Lucrările Seminarului Geografic Dimitrie Cantemir
Vol. 41, October 2016, pp. 63-70
http://dx.doi.org/10.15551/lsgdc.v41i0.07

Elements of Evolution of the Bio-Energetic Status of the Chernozems in Space Between the Prut and Nistru Rivers in Anthro-Pedo-Genesis Conditions

Gheorghe Jigău[1], Elena Cernolev[2], Olesea Tabără[2], Ana Bârsan[1], Viorel Botnaru[3]

[1] State University of Moldova, Republic of Moldova
[2] Academy of Science University of Moldova, Republic of Moldova
[3] National Agency for rural Development (ACSA), Republic of Moldova

To cite this article: Jigău, G., Cernolev, E., Tabără, O., Bârsan, A., Botnaru, V. (2016). Elements of Evolution of the Bio-Energetic Status of the Chernozems in Space Between the Prut and Nistru Rivers in Anthro-Pedo-Genesis Conditions. *Lucrările Seminarului Geografic Dimitrie Cantemir*, Vol. 41, pp. 63-70. DOI: 10.15551/lsgdc.v41i0.07

To link to this article: http://dx.doi.org/10.15551/lsgdc.v41i0.07

ISSN: 1222-989X www.seminarcantemir.uaic.ro

ELEMENTS OF EVOLUTION OF THE BIO-ENERGETIC STATUS OF THE CHERNOZEMS IN SPACE BETWEEN THE PRUT AND NISTRU RIVERS IN ANTHRO-PEDO-GENESIS CONDITIONS

Gheorghe Jigău[1], Elena Cernolev[2], Olesea Tabără[2], Ana Bârsan[1], Viorel Botnaru[3]

Abstract. The anthropedogenesis of chernozems involves a complex of processes of degradation evolution of their bio-energetic resources. In the anthropized evolution of the bio-energetic resources of chernozems increases the share of the mineralization processes associated with the reduction their consumption efficiency in pedogenesis. This development occurs in stages with transfers energy and structural-functional conditions. By knowing the stages of anthropized staggered evolution of the chernozems, it provides conceptual and methodological support of assurance of their bioenergetical resources sustainability.

Keywords:bio-energetic status, chernozems, anthro-pode-genesis conditions

1. Introduction

The evolution of chernozems of the space between Prut and Nistru is determined by the dominant role of humification process, which determines the integration mode of the abiotic and biotic components within the biorutinist system of the chernozems. The modification in the content and system component of the organic substances implicates the modifying of soil characteristics (qualities) and regimes.

In the modern farming practices used in the region, the harvests of the agricultural crops are formed, mostly, due to natural potential of the soils, the role of bio-energetic resources is determined, primarily, by their place in the defining of the soils characteristics, pedogenetical regimes and their functions in dealing with landscape components. In the circumstances when the applied intensive technologies involve multiple processes of degradation (the destructuration, disaggregation, compacting, the reduction of the retention and buffering capacity, etc.), the role of the energy resources in the functioning of soils becomes more important.

[1] State University of Moldova (www.usm.md)
[2] Academy of Science University of Moldova
[3] National Agency for rural Development (ACSA) (www.acsa.md)

2. Objects and methods of study

The research has included applications on the field and laboratory studies. During the applications on the field, soil samples were collected from the active pedogenetical layer according to the existing instructions. Each land was divided into elementary plots with an area of 12 hectares, from which were collected individual soil samples and were made mixed samples.

The laboratory studies were conducted by using the standardized methods in Republic of Moldova (Tab. 1)

Table 1: Methods used in order to evaluate the soils

No.	The determined parameters	Unit of measurement	Methods for determination	STAS
1	The quantity of humus	%	Tiurin in modification TINAO	26213-91
2	The quantity of P_2O_5	mg/100 g of soil	Macighin	26205-91
3	The quantity of K_2O		Macighin	26423-85
4	The quantity of total nitrogen	%	Tiurin	

The humus composition was studied by the method of M. M. Cononova (1953).

In this regard, it is unanimously recognized that the forced mobilization of the natural fertility potential of chernozems, in order to increase the productivity of agro-ecosystems, leads to the disruption (disorder) of physical, chemical, physical-chemical and biochemical processes, the reduction of retention capacity and extended reproductive capacity of the natural fertility with modification of the evolutionary trend direction of chernozems.

Starting from this, as part of the present research, as an integrator index (indicator) of chernozems evolution and their fertility, there are used indicators of the bio-energetic resources status and its trend in conditions of anthropedogenesis.

3. Materials and discussions

The mobilization of the bio-energetic status indicators of chernozems is determined by the interaction of two processes oriented contrary: the formation of humus and its mineralization. In the natural ecosystems, the specified processes are in quasi-equilibrium and its dynamics is determined by the dynamics conditions of landscape with the assurance of evolutional-progressive trend of the black earth (chernozems) type of soil formation.

The perturbation of landscape conditions led to disruption of the balance between the formation and mineralization of the humus and beginning of a trend anthropo-modified.

In the early stages, the first 3-5 years after framing in the circuit, the evolution of chernozems bio-energetic indicators was determined by the enhancing mineralization process as a result of increasing the degree of soil aeration in the arable layer. This involves the humic (humus) substances decomposition less stable with insignificant quantitative changes. The humus losses were compensated by the formation of fresh humic substances as a result of the humiferous dendrite-humification. The next 10-15 years, it is characterized with the highest intensity of processes of reducing of the chernozems energy resources due to the accelerated mineralization of the humiferous detritus. This stage is characterized by the significant increase of the agro-ecosystems productivity. This involved increasing the amount of fresh organic debris (residues) and enclosed in pedogenesis.

The dehumification process was limited mainly to the first 25-30 cm (the arable layer). The subjacent layer, practically, is not affected by the dehumification process. At this stage, to the evolutional trend, there are determined changes mostly with quantitative characteristic (element).

The next phase of evolution of the indicators of bio-energetic status of soil is determined by the primary role of structure, crop rotation and fertilization system. This assumes the modification of the amount dynamics and the substances circuit structure in pedogenesis. The evolution of bio-energetic resources of the chernozems involves qualitative changes which include: the modifying of the ratio Coh: Cot, C:N ratio in humus composition etc. At this stage, the changes affect the underlying layers (subjacent).

In terms of quantity, the degradation of bio-energetic resources is materialized by reducing the reserves of humus and biofile elements in soils with the subsequent degradation of soils biological regime. In this regard, the current research calculations indicate the predominance in central and south regions of the republic of Moldova of soils with moderate humus content (78-81%). Optimal soil humus content (4-5%) account for just 7-8% humus and those containing less than 2% is respectively 12-14% (Tab. 2 and 3).

The results indicate that contemporary soil evolution processes of humus status of the chernozems in space between the Prut and Nistru rivers lead to the deletion of genetic differences between the typical moderate humiferous and low humiferous chernozems in the central region and low humiferous and carbonate in the south. Therefore, in the anthropogenic pedogenesis framework, the process of humus formation and accumulation no longer fulfills the dominant role in the unidirectional progressive evolution of the chernozems.

Table 2: The surfaces share with different insurance level of humus and macro elements (%) of the typical moderate humiferous chernozems in central region of the Republic of Moldova

Category	Humus content,%	Total nitrogen content,%	Nitrogen ensuring, %	Mobile phosphorus ensuring, mg/100g soil	Exchangeable potassium ensuring mg/100g soil
Very low	-	-	-	-	-
Low	14	-	14	36	7
Moderate	78	86	78	14	8
Optimal	8	-	8	22	57
High	-	14	-	7	14
Very high	-	-	-	7	14

Table 3: *The surfaces share with different insurance level of humus and macro elements (%) of the typical moderate humiferous chernozems in south region of the Republic of Moldova*

Category	Humus content, %	Total nitrogen content,%	Nitrogen ensuring, %	Mobile phosphorus ensuring, mg/100g soil	Exchangeable potassium ensuring mg/100g soil
Very low	-	-	-	6	6
Low	12	16	12	44	15
Moderate	81	84	81	-	56
Optimal	7	-	7	12	6
High	-	-	-	26	29
Very high	-	-	-	12	-

Chernozems of south and center area of the republic of Moldova are characterized by moderate nitrogen content of total accounting for 84% and 86% of evaluated surfaces. However, in the central area approx. 14% of soils are with high content of nitrogen and 16%

of the land in the south is characterized with low content of total nitrogen. The conducted research reveals the high variability degree of mobile phosphorus content, both in chernozems of central and south areas, caused by the natural anthropogenic evolution of the landscape. Thus, in the south area about 50% of the studied soils are characterized by very low and low mobile phosphorus content. The soils of the central area are, also, in the area of requirement with mobile phosphorus (36%), and the moderate soils provided with mobile phosphorus constitute 14% of the investigated soils. Half of the southern studied soils are characterized by a relatively optimal (12%) to high (26%) content of phosphorus, for the central area being typical only 14% of land supplied high and very high with mobile phosphorus and 22% optimally supplied.

Thus, we conclude that the phosphorus content variability in soils is influenced by anthropogenic factors evaluated by uncontrolled phosphorus fertilizers use. However, analyzing the current situation of phosphorus supply status, we can conclude that the residual effect of the phosphorus fertilizers used in the past is limited in time, that in soil cannot be formed reserves able to maintain a longer period of time a stable mobile phosphorus content that would ensure the soil for longer period.

The potassium content is more stable due to the nature and origin of this element. Research results show that more than 80% of soils are supplied with optimal or high potassium content. The vast majority of soils, spontaneously, regenerate the potassium content adsorbed in the primary and secondary minerals structure. This process is facilitated by roots by carrying the potassium from deeper soil horizons. Thus, according to research, the physicochemical mechanism for the recovery of the mobile potassium is even more pronounced as the potassium insurance status of the soils is better (Ковда, 1983).

In qualitative aspect, the bio-energetic degradation involves the mechanisms modification of the humification process. In tables 4, 5 and 6, there are shown agrogen degradation factors of humification process and evolutionary trends types, as well as the evaluation indicators of these processes. In this regard, we are mentioning the degradation of the organic substances system, the reductions in humus reserves and its composition with impact on soil ecosystem functioning.

The system degradation of organic substances includes:

- the modifying of the ratio between humiferous dendrite reserves and those of humus that determines the degree of stability of the organic substances system;
- the reducing of humus reserves;
- the modifying of the ratio between inert and labile forms of humic substances.

In this chapter, our research has shown that by reducing the non-humificate organic substances amount entails the humus mobility increasing, which protects the inert humus from deep destruction. In these circumstances, it is attested the absolutely reduction of inert humus content and its share in the organic substances system.

When the non-humic organic substances content increases, the mobile humic substances content and its share in the organic substances system is decreasing.

According to our research, in fallow soils (uncultivated) the humic dendrites content is approximately 8-12% from the total content of organic substances. In arable soils, its content is reducing up to 0.5-3%. The content of labile humic substances is determined by cultivated crops and its harvests and constitutes 1.8-4.3% of the total humus content and is 36-44% lower than in fallow soils. Also, it was determined that the agricultural system components differently influence the organic substances system:

- Crop structure and its rotation duration influence humic dendrites content.
- The fertilizer system influences the content and composition of the labile humus fraction (portion). It has been established that for bioclimatic conditions of space between the Prut and

Nistru rivers the optimal values of the ratio C:N = 10-12. Smaller values denote nitrogen nonproductive losses and higher values indicate different nitrogen to achieve the humification process.

- The working system influences the humic dendrites content and labile humic substances compounds.

Significant changes endure the humus composition in arable soils. In this regard, it is attested the reducing of humic acids content and slow humus fulvatization.

Table 4: *Anthropogenic humus degradation factors and categories of evolutionary trends*

Degradation factors	The character of anthropogenic impact	Type of degradation	Evolutionary trends
Agrogen	Substitution of biocenoses with agro-phytocenosis	Chemical Physicochemical Biological	Agrogen-degradational
	Long practice of mineral fertilizers		
	Chemical soils treatment	Biological Biochemical	
Natural-agrogen:			
a) Hydrologic	Hydric regime modification	Chemical Physicochemical Biological	Natural-agro-degradational
b) Erozional	The use in agriculture of land with erosion risk	Physical Mechanical	Natural-agro-erosional
c) Agrotehnogen	The unblocking plowing, drainage-draining irrigation	Physical Mechanical Physical, Mechanical, Biological, Chemical	Agro-tehnogen-disrupted

Table 5: *Humus degradation indicators depending on the anthropogenic impact character (I)*

The anthropogenic impact	Disturbance modes of humification conditions	Degradation indicators
Chemical, physicochemical and biochemical degradation		
Substitution of biocenoses with agro-phytocenosis	Humus source deficiency, decalcification	Easy clay destruction; cationic exchange capacity reduction; reducing the content of freshly formed humus; slight humus fulvatization; slight increase Ca:Mg ratio in [CAS]
Long practice of mineral fertilizers	Impairment of soil biota. Composition disruption [CAS] and pH values.	Reducing of humus content; disruption of C:N ratio values and Cah:Caf values; cationic exchange capacity reduction
Biological and biochemical degradation		
Chemical soils treatment	Deficiency of humus sources Reducing of biological activity	Reducing of the soil biological activity; C:N ratio disruption Reducing the proportion of labile humus content

Table 6: *Humus degradation indicators depending on the anthropogenic impact character (II)*

The anthropogenic impact	Disturbance modes of humification conditions	Degradation indicators
Chemical, physicochemical and natural-agrogen biochemical degradation		
Intensifying the degree of over wetting of the soils	Modifying of air-hydric, hydrothermal, redox, biological regimes. Modifying the composition of structural units	Reducing the intensity of humification and mineralization processes. The formation of rough humus. Modifying the Cah:Caf and C:N ratios. Increasing the mobility degree of humus on the organic compounds account with NA^{+}
Mechanical natural-agrogen degradation		
The use in agriculture of land with erosion risk	Modifying of granule metric composition and structural units composition	Reducing of humus reserves. Modifying the Cah:Caf and C:N ratios. Reducing of mobile humic substances

Table 7: Humus status of fallow and arable chernozems in space between the Prut and Nistru rivers

Soil	**Level**	**Humus, (%)**	**Humic acids, (%)**				**Fulvic acids, (%)**				**Cah:Cat**
			1	2	3	sum	1	2	3	sum	
Tipical moderate humic chernozem (n=28)											
fallow	Ader	6.2	7.8	25.9	9.8	43.5	3.6	8.8	4.4	16.8	2.53
	A	6.0	8.8	26.7	9.9	45.4	5.7	7.3	4.1	17.1	2.65
	AB	5.1	8.7	24.3	8.8	41.8	6.8	8.9	5.3	21.0	1.98
	B1	3.9	6.3	22.8	8.7	37.8	7.4	10.2	7.0	24.6	1.53
arable	Aph1	4.7	6.9	24.1	7.3	38.3	3.9	9.2	4.7	17.8	2.15
	Aph2	4.5	7.3	24.6	7.8	39.7	5.9	9.4	4.9	20.2	1.97
	AB	4.9	8.3	24.0	8.4	40.7	7.4	9.0	5.8	22.2	1.83
	B1	3.8	6.2	22.6	8.8	37.6	7.8	10.5	7.0	25.3	1.49
Tipical low humic chernozem (n=26)											
fallow	Ader	5.1	6.1	23.3	7.8	37.2	4.4	10.3	5.0	19.7	1.73
	A	4.8	6.4	24.1	8.3	38.8	4.9	10.7	5.9	21.5	1.80
	AB	3.9	6.9	23.7	7.8	38.4	5.5	9.3	5.2	20.0	1.92
	B1	2.4	6.9	22.1	6.5	35.5	6.1	10.8	7.4	24.2	1.47
arable	Aph1	4.0	7.1	21.9	6.9	35.9	4.7	10.9	5.8	20.8	1.73
	Aph2	3.8	7.0	22.6	7.6	37.2	5.6	11.4	6.9	23.9	1.57
	AB	3.0	7.8	23.2	7.8	38.8	6.9	10.9	5.8	23.6	1.64
	B	2.2	7.8	21.9	6.3	36.0	6.9	11.5	7.9	26.3	1.37
Carbonatic chernozem (n=18)											
fallow	Ader	4.1	7.7	21.6	7.3	36.6	6.5	10.5	7.1	24.4	1.50
	A	3.2	7.2	22.1	7.8	37.1	6.5	11.5	7.0	25.0	1.48
	AB	2.8	7.3	22.7	8.5	38.5	6.9	12.8	8.3	28.0	1.38
	B1	1.8	7.3	20.7	7.7	35.7	7.8	14.4	8.8	31.0	1.15
arable	Aph1	3.7	8.1	20.9	7.0	36.0	7.4	11.0	7.0	25.4	1.42
	Aph2	3.0	8.0	21.7	7.0	36.7	7.7	1166	7.6	26.3	1.36
	AB	2.7	8.0	22.0	8.3	38.3	7.3	13.1	7.9	28.3	1.35
	B1	1.8	8.3	20.7	7.7	36.7	7.9	13.9	8.0	29.8	1.23

Increasing content fractions HA-1 and FA-1 indicates the soil nutrient regime improvement but on the other hand to direct the process towards a greater of humification share, mobile humic substances forms and humus mineralization enhancing. Decreasing of HA-2 fraction content leads to reducing the intensity of the ground substance aggregation process.

Humus state evolution indicates to ambience pedogenetical dryness as a result of changes of the porous space and the arable chernozems aerohidric and hydrothermal regime.

Humification process dynamics in typical moderate humus arable chernozems has more common traits with the one in typical weak humus fallow chernozems. At the same time the humification process dynamics in typical weak humus fallow chernozems has common traits with the humification process dynamics in carbonic fallow chernozems. Thus, the organic substances agrogen system evolution leads to geographical humus state parameters inversion of chernozems on subtype level.

ALSO, data from Table 3 indicates that there are clearly outlined 4 layers in the functional organic profile of arable chernozems, which have different dynamics and direction of humification process:

- Arable horizon (Aphf) is characterized by the predominance of organic substance mineralization processes, including humus. In this horizon is found a stable trend of clay disintegration, which is determined by organic mineral clay discharge and disaggregated clay eluviation. There is a tendency of intensity reduction of the biogenic accumulation processes and the shaping of a technogenic accumulation progressive trend (intake from the outside, but also mechanical intake from underlying horizon account).
- Sub-arable horizon (Aph2) is characterized by the significant reduction of biochemical processes as a result of porous spaces of the humus. Under these conditions, there is reduced not only the synthesis intensity of organic substances, but also the one of destruction processes - their mineralization. This is also due to the fact that there are a smaller number of crop roots in arable layer in comparison with the sub-arable layer. However, the humus balance in arable layer is positive, which is determined by the lavation of the eluvial substances from the arable horizon.
- AB horizon is characterized by maximum intensity of humification process, with the formation mainly of humic acids, a phenomenon supported by unfavorable reserves of productive water; their dynamics is analogous to their dynamics in natural ecosystems. Therewith, in this horizon is attested the partial accumulation of eluvial humic substances from upper layers.
- B Horizon is characterized by the decrease of humification process intensity due to the small amount of plant debris and low water reserves. At the same time, this horizon actually does not contain humic substances from underlying layers. Thus, the current stage of chernozems evolution between the Prut and Dniester rivers is characterized by minimizing the role of humic substances in the horizon B evolution.

Such status of chernozems is assessed as a functional-stagnant one, with a regressive further evolution; with the reduction of bioenergetics system capacity to assure the phitosanitary stability of the soils within the ecosystems and the increase of phitosanitary risks. In this regard, it is established that with the reduction of soil humus content, the homeostasis state of the chernozems is disturbed and the share of pathogens and pests increases, thus determining the toxicosis and exhaustion state of the soils (Anaeba et al. 2011).

Conclusions

The anthropopedogenesis of chernozems implies a complex of degradative evolution processes of their bioenergetics resources.

Within the anthropogenic evolution of bioenergetics resources of chernozems there is an increase of mineralization processes share, associated with the efficiency decrease of their consumption in pedo-genesis. This evolution is a phased one with transfers of energetical and structural -functional states. The knowledge of the phases of soil's phased evolution provides the conceptual-methodical support to assure the sustainability of their resources.

Bibliography

1. Апаева Н.Н., Матушкин С. Г. Фитосанитарное состояние почв в зависимости от ограничениях почв возделываемых зерновыми культурами. Вестник Алтайского Государства. Агрономия Университета 2011, No. 2 (74) стр- 26-31.
2. Ковда В. А. Прошлое и настоящие черноземов // Русский чернозем 100 лет после Докучаева. Изд-во „Наука", 1983, с. 253-281.
3. Масютенко Н. П. Трансформация органического вешества в черноземах и в системе его воспроизводства – Москва, 2012- 150