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ORGANIC SUBSTANCE AND CLASSIFICATION OF THE MELIORATED SOILS FORMING AS A RESULT OF PEAT LAYER DESTRUCTION

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A b s t r a c t. Scientific data on the evolution of meliorated peat soils under the impact of agricultural use are presented. The following 3 soil groups are formed as a result of destruction of a peat layer after drainage of mires: peat soils containing more than 30% of organic matter, organic-mineral and mineral residual-peaty soils containing 15-30% and less than 15% of organic matter, respectively. The classification of each of this group based on the criteria of the morphology of soil profile, ratio between organic and mineral parts of the soil and granulometric composition of mineral bedrock is given. Suggestions about nomenclature of new soils are presented.

K e y w o r d s: organic substance, meliorated soils, peat soil.

INTRODUCTION

With the beginning of mires melioration, the process of cultural soil formation changes peat formations. It is accompanied by more deep humification and transformation of peat organic matter. As a result arable layers are enriched with humus particles during agricultural exploitation, and the degree of decomposition of peat increases [4,8] up to 60-70%. This results in the formation of new type of soils which have been called "earthy" peat soils [9] or "moorshes" in the Okrushko's classification [5].

Simultaneously with the qualitative transformation of organic matter, decreases its thickness at the expense of mineralisation processes and soil erosion. As a consequence, there is at first a decrease of peat layer and after that, its mixing with the bedrock. The share of organic matter in the soil decreases by this.

The soils which contain 15-30% of organic matter have been referred as "anmor" type in the German classification [2]. They are called organic-mineral soils in Belarus, and there are two groups of them in the Polish classification [6]: "moorsh-like" formed from sandy bedrock and "chernozem-like" soils on clay and silty grounds. These soils belong moorshy black soil like to the mineral group if they contain less than 15% of organic matter. Agronomic value of this groups of soils is varied. Composition of organic matter has not been studied in practice although they occupy the area of more than 100 thousand hectares in Belarus and process of thier formation is continuing.

OBJECTS AND METHODS OF INVESTIGATIONS

The object of this investigaation are drained peat soils typical for Belarus found at the experimental peat Mire Station (MEMS), Polesye Experimental Meliorative Station (PEMS), agricultural enterprises Rakitno of Luninets district, Pochepovo of Pinsk district, and Sutin of Pukhovitchy district. The soil sampling was made in these objects at several points with different content of organic and mineral components. This allowed us to get soil samples at different stages of peat layer mixing with bedrocks. This way series of samples of soils which are located within one object, have the same nature and duration of agricultural usage, but differ in the ratio between organic and mineral substance were gathered.

Content of ignition residue (A), bitumen (B), humic substances (HS), humic acids (HA), fulvic acids (FA), easy hydrolysable substances (EHS), difficulty hydrolysable substances (HHS), and nonhydrolysable residue (NHR) were determined in the soil samples. The nitrogen fund in the soils was divided into 5 fractions with different stability of acid hydrolysis. Regimes for each of the groups and fractions are given in Figs 1 and 2.

RESULTS AND DISCUSSION

Our investigations have shown that transformation mechanism of peat soils with the formation of humic or moorsh arable layer does not always take place. Genetic peat kind influences this process a lot. Soils developing on moss and sedge-moss kinds of peat as a rule show degree of decomposition not higher than 25-30% even if they have been used for a very long time, for instance 100-250 years. At the same time soils developing on woody and reed kinds of peat show degree of decomposition into an arable layer about 45-75% [1]. Permanently low degree of decomposition of moss and sedge-moss peat kinds into arable layers shows that there is no formation of the biochemically stable humic substances by the decomposition and mineralisation of such peat types. That is why there is no accumulation of humic particles in the arable layers which consist of moss and sedge kinds of peat.

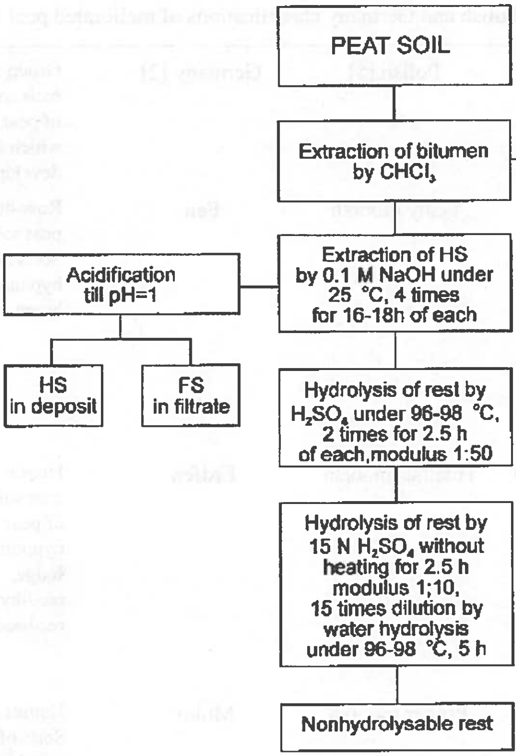

Fig. 1. Scheme of group analysis of organic matter of peat soils.

The Russian, Polish and German classifications of cultivating peat soil are given in Table 1. All these classifications foresee separation of 3 groups of peat soils relating to the degree of transformation of peat material. There is no principle difference between the three groups of soils distinguished in different countries. The term "degree of decomposition" in Polish and German classifications has been substituted by the terms "moorsh" and "vererdung", respectively. This is related to the specific method applied for the estimation of humification degree by von Post. It cannot be applied to drained peat soils resulting from dewatering of peat and coagulation of its colloids.

Our subdivision of peat soils into three morphological groups (coarse-fibric, humus-fibric and humus soils) coincides practically with all the above mentioned classifications, but at the same time our data show that there are genetic groups of peat which preserve coars-fibric morphology of arable layer during the whole exploitation period.

Table 1. Comparison of Russian, Polish and Germany classifications of meliorated peat soils

Base morphological signs of peat in arable layer of soil	Russian [9]	Polish [5]	Germany [2]	Group of peat soils and sorts of peat on which it develops
Weakly decomposed peat (R<30%) with the predominance of fibres and tissues of mire plants and with weakly expressed humus particles	Peat soil	Peaty moorsh	Fen	Row-humic peat soil. Sorts of peat: hypnum, sedge, hypnum-sedge
Middle decomposed peat (R=30-45%), mixture of humified particles; scraps of fibres and tissues of mire plants	Humus peat soil	Humous moorsh	Erdfen	Humus-fibric peat soil. Sorts of peat: woody-hypnum, woody-sedge, reed-hypnum, reed-sadge
High decomposed peat (R>45%) consisting predominantly of small deeply humified particles; the residues of mire plans have not been observed	Humus soil	Proper moorsh	Mulm	Humus peat soil. Sorts of peat: woody, reed, calamagrostis, woody-reed

All the above considerations are related to the evolution stage of drained peat soils when arable peat layers are present. A new evolution stage begins together with the beginning of mixing of arable peat layers with underlying mineral bedrocks. This stage has been studied less of all, that is why the questions of qualitative estimation of organic matter, classification and nomenclature of such soils require additional investigations.

The Kononova's [3], Ponomariova's [7] and Turin's [10] classic investigations showed that the organic matter group composition is quite characteristic of every soil type and it reflects specificity of soil formation processes in different soil-climatic zones very well. However, the group composition of organic matter does not allow to differentiate the soils inside each kind of the smallest taxonomic units.

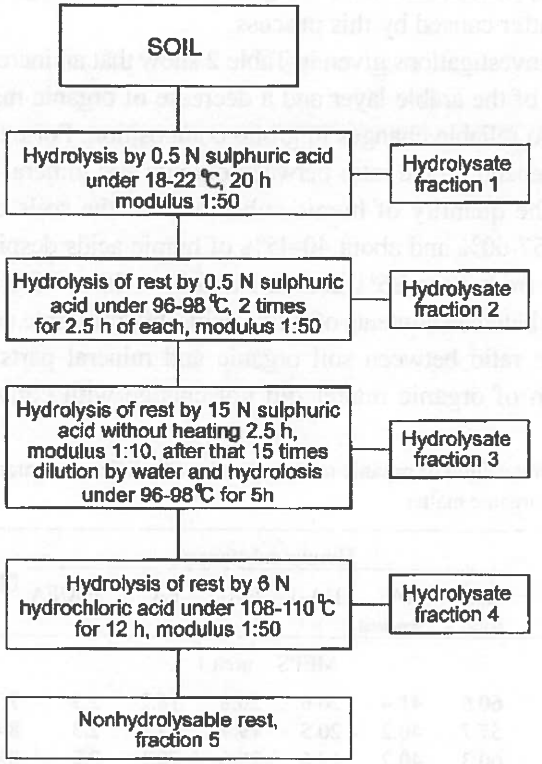

Fig. 2. Scheme of nitrogen fund fractionation.

For the estimation of group composition of meliorated peat soils which are at different stages of transformation into varieties of organic-mineral soils, it is necessery to take into account the following phenomena:

Firstly, transformation of peat soil organic matter after drainage takes place in the conditions of converting water-air regime of root living layer from anaerobic to aerobic that promotes oxidation and destruction of biochemically unstable components and further humification of organic matter.

Secondly, residues of cultural and weed plants come into organic matter of arable layer every year. Their chemical composition is different than the composition of mire plants, which formed peat. With the increased duration of soil agricultural use the relative share of humus formed from residues of cultivated plants in the arable layer increases and the share of peat humus decreases.

Thirdly, with the decrease of peat layer, new portions of peat come from subarable layer. This restrains the speed of change in organic matter quality in the arable layer. The question arises: how significant is the change of group composition of organic matter caused by this process.

The results of investigations given in Table 2 show that an increase in ignition residue up to 93-95% of the arable layer and a decrease of organic matter volume to 5-7 times do not lead to reliable changes in group composition. For example, the bitumen content does not depend on the ratio between organic and mineral components in the soils of MEPS. The quantity of humic substances in the soils of areas 1 and 2 is fluctuacting near 57-60% and about 40-45% of humic acids despite the ignition residue varies widely: from 30 to 86% in area 1 and from 20 to 76% in area 2. Similarly there is no relation between contents of fulvic acids, hydrolysable and nonhydrolysable substances and the ratio between soil organic and mineral parts in each area. The group composition of organic matter did not change with convertion of peat soil

T a b l e 2. Group composition of organic matter of soils with different content of organic and mineral components, % to organic matter

IR	IL	B	Humus substances						EHS	HHS	NHR
			sum total	HA sum total	HA-1	HA-2	FA	HA/FA			
					MEPS area 1						
29.7	70.3	1.5	60.6	41.4	20.6	20.8	18.2	2.3	7.1	5.4	25.4
44.1	55.9	0.9	57.7	40.2	20.5	19.7	17.5	2.3	8.4	2.8	30.2
86.1	13.9	1.1	60.3	40.2	19.6	20.6	20.1	2.0	8.4	3.7	25.6
					MEPS area 2						
20.6	79.4	2.8	58.2	44.1	21.3	22.8	14.1	3.1	10.1	5.7	23.2
51.6	48.4	3.4	60.8	43.9	23.0	20.9	16.9	2.6	10.2	6.2	20.4
60.6	39.4	2.0	57.9	43.5	21.8	21.7	14.4	3.0	11.2	8.0	20.9
64.3	35.7	1.9	59.4	42.2	20.9	21.3	17.2	2.4	10.8	6.5	21.4
69.2	30.8	1.5	56.5	39.7	19.1	20.6	16.7	2.4	12.3	7.3	22.4
75.7	24.3	1.5	60.3	45.4	23.2	22.2	17.9	2.5	9.7	6.5	21.6
					Pochepovo						
15.5	84.7	2.1	55.3	40.8	6.9	33.9	14.5	2.8	14.0	7.2	21.4
26.4	73.6	2.5	51.9	43.7	10.5	32.2	8.2	5.3	14.3	5.2	26.1
67.5	32.5	2.1	55.3	40.4	10.0	30.4	14.9	2.7	15.2	5.5	21.9
78.0	22.0	2.4	52.1	37.6	10.6	27.0	14.5	2.6	15.3	6.8	23.4
					Sutin						
17.5	82.5	5.6	56.6	40.8	18.3	22.5	15.8	2.6	13.9	9.4	21.1
53.3	46.7	5.2	55.5	42.7	21.8	20.9	12.8	3.3	12.7	6.2	20.4
87.2	12.8	5.5	57.2	47.7	19.1	28.6	9.5	5.0	10.3	6.0	21.3

IR - ignition residue, IL - ignition loss, B - bitumen, HA - humic acids, FA - fulvic acids, EAS - easy hydrolysable substances, HHS - difficulty hydrolysable substances, NHR - nonhydrolysable substances.

into organic-mineral one at the MEPS even during 80-years of exploitation.

Similarly the data obtained from the other objects (Pochepovo and Sutin) allow to confirm that the change of ratio between organic and mineral compounds in the soil did not lead to any changes of organic matter group composition.

The data obtained allow to say that group composition of soil organic matter in various objects differ more than group composition within one object. It means that group composition of organic matter depends on genetic peculiarities of peat (kind, degree of decomposition, pH and others) but not on the degree of peat layer mixing with mineral bedrock.

The question arises: why there is no considerable change in group composition of organic matter changes of soil? Most likely this is caused by a multiple predominance of native peat organic matter in the soil above the new soil humus created at the expense of humification of post-harvest plant residues. For example, there are 1.5-2.5% of humus in soddy-podsolic soils, but there is 5-15% of organic matter in the investigated mineral soils and 15-30% in organic mineral ones formed as a result of destruction of peat layer. It means that soil organic matter formed from peat dominates over organic matter formed from post-harvest residues in mineral soils 2-7.5 times and from 7.5 to 15 times in organic-mineral soils. There is no possibility to estimate the difference in group composition under such multiple predominance of peat organic matter above the newly created soil humus.

It may be assumed that the newly formed mineral soils that take place of destroyed peat soils will preserve group composition of organic matter which should be similar to peat soils as long as humus quantity in the new mineral soils decreases to 2-2.5%. Only in this case the new soil humus will begin to dominate over organic matter of peat origin. It means that group composition of organic matter cannot be classification characteristics for the soil division into groups of peat, organic-mineral and mineral soils formed as a result of peat layer destruction. At this stages of soil evolution classification characteristics should be restricted by the profile morphology and quantitative ratio between organic and mineral components of the soils.

Nitrogen fund in the investigated soils was divided in to 5 fractions as shown in Fig. 2. The results are given in Table 3. According to Turin [10], the influence of acidic hydrolysis on the soil organic matter is similar to the influence of microorganisms.

The content of easy hydrolysable nitrogen in mg/100 g dry matter decreases considerably at the transition from peat soils to organic-mineral and mineral soils. For example, peat soil with 22.2% of ignition residue with perennial grass cover contains 115.3 mg/100 g of easy hydrolysable nitrogen, but the soil with 67.3% of ignition residue contains 47.9 mg/100 g only. In the raw crops at the transition from peat to mineral soil (ignition residue is 45.4 and 92%, respectively) the quantity of

T a b l e 3. Fraction of soil nitrogen in arable layer: (numerator - mg/100 g of soil, denominator - % to N_{total})

IR	IL	N_{total}	Hydrolysable nitrogen					Nonhydro-lysable nitrogen
% to dry masse of soil			0.5 N H_2SO_4	1 N H_2SO_4	15 N H_2SO_4	6 N HCl	Sum total	
PEMS, perennial grasses, 14 years								
22.2	77.8	3.26	115.3	900.5	860.5	576.3	2452.6	807.4
			3.53	27.6	26.4	17.7	75.2	24.76
67.3	32.7		47.9	331.2	337.2	28.3	744.6	235.4
			4.9	33.8	34.4	2.89	75.9	24.02
PEMS, row crops, 14 years								
45.4	54.6	2.32	95.8	761.9	653.0	326.5	1837.2	428.8
			4.31	32.8	28.1	14.07	79.2	20.82
92.0	8.0	0.36	17.04	132.7	115.0	21.23	285.9	74.1
			4.73	33.6	31.9	5.89	79.4	20.6
Rakitno, crop rotation, 15 years								
32.1	68.9	2.58	118.9	802.1	744.8	320.8	1986.6	593.4
			4.61	31.1	28.8	12.43	77.0	23.0
70.6	29.4	1.16	47.1	337.2	252.9	174.4	810.6	349.4
			4.06	29.1	21.8	14.9	70.0	30.0

easy hydrolysable nitrogen is decreasing from 95.8 to 17 mg/100 g, but the percentage share of total nitrogen does not change with the increase of ash content (about 4.3-4.7%). The share of nitrogen hydrolysed by 5 % sulphuric acid varies from 27.6 to 33.8%. Total content of all the fractions of hydrolysable nitrogen does not depend on the ratio between the ignition loss and residue. It is up to 75.2-75.9% in the soil under perennial grasses and 79.2-79.4% under raw crops. The quantity of nonhydrolysable nitrogen does not depend on the degree of peat layer mixing with mineral bedrock either. It is 24.1-24.9% in the soils under perennial grasses and 20.6-20.8% under raw crops.

Similar results were obtained for the soils of the polder system Rakitno. They confirm the results of group analyses. Composition of nitrogen fraction does not depend on the degree of peat layer mixing with underlying mineral bedrock at that stage of soil evolution when peat organic matter dominates over the newly formed organic matter of post-harvest plant residues.

So, group composition of organic matter and fraction composition of nitrogen input of organic-mineral and mineral soils formed as a result of peat layer destruction

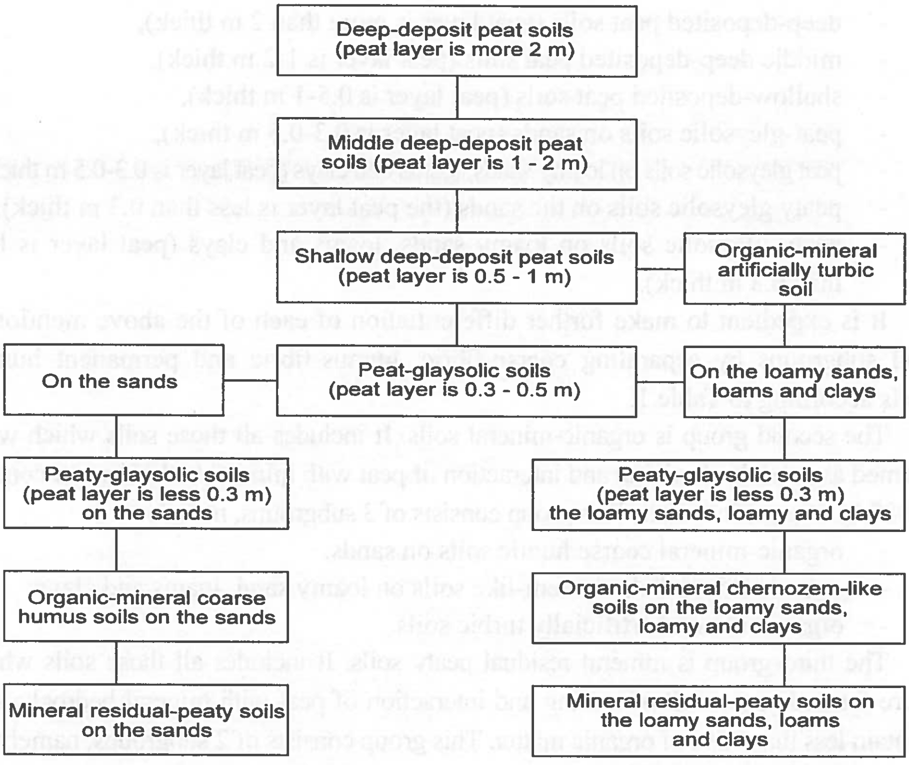

Fig. 3. Scheme of peat soils classification.

are similar to the composition of organic matter and nitrogen input of the peat soils from which organic-mineral and mineral soils were formed. Such similarity was stipulated by the multiple dominance of peat organic matter over a new organic matter which is formed from post-harvested residues and not from mire organic matter.

Taking into account what has been said above it is expedient to use the term "residual peaty" soils that reflects soil genesis and properties.

The most reliable classification criteria for the new soils formed as a result of peat layer destruction, are the morphology of soil profile, quantitative ratio between organic and mineral parts of the soils, and granulometric composition of mineral bedrock on which primary peat soils were formed.

On the basis of our results, we suggest the following classification of the soils formed in the evolution process of meliorated mires (Fig. 3).

The first group are peat soils. It includes all the soils which have a morphologically well distinguished peat layer and contain organic matter (not less than 30%). This group includes 7 subgroups, namely:

- deep-deposited peat soils (peat layer is more than 2 m thick),
- middle deep-deposited peat soils (peat layer is 1-2 m thick),
- shallow-deposited peat soils (peat layer is 0.5-1 m thick),
- peat-gleysolic soils on sands (peat layer is 0.3-0.5 m thick),
- peat gleysolic soils on loamy sands, loams and clays (peat layer is 0.3-0.5 m thick),
- peaty gleysolic soils on the sands (the peat layer is less than 0.3 m thick),
- peaty gleysolic soils on loamy sands, loams and clays (peat layer is less than 0.3 m thick).

It is expedient to make further differentiation of each of the above mentioned soil subgroups by separating coarse-fibric, humus-fibric and permanent humus soils according to Table 1.

The second group is organic-mineral soils. It includes all those soils which were formed as a result of mixing and interaction of peat with mineral bedrocks and contain 15-30 % of organic matter. This group consists of 3 subgroups, namely:

- organic-mineral coarse humic soils on sands,
- organic-mineral chernozem-like soils on loamy sand, loams and clays,
- organic-mineral artificially turbic soils.

The third group is mineral residual peaty soils. It includes all those soils which were formed as a result of mixing and interaction of peat with mineral bedrocks and contain less than 15% of organic matter. This group consists of 2 subgroups, namely:

- residual peaty soils on sands,
- residual peaty soils on loamy sands, loams and clays.

This soil subgroups should be further subdivided according to the content of organic matter in the arable layer, for example, into subgroups with high, middle and low humus content. Quantitative criteria for such subdivision are the object of further investigations.

CONCLUSIONS

1. The most reliable classification criteria for the new soil formation as a result of destruction of a peat layer are the morphology of soil profile, quantitative ratio between organic and mineral parts of the soil and granulometric composition of mineral bedrock on which the initial peat soil was formed.

2. The group composition of organic matter and fraction composition of nitrogen fund of the soils, leading to, as a result peat layer destruction, are similar to the ones for peat soils from which new organic-mineral and mineral soils were formed. Such similarity of qualitative composition of organic matter of all the three soil groups is stipulated by the multiple predominance mire generated organic substance above

non-mire generated organic substance formation from post-harvest plant residues in them.

3. It is expedient to use the term "residual peaty soils" for the new soil formations that resulted from the peat layer destruction in order to reflect their genetic peculiarities and properties.

4. The group composition of organic matter is one of the conservative soil signs which depend on the genetic peculiarities and changes very slowly with the agricultural use of the soil.

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