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SOME ASPECTS AS A RESULT OF THE EVALUATION OF HUMUS CONTENT IN ERODED SOILS

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Abstract

Visible soil erosion processes began to develop in the territory of Moldova around the second half of the 19th century. For a long time, their quantitative indicators of its spatial spread were not due to the lack of such cartographic data. After the early 1950s, soil mapping in agricultural units and administrative districts. Fragmented relief is one of the indispensable conditions for the development of slope processes, including erosion processes. Anthropogenic impact plays an important role in increasing the areas affected by erosion. The purpose of this paper is to examine the content and distribution of humus in eroded soils in the Republic of Moldova to assess their fertility. As a result of the evaluation of the humus losses on the three degrees of erosion, it was found that, for chernozems, they correspond approximately to the row: 20, 40 and 60%. Some trans-boundary passages are observed in carbonate chernozems - being the least resistant to erosion (28, 48 and 69%) and an insignificant variation are characteristic of typical chernozems and to a lesser extent leached (17, 39, 60 and 16, 38, 64%), but in soils with a high erodibility these figures of humus losses, almost equal. Brown soils are related to erosion on average for chernozems approximately 20, 40, 65%. We can state that, exclusively, it presents the gray soils in which the degree of erosion, weak and moderate, is distinguished by lower humus losses. If we refer to the whole, then the series of 20, 40 and 60% humus losses in the eroded soils compared to the standard, we are quantitatively characterized by their real degradation effect, quite terrible, caused by erosion. But from a practical point of view it is essential, because these figures characterize the real humus degradation of the underlying soil layer (50-100 cm), which has a significance for assessing their fertility especially for perennial crops, which develops a deep root system.

Key words*: humus content and losses, soil erosion process, soil type and subtype.*

INTRODUCTION

Humus is an essential component of the soil on which its main qualities and peculiarities depend. The humus content also conditions the taxonomic level in the systematics of some soils. The results of the generalization of contemporary analytical data allow the introduction of a system of quantitative indices for assessing the degree of humification of taxonomic units and their division by gender (Ursu, 2014). In the process of pedogenesis in the soil profile, a chemical with a very complicated composition is formed and accumulates, which has been called humus. This substance is formed as a result of the interaction of soil biota with organic residues from the decomposition of organic matter. Humus is the main component and conditions the main properties of the soil. Over time, these indices gave way to the taxonomic level, currently we are still considered in contemporary classifications (SWSR, 2015). However, humus has not lost its primary role in pedogenesis, a current problem of the condition of reclaimed soils is dehumidification.

In the Republic of Moldova, the role of humus in soil pedogenesis and taxonomy is aware (used in the classification of chernozems), but the humus content is not limited by quantitative indices (Ursu, 1999). The problem is that the humus content is dependent on many factors: phytocenosis (steppe, meadow, forest), particle size composition (clay, dust, sand), land use (plantation, pasture, protection strip), the degree of degradation and the method of technogenetic transformation of the exploited soils (erosion, plowing, clearing, etc.). On the territory of the Republic of Moldova, grass steppes (fescue-grass) on virgin chernozems have not been preserved. The total capitalization of chernozems and their work over hundreds of years have caused their degradation - destructuring and dehumidification with all the

respective consequences. The maintenance of chernozems with perennial grasses and the establishment of forest plantations (anti-erosion forest strips, etc.) within 4-5 decades can obviously restore the upper part of the chernozem profile (horizon A) - partly grainy structure and humus content (Ursu, 2005). Such "improvements" occur only in slightly degraded soils, which have kept their vertical profile. In heavily eroded soils these processes occur very slowly.

In the Republic of Moldova, due to inadequate and extensive human activities, other objective and subjective factors, the humus content in soils decreased from 5-6% to 2.5-3.0%, the surface of eroded land increasing to about 850 thousand ha, which constitutes over 35 percent of the agricultural land area. The surface of landslides affected by landslides has also increased, which currently constitutes over 55 thousand ha of active landslides and about 350 thousand ha of landslides in a state of stagnation (Ursu, 2013; Крупеников, 1967). The landslide led to the removal to the earth's surface of the underlying horizons of low-humid soils of the initially eroded soils. The surface humus horizons were buried to a depth of 30-50 cm, thus being preserved.

Microtraising and weeding between rows in fruit plantations has led to a decrease in erosion processes. As a result, the processes of accumulation of organic matter have intensified in the former underlying horizons moderately humiferous, returned to the surface by unclogging. In the fields where the vineyards and orchards were cleared about 20 years ago, and the lands were turned over to arable land, the erosion processes intensified, the fertile soil losses increased. Therefore, with the recent deforestation of old vineyards and orchards and the transfer of arable land, we can predict an intensification of erosion processes on the territory of the reception basin. According to the humus content in the recently arable-postarable layers (0-30 cm), the researched soils not eroded and weakly eroded are moderately humiferous (humus content 3.0-3.3%), those moderately eroded - submoderate humifers (2.7-2.9%), and the strongly eroded ones - weakly humic (1.9-2.3%). The problem of increasing the flow of organic matter in both eroded and not eroded soils is the main one in maintaining their quality status and production capacity (Cojocaru, 2016).

MATERIALS AND METHODS

Pedological research carried out for various purposes necessarily includes the analytical assessment of the humus content in different horizons. However, these results are not taken into account in the name of the soil. In the current classification (Ursu, 1999) the humus content conditions the division of the typical chernozem into moderately humiferous and weakly humiferous (usual). This division mainly refers to the reclaimed land, but the quantitative criterion is missing.

Recently, research conducted in downy oak forests has highlighted the taxonomic variability of chernozems at the subtype level (leachate, typical, carbonate) and humus content (Ursu 2012; 2013; Ursu et al., 2012). Thus, at present we have a considerable variability of chernozems with different humus content (and with different thickness of humified profiles), which is not taken into account in the current classification. Research on typical gray soils in different regions and under different types of forests, has established an obvious difference in humus content in the upper and underlying horizons (A1, A2 and B1). This quantitative index in the previous classifications was taken into account when assessing the degree of podzolization (podzolite ash, poorly podzolite ash). The humus content in brown soils and in the types of azonal soil classes (lithomorphic, hydromorphic, halomorphic, dynamomorphic) is not taken into account.

Given the role of humus in pedogenesis, I consider it appropriate to introduce into the taxonomic system of Moldovan soils the quantitative indices of humus content at the level of gender (content) and at different levels (profile thickness). The following is a system of quantitative indices for different soil types. The assessment of these indices was performed by analyzing the database, collected in recent decades, and adapting them to the taxonomic classification system of the higher soil units of Moldova (Ursu, 2011).

In brown soils, the humus content in the 0-10 cm layer varies between 4.5 and 7.7% in the profiles dug in the forest and 3.2-1.1% in the reclaimed

soils. In white and typical ash soils, the humus content is 6.8-2.9% under forests and 3.8-1.6% in plowing, in soft ash, respectively 10.9-8.9 and 4.1-2.6%. The humus content in chernozems is also quite variable. The most humidifying is the clay-iluvial chernozems, leached and typical under the forests of common oak (clay-iluvial), fluffy oak (leached and typical) and forest strips (4.5-11.3%). Weak humifiers are the typical chernozems and carbonate dehumidified as a result of recovery and work over the centuries. The humus content (Ursu, 2014) in lithomorphic, hydromorphic, halomorphic and dynamomorphic soils varies depending on different factors (granulometry, phytocenosis, recovery, clogging, improvement, etc.).

RESULTS AND DISCUSSIONS

The content and distribution of humus per profile in eroded soils serves not only to specify their classification status (degree of erosion) but also to a lesser extent to assess their fertility (reclamation) and characterize most other ecological functions of soils as their degree of erosion. manifestation is in a rather high dependence (close to the linear one) on the amount of humus (Крупеников, 1990; 1997; Добровольский, Никитин, 1990).

Under the influence of erosion, the general humus impoverishment of the soils on appreciable spaces takes place. Such a situation should not only be considered as a simple summation of the loss of humus by separate portions of land, but should be seen as something of a principle that turns the soil cover into another essence. Kovda B.A. (1981) put forward an idea of assigning a special status to the separate humus sphere in the biosphere by presenting the spatial junction of the humiferous horizons as such as the soils of the earth's crust. Humusosphere - after the gradations of erosion in the erosional queens it loses successively its characteristic aspects it moves away from the initial humispheric level. This can be seen from the string of humus content in the chernozems shown and the gray soils as a measure of the increase in erodibility (Table 1).

Table 1. Average indices of humus content and losses (%) in the 0-50 cm layer in chernozem subtypes and gray soils by degree of erosion

Soil types and subtypes	Standard %	weak eroded		moderately eroded		strongly eroded	
		1	2	1	2	1	2
Carbonate chernozem	3.36	2.40	28	1.75	48	1.03	69
Ordinary chernozem	3.47	2.65	21	1.94	44	1.01	62
Typical chernozem	3.74	3.11	17	2.23	39	1.50	60
Levigated chernozem	3.40	2.84	16	2.01	38	1.22	64
Average - for chernozems	3.52	2.75	20,5	1.98	42	1.19	64
Dark gray soils	2.49	2.02	20	1.48	40	0.87	65
Gray soils	1.82	1.55	16	1.35	25	0.72	60

Note: 1- average; 2 - % losses compared to the standard

There is some difference in some soil subtypes but the principle (trend) of humus loss on the three degrees of erosion for chernozems corresponds approximately to the range: 20, 40 and 60%. Some "overrun" is observed in carbonate chernozems - the least resistant to erosion (28, 48 and 69%) and a small "lag" are characteristic of typical chernozems and to a lesser extent leached (17, 39, 60 and 16, 38, 64%) but at high erodibility the loss figures almost equal. Dark gray soils are related to the average for chernozems (20, 40, 65%).

Exclusivity shows gray soils in which the degree of erosion is weak and moderate, distinguished by lower losses. But overall, the range of 20, 40 and 60% humus losses from the standard quantitatively characterizes the really terrible degradation effect caused by erosion: there is a rapid and increasing extinction of the humus sphere. According to the principle in Table 1, the losses by the soils of the amount of humus in the layer 50-100 cm are also calculated. Of course, only in the case of heavily eroded soils do we have to deal with real losses, but in other cases this situation is related to the proximity to the surface due to the erosion of the less humic layers of the soil. But from a theoretical point of view it is important and practically essential that

these figures characterize the real humus degradation of the second half meter of the soil, which has a significance for assessing their fertility especially for perennial crops, which develop a deep root system (Table 2).

Table 2. Average indicators of humus content (%) in the 50-100 cm (Hoyp, 2001) layer at subtypes of chernozems and gray soils by degree of erosion (conventional signs are the same as in Table 1)

Soil types and subtypes	Standard %	weak eroded		moderately eroded		strongly eroded	
		1	2	1	2	1	2
Carbonate chernozem	1.66	0.97	42	0.71	57	0.47	71
Ordinary chernozem	1.73	1.26	26	0.89	47	0.60	65
Typical chernozem	1.83	1.42	21	1.14	37	0.67	63
Levigated chernozem	1.95	1.36	24	0.97	50	0.46	77
Average - for chernozems	1.77	1.25	28,5	0.92	48	0.55	69
Dark gray soils	1.09	0.84	26	0.65	46	0.53	51
Gray soils	0.72	0.58	20	0.29	41	0.36	50

For the 50-100 cm layer the dispersion of the values and the values of losses themselves is somewhat higher than for the 0-50 cm layer; the average value for chernozems is a string: 28.6; 48 and 69% compared to 20.5; 42 and 64% in the 0-50 cm layer. At the quantitative level, it can be concluded that as the erosion increases, there is an intensified degradation in terms of humus content and in the second half of the soil. The values obtained (Table 3) also have a significance for the correction with the help of laboratory analyzes of the data of the field diagnosis of the soils regarding the determination of the degree of their erodibility.

Table 3. Average depth, in cm of humus content of 1% in Moldovan soils with full profile and eroded (Hoyp, 2001)

Soil subtype	Full profile	Eroded soil		
		weak	moderately	strongly
Chernozems				
Carbonate	110	70	50	30
obişnuit	110	90	70	40
Typical	110	90	70	60
Levigated	110	90	70	40
Dark gray soils	80	70	50	20
Gray soils	60	60	40	20

An unanimously accepted index for diagnosis and soil appreciation contributes to the depth of the layer with humus content over 1% (Table 3). Deep chernozems, all their subtypes have on average such an amount of humus at a depth of 110 cm. In case of weak erosion at the carbonate chernozem this value is reduced up to 70 cm at the rest of the subtypes up to 90 cm at the degree of moderate erosion at the carbonate chernozem up to 50 cm at others - 70 cm. At strong erosion the variety of values is expressed more clearly, for example at carbonate chernozem only 30 cm; in the usual and leached - 40, in the typical - 60 cm. In both subtypes of gray soils all values are essentially lower and in strongly eroded varieties it decreases by up to 20 cm.

The value of these quantities (Table 3) is important for solving such problems as: 1) determining the allowable plowing depth; 2) the possibility to perform unclogging; 3) alienation of land "at rest" through debauchery.

The varieties of strongly eroded carbonate chernozems of both subtypes of gray soils can in no way be used as arable land, vineyards and orchards but must be expropriated for cultivation and at the same time the hope for the relative restoration of the soil profile is not too great here. it is probably possible to create very shallow soils over time in conditions of their permanent and regular use for fodder uses.

It is necessary to make a remark regarding the standards: in the period of 15-20 years that have passed since the editing of the guidelines on the statistical parameters of the soils, the thickness of their genetic horizons has not changed but the humus content especially in the 0-30 cm layer, indisputably reduced, it must be assumed by 0.1-

0.3%. But mass figures on this issue do not exist. Therefore, we consider that it is possible to use as standards parameters of the humus content mathematically representative, established according to the large numerical totality obtained before. In this case it is about full profile soils (standards). Regarding the eroded soils of three degrees of erosion, here things are presented in a simpler way: their surfaces have increased but the characteristics of the humus content of all gradations have remained unchanged. We will examine the content and composition of clay minerals in Moldovan soils as this parameter as well as the particle size composition also to some extent influences the anti-erosion resistance of soils.

Of these minerals, which fall into the fraction of clay only soil particles with a size of less than 0.001 mm play the most essential role in this respect is played by the illit-smectitic group and that of the illite (as a whole in the past, and sometimes even now mineral is called montmorellonite). In the subtypes of chernozems with full profile in their 0-30 cm layer, the amount of smectite and illit-smectitic oscillates within the limits of 13.4% (carbonate chernozem) up to 16.8% (podzolytic chernozem) in the corresponding horizon B 12.8-19.6%.

According to the illiterate, the image of its distribution on the profile is essentially completely different: analogous figures constitute 10.5-16.4% and 7.2-13.6%, which is with depth the content of this clay mineral decreases. Overall, it can be said that the chernozems of Moldova are characterized by a fairly high content of clay minerals. (Почвы Молдавии. Том I., 1984, p.111). You can also find the corresponding figures for all other chernozem subtypes to 4-5 depths of the profile, there are also data for brown and gray soils (Алехеев, 1999).

For eroded soils and only for chernozems, very little is given. After smectite, smectite-illite the differences in the degree of erosion are significant, and after illite they are quite essential: for example in the horizon Ap (0-40 cm) of the carbonate chernozem the amount of illite is 9.1-10% in the varieties eroded in depending on the gradations, 8.9-7.1% (Алехеев, Арапу, 1987) which is as the erosion increases, the soil resistance to erosion based on this indices must decrease but it must be assumed that the significance of this parameter in general is less essential.

The most initial figures for the entire republic on the spread of eroded soils refer to 1967 when eroded soils (which is moderately and heavily eroded, ravaged and affected by landslides) occupied 641.7 thousand ha or 19% of the territory of Moldova; eroded ash soils cultivable by these degrees of erosion - 66.2 thousand ha or 2% (Крупеников, 1967, p.144). According to the pedological provinces (according to their separation at that time) the eroded chernozems were distributed as follows in % of the surface of the province: northern Moldovan forest-steppe - 19.5; Central Moldova forestry - 17.7; plain near the Danube (Predanubiean); Ukrainian steppe plain - 15.9% (Крупеников, 1967, p. 367). Such data were reported on pedological districts and sub-districts (Крупеников, 1967, pp. 380-382). Here we have a relatively lower figure for the central province (17.7%) which, as it has been known since then, has suffered more than other provinces due to erosion, this is explained by the fact that the calculations were carried out. for the whole area without excluding the areas occupied by forests, which here are the most (about 40%) and the soils under forest vegetation are practically not affected by erosion. In general, it can be said that by the end of the 1960^{s}, the deterioration of the republic's soils caused by erosion was already very significant and alarming (21%, which is about one-fifth of the territory of Moldova). Next, a calculation was made of full-profile and eroded soils of three degrees of erosion - according to the soil map of Moldova. They were more precisely genetically differentiated and quite reasonably determined soil surfaces in terms of their subtypes, and among them full profile and eroded three degrees after the state in the early - mid '80^{s}.

The complete data of these estimates are given in volume 2 “Почвы Молдавии” in special tables (pp. 20-21). We chose from these those materials that refer to eroded soils (Table 4). Regarding the accuracy of the ground map at a scale of 1: 50000 it has not been discussed and decided mono-semantically that it is accurate, as this notion is appropriate to the given scale map and was drawn up by generalizing the maps at a scale of 1: 10000 or more precisely. In general,

of course, some small areas merged, and at the same time, naturally, the degree of information on the map decreased. However, since the merger of accounts was often done in one direction or another, its final result had to be obtained more or less truthfully starting from the law of large numbers.

Turning to the analysis of Table 4, it should be noted that we do not have a better and more complete source of quantitative information about the soil cover of the republic. The share of all eroded soils changed slightly compared to 1967 (21%) according to new data, it accounted for 22.5% of the country's territory. If we consider only soils that are subject to erosion and exclude those that are exempt from it (alluvial soils from meadows, alluvial soils, wetlands, etc.) then the total level of erosion of the soil cover will increase up to 31%. reaching almost a third of the total area, which is the excess is about 30%. But about 10-15 years have passed since the map was drawn up, and naturally the eroded soil surfaces have now grown. This is an indisputable fact, but we do not know its precise quantitative expression. It will be shown below that we may have some new opinion on the issue at hand (Table 4).

Table 4. Surfaces of Moldovan soils (Hoyp, 2001) with full profile and eroded

Soil type and subtype	Full profile		Eroded soil							
			Weak		moderately		strongly		total	
	1	2	1	2	1	2	1	2	1	2
Brown	19332	92.5	956	4.6	603	2.9	0	0	1559	7.5
Light gray	3905	96.2	145	3.6	9	0.2	0	0	154	3.8
Gray	102283	77.2	17471	13.2	11167	8.4	1546	1.2	30184	22.8
Dark gray	119781	78.0	24583	16.0	8510	5.5	738	0.5	33831	22.0
Carbonated chernozems	359612	55.8	160122	24.2	101082	15.5	32864	5.0	294068	44.2
Ordinary chernozems	492148	77.6	101574	16.0	36355	5.8	4023	0.6	141952	22.4
Forest xerophytic	14579	80.9	2966	16.3	596	3.3	0	0	3562	19.6
Typical chernozems	217780	77.4	46838	16.6	14947	5.3	1972	0.7	63757	22.6
Levigated chernozems	270461	68.4	84844	21.4	34778	8.8	5452	1.4	125074	31.6
Podzolytic chernozems	97364	82.7	15203	12.9	4899	4.2	271	0.2	20373	17.3
Compactly	11596	84.5	1228	9.0	664	4.9	217	1.6	2109	16.5
Solonized and salted	10504	61.0	3005	17.4	3438	20.0	278	1.6	6721	29.0
Rendzine	13824	42.7	6457	19.9	9970	30.8	2146	6.6	18573	57.3
Total area	1733169		455392		227018		49507		741917	
% of the surface of Moldova (3 million 376 thousand ha)	-	52	-	14	-	7	-	1.5	-	22.5
% of the surface of soils subject to erosion (2 million 482 thousand ha)	-	69.5	-	18	-	9.5	-	2.0	-	31

Note: 1 - thousand ha; 2 -% of the subtype area

Carbonate chernozems (44.2%) are the most subject to erosion, followed by leached chernozems (31.6%). Two central subtypes of common and typical chernozems (22.4 and 22.6%) are close to each other and also to the value of the total damage (22.5%). Leaving aside the little-spread soils, we note that the ash and dark ash soils (22.8 and 22% as well as the podzolytic chernozems (17.3%) on significant areas are occupied by forests and therefore the figures obtained for them are reduced according to after the total surface of the soils moderately and strongly eroded in the first place are the carbonate chernozems (20.5%) and levigated (10.2%), ordinary (6.4%) and typical (6%) are

close and in this case by each other and by the average index per republic as a whole (8.5%).
As a clear reason for the reduced erosion resistance by carbonate chernozems, the peculiarities of their granulometric composition serve (Table 5); among them almost 40% of the soils have a muddy texture and even lighter than the number of chernozem subtypes, in this respect they suddenly surpass all the others.

Table 5. Distribution of some Moldovan soils (Hoyp, 2001) according to particle size distribution

Soils	% of subtype area			
	clay-loamy and loam-clayey	Clay	clay-sandy	sandy and sandy-loamy
Gray	43.5	30.5	18.4	7.6
Dark gray	65.1	22.1	7.5	2.3
Chernozems				
Carbonated	58.9	36.7	3.2	1.0
Ordinary	79.0	17.8	2.2	1.0
Typical	89.8	8.4	0.9	0.9
Levigated	83.6	11.4	3.0	2.0
Podzolytic	76.8	10.2	2.4	0.6

The influence of the degree of clay on the predisposition of fragile soils and surface rocks to erosion has been discussed above. According to their granulometry, chernozems are related to forest soils, but in this case the general erosion effect is reduced due to the fact that they are probably half under the forest. Regarding the levigate chernozems, it is not possible to talk about the influence of the specificity of the granulometry on their low resistance against erosion, here they probably influence their acid reaction in the superficial horizons, unsaturated in the bases, the less hydrostable structure.
We must be interested not only in the eroded soil surfaces but also in their dynamics: according to the very logic of this process, the eroded soil surface can only increase from year to year: in previous capitals it has been shown that this increase goes fast and as if in two ways: 1) it increases the total surface of the eroded soils; 2) in their composition with exceeding rhythms increases the share of moderately and strongly eroded soils. It was not possible to compare this dynamic for the entire surface of Moldova and the "key method" was applied, which is widely used to describe different geographical, climatic and biological spatial objects. The ground plans of the households were selectively drawn up - 171 in number (this constituted about 20% of their total number) with the interval of their mapping separated from each other by approximately 18-25 years. The households were located to certain pedo-geographical (natural) regions, respectively, for reasons that this method mirrored the situation more objectively than the sighting in the administrative districts (Захаров, 1978, Крупеников, 1992). Depending on the area of the districts and partly on the presence of materials, the number of control households in the districts varied from 10 to 16.

CONCLUSIONS

The organic part of each soil is distinguished by the composition and content of humus in the upper horizons and the thickness of the humus layer.
The humus content is a very important integral criterion for the characteristic of the pedogenesis of the soil profiles, the avoidance of the degradation processes.
In the current classification of soils, which refers to the higher taxonomic units, the humus content is not taken into account, because this soil-specific index is at a lower taxonomic level than the subtype.
In order to characterize the soils, taking into account their current state, degradation trends, etc., a system of quantitative indicators of humus content at the taxonomic level of gender is proposed for all higher units.
It is recommended to use the full name of the soil, including at the level of genus: typical brown soil moderately humiferous; levigated humiferous chernozem in the deep, etc.
The humus content can also serve as a characteristic of azonal soils. Quantitative

indices of humus content in the soil characterize not only the properties, but also the pedogenetic conditions, especially biotic factors, biocenoses. The degrading effect of soil erosion is not limited to the removal of fertile layers and the deterioration of its physical, chemical, water and biological properties. The indirect impact of the erosion process on the components of the environment refers to the entrainment in the circuit of some organic and mineral compounds from outside the agricultural lands. The evaluation of these losses was made based on the value of the mass of soil evacuated by erosion and the content of organic matter and nutrients in the washed soil.

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