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DIVISION OF DIFFERENTLY SILTED PEAT FORMATIONS INTO CLASSES ACCORDING TO THEIR STATE OF SECONDARY TRANSFORMATIONS*

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A b s t r a c t: Three groups of moorsh formations distinguished on the basis of their ash content were divided into classes according to the state of progress of their secondary transformations. The basis for the division were numerical values of their water-holding capacity index W_1. It was found that with the increase of ash content, the threshold value of the W_1 index that distinguishes peats without any signs of secondary transformations from the peat formations secondary transformed, i.e., moorshes, also increases. In the moorshes with the lowest ash content (<25%) and weakly silted moorshes (26-50%), the threshold value of the W_1 index is 0.35, whereas in the strongly silted moorshes with the mineral part content from 51 to 80%, it is 0.40. Five classes were defined in each of the group of moorshes - the first of them includes moorshes at the initial stage of secondary transformations, and the fifth one totally degraded formations.

K e y w o r d s: secondary transformations of peat soils, peat and moorsh formations, peat moorshing process.

INTRODUCTION

Continuous and gradually deepening changes of peat soil characteristics together with the process of their disappearance caused by peat mineralisation processes are basic attributes of the decession phase in the evolution of these soils. When peat-land is dewatered, the process of transformation of the accumulated peat mass into a formation called moorsh with different properties under the influence of various soil processes stimulated by the access of air starts. Moorsh is different from peat, among others because its soil mass is of greater density and lower ability to retain water. The transformation mentioned above that finds its reflection also in the chemical properties of these soils, is referred to as secondary transformations

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[9,11]. Their rate and range are closely connected with occurance of depth of ground water level and the way the soil is utilised. Peat-moorsh soils used as cultivated fields and dewatered woodland soils are transformed the most and the quickest. The most effective protection of the agriculturally utilised peat soils against procesess of secondary transformation is permanent turfing. It limits not only peat mineralisation but also counteracts deepening of the sphere of moorshification process in the soil profile.

The so far used evaluation methods for the secondary transformations of post-bog peat soils are mainly based on the morphology of the soil profile that gets differentiated in the moorshing process and on the degree of moorsh granulation [10]. There are three moorshifing stages of soil (MtI, MtII, and MtIII) and three kinds of moorsh formations that differ in their structure and state of transformation. They are called peaty moorshes (Z_1), humous moorshes (Z_2), and proper or granular moorshes (Z_3). The above enumerated stages of moorshing and kinds of moorsh cannot be used as quantitative indices of the state of secondary transformation of peat soils as they are subjectively determined using an organoleptic method. Moreover numerical values that characterise basic soil properties (e.g., bulk density, total porosity and differential porosity, etc.) do not separate, mutually exclusive intervals in the case of moorshes. The above conditions can be fulfilled by the water-holding capacity index W_1 established on the basis of the phenomenon of decreasing water retainability of peat in the process of moorshing [2,5].

Hooghoudt *et al.* [7] and others characterised the state of secondary transformation of peat soils on the basis of the phenomenon of their irreversible drying. A 10-stage evaluation scale assumed by the above authors expresses the ratio of water holding abilities exhibited by the moorsh taken from the surface horizon of the soil-profile to the same abilities of the peat formation located below the ground water level. The value of the index determined in this way can be, undoubtedly, different even for the soils that have been transformed in the same way as the factor that influences its value is to a large extent water holding capacity of deeper lying peat layers. This peat, due to the phenomenon of stratigraphic variability, is not always identical with the parent moorsh formation lying at the surface layer of the soil-profile.

Schmidt [12] worked out a method for the determination of the so-called unit water-holding capacity that as an index free from subjective estimation can supplement the method of field organoleptic evaluations of the peat soil characteristics. A unit water-holding capacity is edometrically determined as a quotient of the water mass held by the soil after the pressure of 100 hPa has been applied to it and dry soil mass.

The aim of the present study was to divide moorsh formations with differentiated content of mineral parts into classes according to the advancement of their secondary transformations as determined by the numerical values of the water-holding index W_1. In the previous divisions these formations were classed together no matter what their ash content was [2,5]. This was due to the fact that previous divisions have been done for the collection of mixed samples, i.e., the samples consisting of both the moorshes formed from proper peats with the lowest ash content (<25%), and weakly (ash content from 25-50) and strongly silted up (ash content from 50 to 80%) moorshes; however, the moorshes form the first group were clearly most numerous. The content of mineral parts in peat differentiates physical and chemical properties of the soils originating from it and, hence it also influence conditions for plants vegetation.

MATERIALS AND METHODS

The study soil material collected represented proper peats (ash content< 25%) and peats weakly and strongly silted up that contained, respectively, from 25 to 50%, and from 50 to 80% of mineral parts, as well as moorsh formations originating from the above peats with differentiated structure and various state of secondary transformation. These were peaty moorshes (Z_1), humic (Z_2), and grainy (Z_3) described as proper ones. The soil samples were collected from the peat-moorsh soils that occur in the river valleys in different parts of the country, that is in the Nizina Północnopodlaska (North Podlaski Lowland), Polesie Podlaskie (Podlaski Woodland), Nizina Południowopodlaska (South Podlaski Lowland), Nizina Południowowielkopolska (South Greater Poland Lowland), Wzniesienia Południowo-mazowieckie (South Mazowsze Upland), and Wyżyna Lubelska (Lublin Upland). From each of the soil profile chosen for the present study a peat sample from the level below the moorshing zone (45-75 cm) and from the surface layer was taken. In the weakly moorshified soils this was the subturf level (5-10 cm), whereas in the medium and strongly transformed soils (stages MtII and MtIII) - the levels that occur deeper (5-15-25 cm).

Evaluation of the state of secondary transformations of moorshes was carried out on the basis of the numerical value of the water-holding capacity index W_1. The index, partially based on that of Hooghoudts *et al.* [7], expresses the ratio between the lowest water-holding capacity of the peat formation, i.e., after it has been dried up to the absolutely dry state to its highest water-holding capacity that it exhibits when fresh, i.e., immediately after the soil sample has been collected from the field. The following formula describes the above index in mathematical terms:

$$W_1 = \frac{c}{a} \qquad (1)$$

where: a - water content in the fresh soil sample that had been previously saturated with water for 7 days, and then centrifuged at the speed equal to the acceleration of 1000 g, in g of water per 100 g absolutely dry soil mass; c - water content in the sample previously dried at the temperature of 105 ^{o}C, and then saturated and centrifuged in the conditions identical to the ones described above, in g of water per 100 g of absolutely dry soil mass.

A detailed procedure for the preparation of soil samples and determination of the W_1 index, as well as the remaining parameters, i.e., ash content (A), bulk density (B_d) and total porosity (P_o) have been described elsewhere [5].

Taking into consideration the influence of secondary transformations on the state of compaction of the moorsh mass, the results have been statistically worked out in order to determine correlation coefficients between the W_1 index and the remaining parameters mentioned above.

RESULTS

The basis for the division of moosh formations into groups (classes) according to the advancement of their secondary transformations were the results of determinations of the water-holding capacity index W_1 in the peat and moorsh samples collected in the form of three different test populations with differentiated ash content. Since determinations in the peat formations were carried out mainly with the aim to establish threshold values of the W_1 index that distinguish peats without any signs of secondary transformations from moorshes, only the characteristics of the statistical parameters of the formations that underwent secondary transformations, i.e., moorshes (Table 1, A,B,C) have been presented in this paper.

Data in Table 2 show that the threshold values of the W_1 index vary slightly in different groups of moorshes studied here. It is the lowest and nearly the same (0.35) in the first and second group of moorshes formed from the proper or weakly silted peats, so treated farther as one group, and the highest (0.40) in the strongly silted moorsh formations that are characterised by the high content of mineral parts exceeding 50%. A higher threshold value of the W_1 index in the strongly silted moorshes make the intervals characteristic for the secondary transformed formations from this group slightly narrower than in the former two groups of moorshes. Unlike the threshold value, the highest value of the W_1 index is constant and equal to one, since the scale of values assumed for the evaluation was based on the condition of the soil formation that reflects its maximum transformation. It was assumed that the water-holding capacity of the organic soil formations even if they are very strongly transformed cannot be lower than their state after they have been dried to the absolutely dry state, i.e., at the

Table 1. Variability of physical properties of moorsh formations and their statistical parmeters

Parameter	Range	Mean value	St. deviation	Median	Mode
A. Moorsh formations formed from proper peats (n=115)					
A	8.0-24.9	17.3	3.77	17.3	16.1
B_d	0.14-0.39	0.257	0.0508	0.25	0.27
P_o	77.8-91.3	84.6	2.75	85.2	84.7
W_l	0.35-0.81	0.521	0.110	0.510	0.460
B. Moorsh formations formed from weakly silted peats (n=84)					
A	25.1-49.8	35.5	7.60	35.2	42.1
B_d	0.21-0.55	0.34	0.00467	0.340	0.32
P_o	69.9-88.7	81.1	3.77	81.4	82.5
W_l	0.38-0.94	0.619	0.130	0.610	0.45
C. Moorsh formations formed from strongly silted peats (n=52)					
A	53.2-79.4	64.9	6.605	64.9	63.7
B_d	0.26-0.63	0.451	0.0839	0.45	0.38
P_o	71.0-88.0	79.4	3.63	79.3	77.0
W_l	0.44-0.99	0.600	0.129	0.55	0.55

Symbols used: A - ash content, % d.m.; B_d - bulk density, g cm^{-3}; P_o - total porosity, vol. %; W_l - index of water-holding capacity, dimensionless.

Table 2. The classification of moorsh formations according to their secondary transformation

The value of W_l index	CLASSES	Stage of transformation
A. Moorsh formations formed from proper peats and weakly silted peats		
0.36-0.45	I	Initial secondary transformation
0.46-0.60	II	Weakly secondary transformed
0.61-0.75	III	Medium secondary transformed
0.76-0.90	IV	Strongly secondary transformed
>0.90	V	Completely degraded
B. Moorsh formations formed from strongly silted peats		
0.41-0.50	I	Initially secondary transformation
0.51-0.65	II	Weakly secondary transformed
0.66-0.80	III	Medium secondary transformed
0.81-0.95	IV	Strongly secondary transformed
>0.95	V	Very strongly transformed (degraded)

temperature of 105 °C. In this condition organic mass losses its water binding abilities as a result of total denaturation of its colloides. This phenomenon is irreversible and there is not possible to return to the previous state. In order for the soil to regain even a part of its abilities it requires a longer contact with water.

Taking into account the results of the present study and data published so far [2-6] a new division of moorsh formations into classes according to the state of their secondary transformations has been proposed (Table 2). The division is slightly modified in relation to former ones [2,5]. It comprises five different classes in the all groups of moorsh formations investigated. The first classes are called the initial stages of secondary transformations and are intervals denoting transitional character that distinguishes moorshes from peats. Independently of the clear defined border line between the two formations distinguished by the threshold values, now and then, there were peat formations found in each of the test populations secondary not-transformed with the values of the W_1 index slightly higher than the threshold ones. In the above phenomenon, taking into account the depth of soil-profile from which samples have been derived, it is difficult to find a direct connection with the process of secondary transformations, except in the case of alder peats [5]. It is simply the result of specific properties of the peat mass, which make the values of W_1 index slightly higher than the threshold ones.

The last class of the division includes totally degraded moorsh formations that occur in the peat-moorsh soils in the area of depression funnels of ground waters. As has been established in the studies carried out so far, these are mainly moorshes originating from the medium-decomposed tall-sedge peats. The mass of those peats when quickly drying changes into variform aggregates with wedge structure that soak water with difficulty. Hence, the soils that contain so strongly transformed formations in their profile are not able to get saturated with water even after heavy rainfalls and their spring field capa-city determined immediately after soil thawing is equal or close to the critical moisture level for grass with deep root systems [4]. Whereas moorshes that are generated in the process of slowly progressing moorshing of peat do not form these types of aggregates and do not reach such high values of the W1 index, either.

Secondary transformed peat formations become more compact which is manifested on the one hand in the decrease of their total porosity (P_o), and on the other hand, in their increasing bulk density (B_d). It is confirmed by a highly significant correlation of these parameters with the index of water-holding capacity W_1 (Table 3). However, correlation coefficients calculated for this relation are not high which points to a considerable scatter of results and hence to the fact that there is no possiblity of accurate estimation of the scope of secondary transformations indirectly, i.e., by the regression method on the basis of the state of moorsh density.

CONCLUSIONS

1. The threshold value of the water-holding capacity index W1 that differentiates between peat formations without any signs of secondary transformations from the secondary transformed peats, i.e., moorshes, varies slightly in relation to the

Table 3. The dependence of ash content (A), bulk density (B_d) and total porosity (P_o) on W_l value

Feature	r_{xy}	P	Linear regression equation	Standard error of estimation
A. Moorsh formations formed from proper peats (n = 115)				
A(% d.m.)	0.389	0.001	y=0.331+0.01143x	0.102
B_d(g cm^{-3})	0.434	0.001	y=0.286+0.943x	0.000
P_o(vol.%)	-0.359	0.001	y=1.74-0.0144x	0.103
B. Moorsh formations formed from weakly silted peats (n=84)				
A(% d.m.)	-0.084	n.s.	-	-
B_d(g cm^{-3})	-0.433	0.001	y=0.335+0.825x	0.118
P_o(vol.%)	-0.420	0.001	y=1.79-0.0145x	0.119
C. Moorsh formations formed from strongly silted peats (n=32)				
A(% d.m.)	0.190	n.s.	-	-
B_d(g cm^{-3})	0.482	0.01	y=0.266+0.739x	0.114
P_o(vol.%)	-0.489	0.01	y=1.987-0.0174x	0.114

n.s. - not. significant.

ash content in these formations. In the moorshes formed from proper and weakly silted peats, it is 0.35, and in the strongly silted moorshes, it is 0.40.

2. The higher threshold value in strongly silted moorshes narrows the intervals determined for these formations by the numerical values the W_l index. Hence, the classes distinguished by the state of secondary transformation in the studied groups do not have the same values of the W_l index.

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