UDK 631.42

QUALITY MONITORING OF ZONAL SOILS: GRAY SOILS FROM NORTH OF MOLDOVA

Tamara Leah

Institute of Soil Science, Agrochemistry and Soil Protection "Nicolae Dimo"
Moldova, Chisinau–2070, Ialoveni Str., 100
E-mail: tamaraleah09@gmail.com

The research results of monitoring for arable and fallow gray soils of northern Moldova were presented. Their use as arable land led to moderate degradation of physico-chemical properties, manifested by dehumification, destructuration, compaction and loss of nutrients. Further exploitation of arable gray soils in agriculture, in conditions of fertilizer deficit and without protection measures will lead to worsening of their quality.

Keywords: arable, degradation, fallow, gray soil, monitoring, physico-chemical properties.

Introduction. Soil quality monitoring is a complex system based on the ecopedological parameters and indices with spatial and temporary coverage, which provides the information necessary for developing the strategy and measures to prevent the consequences of human activity and natural disasters [1].

The main zonal soils with agricultural destination in Republic of Moldova are chernozems – 1500.0 thousand ha (77.8%), gray soils – 123.7 thousand ha (6.7%) and other soils – 15.5% of the total area [2].

Gray soils occupies the Northern Plateau of Moldova. This geomorphological district is characterized by mild forms of relief, which causes weak manifestation of erosion. Absolute altitudes make up the 250–300 m. Gray soils were formed under deciduous forest vegetation in temperate climate. Parental material is presented by loess sediments. Gray soil is characterized by clear differentiation in the texture of profile. As a result of deforestation they were used as arable in different historical periods. The largest areas of forest were cleared and restored to agricultural land in the past 100 years [1, 3].

Material and methods. The purpose of the monitoring observations on the polygons is tracking the dynamic changes in the soil quality status of soils with full profile under the influence of anthropogenic factors and their use in agriculture.

To determine the changes in the quality status of arable gray soil from North zone of Moldova were placed two monitoring polygons – on the arable land (Profile 24) and in the forest (Profile 25) for their comparison. The frequency of observations – once in 10 years.

In the field was performed morphological description, sampling of soil from genetic horizons and was determinate the bulk density up to 50 cm.

For determination of the physico-chemical properties of soils were used the classical methods of soil analysis.

Result and discussion. ***Gray soils arable.*** Natural degradation factors of arable gray soils are: textural differentiation; excessive compaction of the underlying iluvial horizon. Anthropogenic degradation factors of these soils are: humus losses, deterioration of structure, secondary compaction of the arable layer as a result of irrational agricultural exploitation [4].

Gray soil arable is characterized by type profile: *Ahp1 - Ahp2 – Bhtw - Btw – BCtw – CRk.* After deforestation and land use as arable, in the result of hydrothermal regime modification and change of biological cycle of substances, the eluvial-iluvial process in the profile of these soils has ceased.

The average statistical data on the characteristics of arable gray soils are shown in Tables 1–5 (Profile 24).

Table 1. Soil texture of arable gray soil with full profile (Profile 24)

Genetic horizons and depth, cm	The limits of particle size 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 0–25	2.2	23.6	31.2	9.6	13.2	20.2	43.0
Ahp2 25–35	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
CRk 100–120	9.7	63.7	9.2	5.1	5.3	7.0	17.4

Table 2. Average statistical parameters of structural composition of arable gray soil

Depth, cm	The content of structural elements (size, mm) determinate by dry sieving (numerator) and hydrostabile aggregates (denominator), % g/g				Structural quality (dry sieving)	Structural hydro-stability (wet sieving)
	>10	< 0.25	Sum 10 – 0.25	Sum >10 + < 0.25		
Ahp1 0–12	23.8 / –	8.5 / 64.6	67.7 / 35.4	32.3 / 64.6	good	small
Ahp1 12–25	39.6 / –	4.3 / 64.1	56.2 / 35.9	43.9 / 64.1	satisfactory	small
Ahp2 25–35	34.5 / –	3.5 / 69.4	62.3 / 30.6	38.0 / 69.4	good	small
Bhtw 35–53	22.3 / –	2.9 / 64.9	74.9 / 35.1	25.2 / 64.9	good	small

Table 3. The average statistical parameters of physical properties of arable gray soil

Genetic horizons and depth, cm	Horizons thick-ness, cm	Fractions, %g/g		Hygro-scopi-city	Hygro-scopicity coefficient	Den-sity	Bulk density	Total poro-sity, % v/v	Com-paction degree % v/v
		<0,00 1 mm	<0,01 mm	% g/g		g/cm³			
Ahp1 0–12	12	20.2	43.0	4.1	5.2	2.60	1.30	49.9	0
Ahp1 12–25	13	20.2	43.0	4.1	5.2	2.60	1.45	44.4	11
Ahp2 25–35	10	20.0	43.1	3.8	4.9	2.62	1.52	41.2	17
Bhtw 35–53	18	27.2	47.9	3.5	4.6	2.66	1.61	39.5	22
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		28.0	47.8	3.0	4.3	2.69	1.61	40.1	21
CRk 100–120	–	7.0	17.4	0.8	1.3	2.68	1.51	43.8	6

Table 4. Average statistical indices of chemical properties of arable gray soil

Genetic hori-zons 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	0.104	2.28	0.114	11.6	2.0	14	3.6
Ahp2 25–35	6.3	0	0.086	2.07	0.107	11.2	1.7	12	3.2
Bhtw 35–53	6.5	0	0.059	1.44	0.077	10.8	1.2	10	2.4
Btw 53–71	6.8	0	–	0.84	–	–	–	–	–
BCtw 71–80	7.0	0	–	0.43	–	–	–	–	–
BCtw 80–100	7.2	0	–	0.37	–	–	–	–	–
CRk 100–120	8.0	9.7	–	0.17	–	–	–	–	–

Table 5. The average statistical parameters of exchangeable cations of arable gray soil

Genetic horizons and depth, cm	me/100g soil		
	Ca^{++}	Mg^{++}	Sum
Ahp1 0–25	22.6	3.3	25.9
Ahp2 25–35	21.3	3.2	24.5
Bhtw 35–53	22.1	3.2	25.3
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
CRk 100–120	15.5	2.6	18.1

Gray soils follow of Northern Moldova are absolutely standard for comparing and assessing the changes in soil characteristics of arable gray soils in result of human impact. Absolute altitude – 239 m [5].

Gray soil fallow is characterized by profile type: *Aht –AEh –BEhtw – Bhtw – Btw – BCtw – CRk.*

The Profile 25 was located in the primary forest vis-à-vis of the Profile 24, 100 m south of the northern limit of arable land. Effervescence starts at 120 cm depth. At the depth 120 appear carbonates as pseudomicelii and veins.

The processes that led to the change in clay content in the soil layer Btw of investigated soil are: clay iluviation from layer 0–26 cm and the cambic process of alteration *"in situ"* of initial parent material of this horizon. Data on the characteristics of fallow gray soils are presented in Tables 6–10.

Table 6. Soil texture of fallow gray soil with full profile (Profile 25)

Genetic horizons and depth, cm	The limits of particle size 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
Aht 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
CRk 120–140	1.5	55.2	18.5	5.7	6.3	12.8	24.8

Table 7. Average statistical parameters of structural composition of fallow gray soil

Depth, cm	The content of structural elements (size, mm) determinate by dry sieving (numerator) and hydrostabile aggregates (denominator), % g/g				Structure quality (dry sieving)	Structural hydrostability (wet sieving)
	>10	< 0.25	Sum 10 – 0.25	Sum >10 + < 0.25		
Aht 0–9	7.2	9.3	83.5	16.5	Very good	Very big
	–	26.1	73.9	26.1		
AEh 9–24	9.5	5.2	85.2	14.7	Very good	Very big
	–	17.8	82.2	17.8		
BEhtw 24–35	31.0	3.6	65.4	34.6	Good	Big
	–	23.7	70.2	23.7		
Bhtw 35–53	46.1	4.7	49.2	50.8	Moderate	Big
	–	33.5	66.5	33.5		

Table 8. Average statistical parameters of physical characteristics of fallow gray soils

Genetic horizons and depth, cm	Horizon thickness, cm	Fractions, %g/g		Hygroscopicity	Hygroscopicity coefficient	Density	Bulk density	Total Porosity, % v/v	Compaction degree, % v/v
		<0.001 mm	<0.01 mm	% g/g		g/cm^3			
Aht 0–9	9	19.3	42.7	5.2	6.3	2.51	1.19	52.8	–6
AEh 9–24	15	20.8	43.6	4.2	5.3	2.59	1.27	51.1	–2
BEhtw 24–35	11	25.0	46.5	3.9	5.3	2.65	1.42	46.2	8
Bhtw 35–53	18	27.5	47.4	4.1	5.6	2.67	1.63	39.1	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
CRk 120–140	–	12.8	24.8	2.5	3.7	2.71	1.51	44.3	12

Table 9. Average statistical indices of chemical characteristics of fallow gray soil

Genetic horizons and depth, cm	pH	$CaCO_3$	P_2O_5 total	Humus	N total	C:N	Mobile forms, mg/100g soil		Hydrolitic acidity, me/100g soil
		% g/g					P_2O_5	K_2O	
Aht 0–9	6.4	0	0.147	6.16	0.272	12.9	7.6	39	2.4
AEh 9–24	5.6	0	0.095	3.14	0.153	12.2	3.1	17	6.3
BEhtw 24–35	5.5	0	0.075	2.12	0.112	11.5	2.1	14	5.4
Bhtw 35–53	5.6	0	0.057	1.25	0.067	10.9	2.2	12	3.9
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 of exchangeable cations in fallow gray soil

Genetic horizons and depth, cm	me/100g soil		
	Ca^{++}	Mg^{++}	Sum
Aht 0–9	27.9	2.9	30.8
AEh 9–24	19.7	3.1	22.8
BEhtw 24–35	18.8	3.2	22.0
Bhtw 35–53	19.1	3.3	22.4
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

Comparative characteristic of arable and fallow gray soils on the monitoring polygons (Profile 24 and Profile 25). Comparative characteristic of properties values of arable and fallow gray soils on the layers with standard depths is presented in Table 11. A wider information in this regard can be obtained as a result of comparing the mean parameters of the characteristics of these soils presented in Table 1–5 for arable gray soils and Table 6–10 for fallow gray soils.

Data of Tables 1, 6 and 11 confirms that arable and fallow soil texture is practically analogical: clayey in the upper portion of profile and clay-loamy in the iluvial and iluvial-cambic horizons. In conditions of recent structural state of arable layer of loamy texture of these soils it can be considered as good in terms of soil tillage.

Due to clayey texture the arable layer of these soils is comparatively easy in utilization, the ploughing is less cloggy, than in case of fine textured soils (clayey-loamy, loamy-clay, clayey), clods crumble easily. The texture of iluvial (iluvial - cambic) horizons Bhtw and Btw is clayey-loamy. Medium-fine and monolithic structure led to excessive compaction of these horizons and forming them as unfavourable physical state.

Table 11. Average statistical parameters of main properties of fallow and arable gray soils, on the standard depths (layers) agronomic important

Standard layers, cm	Fractions <0.001mm	Fractions <0.01mm	CH	D	DA	PT	GT	Humus, %	CaO_3	pH	AH
Profile 24. Gray soil 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	–
Profile 25. Gray soil fallow											
0–30	21.2	43.9	5.6	2.58	128	50.4	–1	3.84	0	5.8	5.0
30–50	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 - hygroscopicity coefficient, % g /g; D - density, g/cm^3; DA - bulk density, g/cm3; PT - total porosity, % v /v; GT - compaction degree; AH - hydrolytic acidity, me/100g soil.*

The arable layer structure of gray soil have moderate quality and low hydrostability of aggregates. So a favorable state of physical quality of this layer can be created only through regular tillage the soil over the entire period of the crop vegetation.

The upper layers of fallow soil, Aht, Aeh, BEhtw is characterized with very good structure, formed from hydrostabile aggregates. Using of these soils as arable led to the destruction of the initial favourable structure of fallow soil. Destructuration process decreased the resistance to compaction of this layer. Towards the end of the growing season the arable layer bulk density reaches 1.4–1.5 g/cm², and the underlying layer - higher than 1.5 g/cm² (Table 3 and 11) and creates unfavorable conditions for the plants growth.

The iluvial horizons Bhtw and Btw of arable and fallow gray soils are similar and characterized by monolithic structure, the bulk density (1.61–1.66 g/cm^3) and degree of compaction (20–24) are very high. Remediation of the physical state of iluvial horizon is possible by performing subsoiling at 40–70 cm of depth.

The humus content in arable soil layer of 0–30 cm (2.23%) compared with the humus content of the same layer of fallow soil (3.84%) was reduced by 1.6%. Arable soils have lost up to 42 percent of the initial content of humus.

Dehumification and soil tillage, in their turn, caused the destructiration and compaction of gray soils arable and worsening the physical quality status. As a result of physical degradation was reduced permeability and capacity for water, conductivity and water availability of arable soils.

Gray soils fallow is characterized by a significant accumulation of biofile elements (N, P, K) in surface horizons, the arable soils – with a considerable decrease in the content of these elements in the arable layer (Table 4 and 9).

The reaction of fallow soils is acidic (pH 5–6, hydrolytic acidity – 4–6 me), and the arable soils – slightly acidic (pH 6–7, hydrolytic acidity – 2.5–3.5 me), which led to the stopping the process of eluvial-iluvial in these soils.

Conclusion. Arable gray soil compared to fallow gray soil in the North of Moldova are characterized by moderate degradation as a result of dehumification, destructuration and significant decreased of biofile elements content. The iluvial horizons of gray soil arable and fallow is characterized by unfavorable physical and chemical properties - excessive compaction, acid reaction, low content of nutrients.

Gray soils arable are relatively poor in humus and nutrients; presence of compact iluvial horizons lead to reducing the water permeability, the result of which they are regularly influenced by temporary excess moisture; have poor antierosion stability (soil with medium, medium-coarse and coarse texture); their natural fertility is relatively low. Acidity of arable gray soil was significantly decreased, which led to stopping the eluvial-iluvial process, but still remained quite high.

Under appropriate agricultural technology of sustainable agriculture, due to favorable atmospheric humidity regime, on the arable gray soils can be obtained higher yields of agricultural crops.

Continued use of arable soils under deficit of organic and chemical fertilizers will lead to further impoverishment of their nutrients status and worsening their quality.

Pedoameliorative and agrotechnical measures required for these soils are:

– raising organic matter in arable layer by introducing organic fertilizers, green manure, residues and organic waste, crop rotations regional implementation;

– introduction harmless doses of chemical fertilizers;

– improving the soil tillage (performing once in 3–4 years plowing at 35 cm depth to crumble heavily compacted layer);

– regular soil tillage at depth of 40–50 cm for partial aeration of natural iluvial extremely compacted horizon.

REFERENCES

1. *Monitoringul* calităţii solurilor Republicii Moldova (coord. V. Cerbari). Chişinău: Pontos, 2010. P. 58–87.
2. *Программа* освоения деградированных земель и повышения плодородия почв. Часть II. Повышение плодородия почв. Chişinău: Pontos, 2005. P. 33–61.
3. *Лях Т.Г.* Мониторинг качественного состояния почвенного покрова и продуктивности земель в Молдове. *Тезисы докладов* Международной научно-технической конференции "Системы контроля окружающей среды", СКОС–2016. Севастополь: ИПТС, 24 – 27 октября 2016. С. 98.
4. *Cerbari V., Leah T.* Processes of soil degradation in Moldova and principal actions intended to prevent soil degradation and environmental aggravation of agriculture. In: Soil under Global Change – a Challenge for the 21st Century. Vol. 1. Constanţa, Romania, 2003. P. 103–114.
5. *Программа* освоения деградированных земель и повышения плодородия почв. Ч. I. Мелиорация деградированных земель. Chişinău: Pontos, 2005. P. 29–35.

МОНИТОРИНГ КАЧЕСТВА ЗОНАЛЬНЫХ ПОЧВ: СЕРЫЕ ПОЧВЫ СЕВЕРНОЙ ЗОНЫ МОЛДОВЫ

Т.Г. Лях

Институт почвоведения, агрохимии и охраны почв "Николае Димо"
Кишинев–2070, ул. Яловенская, 100
E-mail: tamaraleah09@gmail.com

Показаны результаты мониторинговых исследований пахотных и залежных серых почв северной зоны Молдовы. Использование серых почв в качестве пахотных земель привело к умеренной деградации физико-химических свойств: снижение содержания гумуса, разрушение структуры, уплотнение пахотного слоя и потери питательных веществ. Дальнейшая эксплуатация пахотных серых почв в сельском хозяйстве, в условиях дефицита удобрений, без защитных мер приводит к ухудшению их качественного состояния.

Ключевые слова: пашня, деградация, залежь, серые почвы, мониторинг, физико-химические свойства.