LUCRĂRILE SIMPOZIONULUI "SISTEME INFORMAŢIONALE GEOGRAFICE", NR. 13.
Anal. Şt. Univ. "Al. I. Cuza" Iaşi, Tom LIII, s. II c., Geografie, 2007

THE IMPACT OF USAGE ON THE SOILS OF THE REPUBLIC OF MOLDOVA

Andrei Ursu, P. Vladimir, I. Marcov, Stela Curcubăt, Vera Krupenicov
Ecology and Geography Institute of the Republic of Moldova Science Academy

Abstract: Our study evaluates the impact of agricultural activities on virgin soils. The percentage of the soils used in agriculture has reached 86%. Along 100 years, soil tillage has led to changes in physical and chemical characteristics, to reductions of humus and nutrients (nitrogen, phosphorus etc.) contents, as well as to downgrading of the agro-physical parameters. We have investigated luvisols, phaeozems, and chernozems. The greatest loss of humus occurs in A horizon. Chernozems display the highest potential of preserving and regenerating the humus content.

Key words: *agricultural activities, soil properties, impact*

Introduction

The soil as a natural body formed during thousands of years, as a result of the interaction between parental materials, relief, climate and biotic factors – all named soil forming factors. The interdependence of these factors conditioned the formation of certain genetic soil units – type, subtype, gender etc. The research conducted by soil scientists and botanists established a relation and interdependency among soil types, the biocoenoses types and other soil forming factors. Thus under forests formed Luvisols and under the steppe vegetation Chernozems. At the same time the pedogenetic processes were influenced by the relief (altitude, aspect, slope etc.), parental materials. The later, together with the presence of underground waters, soluble salts, have conditioned the formation of litomorphous, hidromorphous, halomorphous intra-zonal soils.

Besides the natural soil forming factors, in the last 50–100 years in the Republic of Moldova human activity more and more clearly manifests itself as factor with significant impact on soils.

Study object and methods

To evaluate the anthropic impact on the soil characteristics, have been studied some of the soils from the Republic of Moldavia: entic Luvisols, Phaeozems, argic Chernozems, calcic Chernozems. Also have been conducted comparative studies of the natural and cultivated soils. The research have been conducted on the morphological structure, and the samples taken from each genetic horizon of the soil profile have been analyzed in the laboratory (humus, carbonates, exchangeable cations, cations sum contents, and for the Phaeozems hydrolytic acidity also).

Results

The research conducted on the territory of the Republic of Moldova [1, 4, 7, 10, 11, 13] have demonstrated the negative impact of the excessive usage of sols. This process was intensified during the last 50–100 years. The percentage of soils intensively cropped and exploited reached 86%. Natural vegetation was maintained only on less that 10% of the republic territory. Forests occupy 9–10%.

The negative impact of the anthropic activities on the soil forming processes, first of all on humus content and on other soil components is examined in the present study, without approaching the influence of the natural factors (rock, relief, climate) on these processes.

The humus is one main indicators of soil fertility. It contains about 96–98% of the total nitrogen quantity, 60–70% of the sulphure one. In the arable layer about 50% of the total phosphorous is contained in organic form. This fundamental component of the soil determines largely its physical, chemical and biological characteristics. At the same time with the clearing of the natural vegetal cover and the inclusion of terrains in the agricultural circuit, the humus synthesis and mineralization processes were disturbed, the later suddenly dominating.

The research conducted by the "A. Dimo" Pedology and Agrochemistry Institute have demonstrated that the dehumification (mineralization) speed of the humus in different soils has an average (measured on 25-30 years) of 0,016–0,023 % [1; 4].

Taking into consideration the decisive content of the total nitrogen in the soil humus, its loss may ad also to the loss of nitrogen from soils. The loss of humus leads to the deterioration of soils' physical characteristics.

In the following tables are presented the results of the study regarding the modifications in the characteristics of the un-cropped and tilled soils. There are presented the physico-chemical characteristics of soils determined through the analysis of the samples' substantial component. The presented data prove the severe degradation of the pedo-ecological equilibrium, the diminishment of the humus content in the cropped soils. The diminishment of the humus content takes place for all the genetic units of the studied soils.

The Luvisols are met in the Codri forested area, and occupy the highest altitudes, with increased humidity. They were formed in the conditions of the beech and oak forests, at altitudes of 300–430 m. These soils are separated by their brownish and then yellowish color. At the surface, under the leafage, occurs a brown-grayish humified horizon. The humus content in the A_1 horizon makes up 4–5, sometimes 6–7%, and suddenly decreases with depth (tab.1).

Table 1. *Physical and chemical characteristics of an entic Luvisol*

Genetic horizon	**Depth. cm**	**Hygroscopicity**	**Humus**	**pH (KCi)**	**Exchangeable cations**		
					Ca^{++}	**Mg^{++}**	**∑**
		%			**me/100g sol**		
Forest. profile 89. Central Moldavian Plateau. s. Bursuc (Nisporeni). 2007							
A	0-10	1.62	2.53	6.55	8.94	4.07	13.01
AB	20-30	1.03	1.23	5.20	2.83	4.04	6.87
B_1	45-55	1.09	0.47	5.50	4.04	2.87	6.88
	60-70	1.44	0.36	5.32	6.29	2.64	8.93
BC	90-100	1.98	0.31	5.80	7.75	2.86	10.61
	120-130	1.40		4.55	5.48	3.04	8.52
C	140-150	1.28		4.65	4.46	2.43	6.89
Tillage. profile 90. Central Moldavian Plateau. s. Bursuc (Nisporeni).2007							
A	0-10	1.89	1.09	5.55	8.15	2.45	10.6
AB	20-30	1.70	0.79	5.45	7.55	2.23	9.76
B_1	45-55	1.69	0.76	5.80	8.95	2.44	11.39
	60-70	2.21	0.47	5.40	9.40	2.87	12.27
BC	90-100	2.20	0.28	5.25	9.40	3.27	12.67
	120-130	1.95		5.45	8.16	2.85	11.01

The usage of the Luvisols leads to the diminishment of the humus content in the upper horizon with more than 30%.

Phaeozems occupy the dominant altitudes (220–350m) of the Northern Plateau, Pre-Nistrean Hills and the periphery of the Codri region, locally and in other areas (Tigheci, Puhoi, Rădoaia etc.). They were formed in the conditions of the silvo-steppe under deciduous forests – beech, oak, hornbeam in different mixtures. Are characterized by a differentiated profile: the A horizon at the upper part is grayish, contains up to 7% humus (average 3–5%), has a granular structure, and its lower part is whitish, of eluvial character. The B horizon is iluvial, brownish-reddish, compact, with a polyhedral structure. The Phaeozems is represented by 4 subtypes: albic, haplic, molic and vertic. The Phaeozems have been mostly included in the agricultural circuit. After the clearing of forests and their tillage, they lose in a short period a significant part of the organic mater accumulated in A. Phaeozems are used for the cultivation of crops, orchards, European vineyard types. In the case of their use in orchards and vineyards they have been deeply tilled.

In the a horizon of the haplic Phaeozem, after cropping the humus content diminished with 40–50%, and in the molic one with abut 35% (tables 2,3).

Table 2. *Physical and chemical characteristics of a haplic Phaeozem*

Genetic horizon	Depth, cm	Hygro-scopicity	Humus	$CaCO_3$	pH	Exchangeable cations			Hydrolitic acidity	GSB, %
						Ca^{++}	Mg^{++}	Σ		
		%				me/100 g. sol				
Forest, profile 7, Central Moldavian Plateau, 1999										
A_1	1-5	2.6	7.1		5.8	20.0	3.0	23.0	5.3	81.3
A_2	10-20	2.6	2.6		5.4	16.5	2.5	19.0	6.0	78.0
	30-40	3.8	1.4		5.6	25.0	4.0	29.0	6.3	82.2
B_1	50-60	4.9	0.8		5.6	28.0	3.0	31.0	6.3	83.2
B_2	70-80	4.9	0.6		6.0	32.0	4.0	36.0	3.7	90.7
	90-100	4.6	0.6		6.0	33.0	4.0	37.0		
C	110-120	3.8	0.6	8.1	8.0	28.1	4.4	32.5		
	140-150	3.4		8.0	8.2	25.4	5.4	30.8		
	190–200	3.0		8.8	8.2	22.6	6.4	29.0		
	290–300	3.1		8.0	8.2	22.2	7.8	30.0		
Tillage, profile 29, Soroca Hills silvo-steppe, 1963										
A_1	0–10	2.4	4.16		5.4	17.2	2.1	19.3	2.9	87
A_2	20–30	2.7	1.16		4.7	16.5	2.5	1.90	3.2	85
B_1	38–48	3.1	1.08		4.7	18.2	2.9	21.1	2.8	88
B_2	65–75	3.7	0.61		4.7	22.5	3.3	25.8	2.4	91
B_3	140–150	2.9	0.61		5.4				1.8	

Most part of the Republic of Moldova is covered (>70%) by Chernozems. These differ in what regards the accumulative character, are well humified up to 80–100 cm, well structured and light. Chernozems are represented by 4 subtypes: argic, haplic, calcic and vertic. The repartition of these subtypes is conditioned mainly by the natural zoning and by the biocoenosis under which they were formed. Disregarding the zoning of the Chernozems, in comparison to the other taxonomic soil units they have been used intensively. Nowadays, due to the lack of un-cropped soils, it has been very difficult to find areas with undisturbed conditions so as to study comparatively the modifications in the ecologic equilibrium as a result of their cropping.

Table 3**.** *Physical and chemical characteristics of a molic Phaeozem*

Genetic horizon	**Depth, cm**	**Hygro-scopicity**	**Hu-mus**	**$CaCO_3$**	**pH**	**Exchangeable cations**			**Hydrolitic acidity**	**GSB, %**
						Ca^{++}	**Mg^{++}**	**Σ**		
		%				**me/100 g. sol**				
Forest, profile 28, s. Rădoaia (Sângerei) 2005										
A_1	0-10	3.6	4.75		5.6	12.9	6.2	19.1	8.6	68.9
A_2	10-20	3.5	2.71		5.7	12.4	5.6	18.0	6.3	74.2
B_1	30-40	3.8	1.12		5.7	12.5	4.1	16.6	5.4	75.3
B_2	55-65	6.2	0.85		5.9	21.7	5.5	27.2	4.6	8.5
C	80-90	4.5		27.1	8.5					
	110-129	4.2		20.9	8.4	22.1	5.4	27.5		
Tillage, profile 1, Northern silvo-steppe, s. Ţaul (Donduşeni),1995										
A_1	0-5		2.9		7.2	13.	4.6	18.2		
A_2	5-30		2.6		6.7	13.6	3.5	17.1		
	30-40		1.6		6.8	14.9	4.3	19.2		
B_1	60-70		1.0		7.7	18.0	5.3	23.3		
B_2	80-90		0.7	6.3	8.2	18.1	5.3	23.2		
	90-100		0.9	8.6	8.5	16.9	5.5	22.4		
C	110-130		0.6	12.2	8.5	16.4	5.3	21.7		

Among the Chernozems, in natural conditions the highest humus content is held by the argic ones, who reach 8%. The argic Chernozems have formed in the conditions of oak forests with well developed grass cover, at the contact with the mezophyle grasslands and steppes, or in the conditions. The cropping of these sols leads to a considerable loss of organic matter, which in the A horizon reaches 16–45% (tab. 4).

The haplic Chernozems represent the modal subtype, formed in the conditions of steppe or sometimes oak forests. The A horizon is well humified, structured, light. This subtype is divided in two genders – moderately humified (under mezophyle steppes and oak forests) and weakly humified (under xerophyle steppes with father grass and fescue).

The tillage of the moderately humified Chernozem led to the loss of 23–45% of the A horizon humus (tab. 5).

Table 4. *Physical and chemical characteristics of an argic Chernozem*

Genetic horizon	**Depth, cm**	**Humus, %**	**pH (KCl)**	**Exchangeable cations**		
				Ca^{++}	**Mg^{++}**	**∑**
				me/100 gr sol		
Forest, profile 7, Northern silvo-steppe, s. Țaul (Donduşeni), 1996						
A_1	0-10	6.6	5.0	17.7	3.4	21.1
A	10-20	5.8	5.0	16.9	5.5	22.4
	30-40	4.4	5.6	16.3	5.6	21.9
	40-50	3.1	5.9	15.4	6.0	21.4
B_1	50-60	2.4	6.1	15.5	5.6	21.1
B_2	60-70	1.8	6.3	15.7	6.5	22.2
	80-90	1.6	6.4	15.2	6.8	22.0
BC	100-110	1.0	6.8	14.3	7.9	22.2
	110-120	1.0	6.9	13.8	7.3	21.1
	120-130	1.0	7.4	13.3	7.1	20.4
C	130-140	0.9	7.8	12.5	8.4	21.0
	160-180	0.9	8.2	12.3	7.8	20.1
Tillage, profile 8, Northern silvo-steppe, s. Țaul, (Donduşeni), 1996						
A	0-10	4.0	7.3	16.7	5.9	22.6
	10-20	4.2	7.5	16.3	4.1	20.4
	30-40	2.6	7.3	16.6	4.8	21.4
B_1	50-60	1.7	7.3	18.1	6.5	24.6
B_2	60-70	1.2	7.3	18.0	5.9	23.9
	80-90	1.2	7.9	17.6	4.1	22.7
BC	90-100	0.7	8.0	18.6	4.4	21.0
	110-120	0.9	8.0	13.9	4.4	18.3
C	130-150	0.6	8.2	15.2	4.8	20.0

The data presented in table 5 lead to the idea that the humus content equilibrium may be re-established in 50–55 years. Excluding the moderate-humus content haplic Chernozem from the agricultural circuit has led to the re-establishment of the humus content. The analysis of the samples from the mentioned soil from profile 69, placed under an oak-thorn tree forest belt, as well as from profile 70 from the same area, but at a distance of 50m, in tilled field, proved that the humus content of the soil from the forested belt considerably increased in the A horizon from 5.2–5.4 up to 6.9%, a quantity probably equal to the lost organic matter. This fact confirms that the ecological equilibrium lost after cropping may be re-established. Stopping the mineralization process and helping the organic matter accumulation in soil may be done by strictly respecting crop rotations in which dominate perennial grass crops, and incorporating into soil considerable quantities (10–12 t/ha) of manure and other organic substances, for compensating the humus lost after intensive and irrational cropping and exploitation [1].

Table 5. *Physical and chemical characteristics of a moderate-content haplic Chernozem*

Genetic horizon	**Depth, cm**	**Hygro-scopicity**	**Humus**	**$CaCO_3$**	**pH**	**Exchangeable cations**		
						Ca^{++}	**Mg^{++}**	**∑**
	%					**me/100 g sol**		
Protection forest belt, profile 69, Crop Institute „Selecția”, 2006								
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
A_1	0-10	5.72	6.9		7.95	34.68	5.07	39.75
A	30-40	5.85	3.9		7.50	32.18	5.08	37.26
B_1	50-60	7.43	2.8		7.25	30.72	4.52	35.24
B_2	70-80	5.19	2.0	5.1	8.43			
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
BC	90-100	4.70	1.1	7.7	8.43	26.59	3.56	30.15
C	110-120	4.77		14.0	8.55			
Tillage, profile 70, Crop Institute „Selecția”, 2006								
A_{ar}	0- 10	5.19	3.90		7.10	29.66	5.26	34.92
A	30-40	5.42	3.70		7.20	30.36	5.06	35.42
B_1	50-60	5.38	2.30		7.50	28.45	4.85	33.30
B_2	70-80	5.21	1.40	3.80	8.16			
BC	90-100	4.43	1.00	8.10	8.65	26.32	7.36	30.08
C	110-120	4.34		13.70	8.65			

The weakly humified haplic Chernozem, being rarely met (under grass or turf), re-establishes the initial humus content (tab. 6) and structure. The use of this soil starts a slow but practically irreversible degradation.

The researches on the calcic Chernozem have shown that the difference in the humus content between the soil under forest belt and the tilled one is insignificant. The re-establishment of the organic matter content in the calcic Chernozems from the southern plains is slower, remaining at a low level (tab. 7).

The exploitation of the cropped soils needs an essential modification in the attitude of the landowners towards this production mean [3]. It is strictly necessary to stop the negative balance of the humus. In this purpose may be used different organic composted residues, and obligatorily crop rotations with perennial grasses.

Table 6. *Physical and chemical characteristics of a weakly-humified loamy Chernozem*

Genetic horizon	Depth, cm	Hygro-scopicity	Humus	$CaCO_3$	pH	Exchangeable cations		
						Ca	Mg	∑
		%				me / 100 g sol		
Grass, profile 21, Southern silvo-steppe, Leova, 1973								
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
A_1	0-10	3.26	3.7		7.6	18.4	2.4	20.8
A	20-30	3.5	3.4		7.6	19.0	2.8	21.8
	50-60	3.5	2.4	2.6	7.3	20.6	3.o	23.6
B	70-80	2.9	1.6	10.6	8.3	16.8	3.4	20.2
	90-100	2.6	1.1	17.6	8.3	13.4	3.9	17.3
	110-120	2.5	1.0	15.5	8.4	11.6	5.2	16.8
C	140-150	2.2	0.6	17.3	8.2	12.6	6.3	18.9
Tillage, profile 46, Southern silvo-steppe, Taraclia , 1996								
	0-10	3.2	2.9		7.4	19.4	8.3	27.7
	10-20	3.2	2.8		7.3			
A	20-30	3.4	2.1		7.3	18.2	6.6	24.8
	30-40	3.6	2.5		7.2			
	40-50	3.9	2.1		7.8	20.8	5.4	26.2
	50-60	3.9	3.3		8.1			
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
B	60-70	3.8	1.7	1.1	8.2			
	70-80	3.5	1.5	5.5	8.1			
	80-90	3.3	1.3	6.9	8.1	19.0	5.4	24.4
	90-100	3.4	1.4	9.0	8.1			

Table 7. *Physical and chemical characteristics of a calcic Chernozem*

Genetic horizon	Depth, cm	Hygro-scopicity	Humus	$CaCO_3$	pH	Exchangeable cations		
						Ca^{++}	Mg^{++}	∑
		%				me / 100 g sol		
Forest belt, profile 49, Southern silvo-steppe, s. Samurza (Taraclia), 2006								
A_0	0- 8	3.88	2.83	2.6	8.46	26.8	3.54	30 4
A_1	15-25	3.98	2.08	3.6	8.56	26.62	3.11	29.73
A_2	35-45	4.09	1.64	4.5	8.59			
B_1	60-70	3.79	1.25	5.8	8.59	24.08	3.32	27.40
B	90-100	2.86	0 41	6.8	8.72	16.05	6.58	22.63
C	120-130	3.22	0.49	13.0	8.62			
C	140-150	2.95		10 7	8.72			
Tillage, profile 50, Southern silvo-steppe, s. Samurza (Taraclia), 2006								
A_{ar}	0-10	3.88	2.48	1.3	8.40	27.0	3.75	30 75
	20-30	3.90	2.80	1.7	8.43	27 85	4.15	32.00

A_2	40-50	4.08	1.94	2.3	8.45			
B_1	60-70	3.71	1.42	5.8	8.51	22.82	4.15	26.97
B	90-100	3.29	1.26	10.9	8.59	19.84	5.57	25.41
C	120-130	2.90		7.6	8.62			

Conclusions

The use of the undisturbed soils has led to the modification of the physical and chemical characteristics, to the diminishment in the nutritive substances content (nitrogen, phosphorous) and in the humus content, especially in the intensely tilled a horizon.

The intensification in mineralization and cropped soils' degradation depends on the composition and properties of the genetic units.

The Luvisols and Phaeozems are the most vulnerable soils, in which the ecological equilibrium may be easily disturbed. The loss of humus in these soils after cropping reaches 40% or even more. Chernozems have a superior capacity of maintaining and re-establishing the ecological equilibrium, that decreases from the argic to the calcic subtypes.

References

Andrieş S. *Optimizarea regimurilor nutritive ale solurilor şi productivitatea plantelor de cultură*, Chişinău, 2007.

Buletin de monitoring ecopedologic, ed.3. Chişinău, 1996.

Cadastrul funciar al Republicii Moldova la 1 ianuarie 2006. Chişinău, 2005.

Degradarea solurilor şi deşertificarea (sub red. acad. Ursu A.). Chişinău, 2000.

Natura Rezervației „Plaiul Fagului”. Chişinău-Rădenii Vechi, 2005.

Ursu A. *Unitățile taxonomice de raionare pedologică*, Lucrările seminarului geografic „Dmitrii Cantemir”, ed. 11–12, Iaşi, România, 1995.

Ursu A. *Raioanele pedogeografice şi particularitățile regionale de utilizare şi protejare a solurilor*. Chişinău, 2006.

Докучаев В.В. Наши степи прежде и теперь, 1892. // Избранные сочинения, Москва, 1954.

Крупеников И.А., Феномен чернозема и парадоксы его судьбы. // Starea actuală, problemele utilizării şi protejării solurilor. Lucrările conferinței ştiințifico-practice, Chişinău, 2006.

Урсу А.Ф., Могоряну Н.В. Лесные почвы Резинских Кодр Молдавии. // Вопросы исследования и использования почв Молдавии, сб. 1, Кишинев, 1963.

Урсу А.Ф. Черноземы Приднестровской возвышенности. // Вопросы исследования и использования почв Молдавии, Вып. II, 1964.

Урсу А.Ф. Основные принципы агропочвенного микрорайонирования. // Вопросы исследования и использования почв Молдавии, сб. 1, Кишинев, 1969.

Урсу. А.Ф. Почвенно-экологическое микрорайонирования Молдавии. «Штиинца», Кишинев, 1980.

Урсу А. Ф. Почвы буковых лесов Молдавских Кодр. Москва. «Почвоведение», № 8, 2005.