygon 24. Grey soils moderate humifer, arable											
0-30	20.2	43.0	5.2	2.60	1.40	46.2	8	2.23	0	6.4	3.5
30-50	25.4	46.7	4.7	2.65	1.59	40.0	21	1.60	0	6.4	2.6
0-50	22.3	44.5	5.0	2.62	1.48	43.5	13	1.98	0	6.4	3.2
50-100	28.9	48.5	4.8	2.68	1.61	39.9	22	0.61	0	7.0	-
0-100	***25.6***	***46.5***	***4.9***	***2.65***	***1.55***	***41.5***	***17***	***1.30***	***0***	***6.7***	**-**
Polygon 25. Grey soils moderate humifer, virgin											
0-30	21.2	43.9	5.6	2.58	1.28	50.4	-1	3.84	0	5.8	5.0
3 0-50	26.9	47.3	5.5	2.66	1.58	40.6	20	1.47	0	5.6	4.3
0-50	23.5	45.3	5.6	2.61	1.40	46.3	8	2.89	0	5.7	4.7
50-100	27.9	47.8	6.5	2.69	1.66	38.3	24	0.57	0	5.6	-
0-100	***25.7***	***46.6***	***6.1***	***2.65***	***1.53***	***42.3***	***16***	***1.73***	***0***	***5.7***	**-**

***Note:** **CH** - coefficient of hygroscopicity, % g/g; **D** - density, g/cm^3 ; **AD** – apparent density, g/cm^3; **PT**- porosity total, % v/v; **CD** – compaction degree; **HA –** hydrolytic acidity, me/ 100g soil.

The soil dehumification and tillage, in turn, caused by destructural and compaction of arable Grey soil and worsening their physical quality. As a result of physical damage decreased the permeability and capacity to water, conductivity and water availability of arable Grey soil. The fallow Grey soil is characterized by a significant accumulation of biofile elements in the superficial horizons; the arable Grey soils - with a considerable decrease of the contents of these elements. The reaction of fallow Grey soil is acid (pH=5-6, hydrolytic acidity - 4-6 me), the reaction of the arable Grey soil - slightly acid (pH=6-7, hydrolytic acidity - from 2.5 to 3.5 me), which led to stopping the eluvial - illuvial processes in these soils.

CONCLUSIONS

Grey soil arable in the North zone of Moldova is characterized by moderate degradation characteristics as a result of dehumification, destructuration and considerable decrease of content of biofile elements.

The illuvial horizons of virgin and arable Grey soils are characterized by unfavorable physical chemical properties - excessive compaction, acid reaction, low content of nutrients.

In general, arable gray soils are relatively poor in humus and nutrients, the presence of compact illuvial horizons leads to lower permeability to water and, consequently, are regularly affected by temporarily moisture excess, have poor stability against erosion, their natural fertility is relatively low. The acidity of arable soils decreased significantly, leading to stop the illuvial - eluvial process, but still remained high. The pedoameliorative and agrotechnical measures necessary for amelioration of quality state of these soils are as follows: increasing content of organic matter in arable layer (chemical and organic fertilizers, green manure, sludge and organic waste), implementation of crop rotation, improving the soil tillage (once in 3-4 years to make plowing to 35 cm depth to granulate the compacted recent layer, periodically tillage with polished on 40-50 cm depth for partial loosening of natural illuvial extremely compact horizon). An effective measure for reducing acidity and promote microbial activity in grey soils may be the introduction of 10-15 t/ha of recently acquired defecated of sugar factories.

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