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EVALUATION OF CHANGES IN SOIL CONDITIONS ON PEATLANDS OF THE LUBLIN POLESIE DUE TO DRAINAGE

J. Gawlik, J. Szajda

Department of Nature Protection in Rural Areas, Institute for Land Reclamation and Grassland Farming in Falenty, 05-090 Raszyn, Poland

A b s t r a c t. This paper presents evaluation of changes in soil conditions of peatlands in the Lublin Polesie during the period of the last quarter of the century due to drainage and agricultural use. The main element of the evaluation was the morphological structure of post-bog peat soils as well as their ash content and the compaction state of the organic soil formations building the profiles of these soils. Changes in the humidity conditions of the meadow sites on these soils were also characterised. It was found out that the scope of changes of the elements discussed varied in relation to the drainage depth, thickness of the peat deposit, the genetic type of peat and degree of its decomposition as well as the stage of moorshing at the beginning of the present research.

K e y w o r d s: peat-moorsh soils, peat moorhsing process, transformation of peat soils, consequences of peat degradation

INTRODUCTION

The Lublin Polesie belongs to the least hypsometrically differentiated regions of our country. The flat terrain preventing water outflow contributed to the bogging of considerable areas especially in the accumulation plains with the lowest location. The Wieprz-Krzna canal built in the 60s and internal drainage resulted in the draining of about 75% of the surface area of natural peatlands and swamps and introduced significant changes into the water circulation in the area of the whole region. Even though the changes introduced exerted a significant influence upon peat-moorsh soils rich in organic matter, there is little data in the literature on the characteristics of the quantitative aspect of these changes.

The aim of the presented study was the evaluation of the changes in soil conditions which have taken place in the peatlands of the Lublin Polesie due to drainage and agricultural utilisation in the last twenty five years. In the above

evaluation the main points of interest were the changes in the morphological structure of peat-moorsh soils as well as compactness and the ash content of the organic soil formations building the profiles of these soils. Moreover, changes in humidity conditions of sites of investigated meadow soils. Understanding the rate and scope of such changes, in addition to its scientific value, is also necessary in arriving at decisions for the protection of organic soil against degradation.

MATERIALS AND METHODS

Evaluation of changes in soil conditions of the post-bog peat soils in the Lublin Polesie was carried out by means of comparing the results of soil examinations carried out in 1974 and 1976 on six peatlands representative for the region with the results of the same studies carried out in 2000. The study was performed either immediately or after a few years following drainage and the adoption of the peatlands for agricultural use. The characteristics of peat-moorsh soils and their properties recorded 25 years ago compared to the results of contemporary studies enabled a quantitative comparison of the changes in these soils. The studies were conducted by means of stratigraphic soil cross-sections in the improved meadow locations (melioration objects) chosen which were differentiated in terms of the intensity of their drainage. Observation wells for measuring the ground water level were installed in each cross-section running through the whole peatland. Soil profiles and the stratigraphy of the peat deposits were characterised in places where the wells were located. Soil samples for laboratory examinations were taken from the profiles characteristic of the peatlands studied. The study covered six locations, i.e.: Zbójno, Zienki, Tyśmienica III Krasne, Piwonia Górna I, Piwonia Uhnin, and Zielawa IV Hołowno.

The locations in Zbójno and Zienki, the former located in the Polesie National Park and the latter in their buffer zone, belonged to the most intensively drained.

They were equipped with a system of deep ditches supplemented with draining facilities which permitted the lowering of the ground water level to 180 cm below the surface of this area. Whereas the drainage systems of the remaining locations were adopted to moderate draining reaching as deep as 100 cm [4,5].

Recognition of soil thickness, type of peat formations and the stage of soil processes taking place in them, was carried out according to methods formulated by Okruszko [1,2] and Zawadzki [8]. The physical properties of the soil formations, i.e., ash content, bulk density and total porosity were determined by methods applied in the Institute of Land Reclamation and Grassland Farming [3,7].

Evaluation of changes in the humidity conditions of the soils studied was conducted indirectly on the basis of prognostic soil-moisture complexes (PS-MC) recognized at the initial and at the final stage of the studies based on the types of peat-moorsh soils distinguished according to principles assumed in melioration soil science [1,2,8].

EVALUATION OF CHANGES IN THE SOIL MORPHOLOGY

Characteristics of changes in soil conditions were discussed on the basis of some soil profiles chosen which were the most representative for the individual peatlands studied. Data shown in Figs 1 and 2 proved that the process of subsidence and mineralisation of organic soil mass initiated by peatland drainage resulted in a marked lowering of peatlands surface in the period of the last twenty five years; moreover, due to the considerable deepening of the peat moorshing zone, the character of organic formations in the surface layers of the soil profile changed, consequently the taxonomic position of some soil units distinguished in the initial period altered. It meant a change in soil types and the character of the sites created by them. In Zbójno, in conditions of intensive drainage, peat-moorsh soil poorly moorshified (Table 1, profile 4) formed on the mosaic peat, i.e., moderately decomposed peat underlain by amorphous peat (MtIbc) was transformed into peat-moorsh soil moderately moorshified (MtIIcc), and the moderately moorshified soil MtIIbc (profile 6) was transformed into a strongly moorshified shallow soil (MtIIIc1). Both soils became 15 cm shallower. In the location of Zienki, a moderately moorshified peat-moorsh shallow soil (profile 12) on mosaic peat (MtIIb3) was transformed into mineral-moorsh soil (Mr33), and its surface was lowered by 16 cm. The surfaces of the remaining two poorly moorshified deep soils of this location formed of mosaic peats (MtIbb profiles 15 and 17) were lowered by, respectively 26 and 30 cm (Fig. 1), and changes in their morphology and stratigraphy justified their transfer into the group of moderately moorshified soils (MtIIbb and MtIIba). Soil conditions in the peatlands moderately drained followed a similar route. In Tyśmienica III Krasne, the level of peat-moorsh poorly moorshified deep soils formed on mosaic peats of which one was underlain with fibrous peat, i.e., MtIba (Fig. 2, profile 10), and the other with gyttja, i.e., MtIbgy (Fig. 2, profile 5), lowered by 45 and 30 cm, respectively. The above soils were transferred into the group of moderately moorshified soils, i.e., MtIIba and MtIIbgy. The relatively large lowering of MtIba soil after twenty five years, i.e., by 1.8 cm per year, undoubtedly resulted from the appearance of poorly decomposed

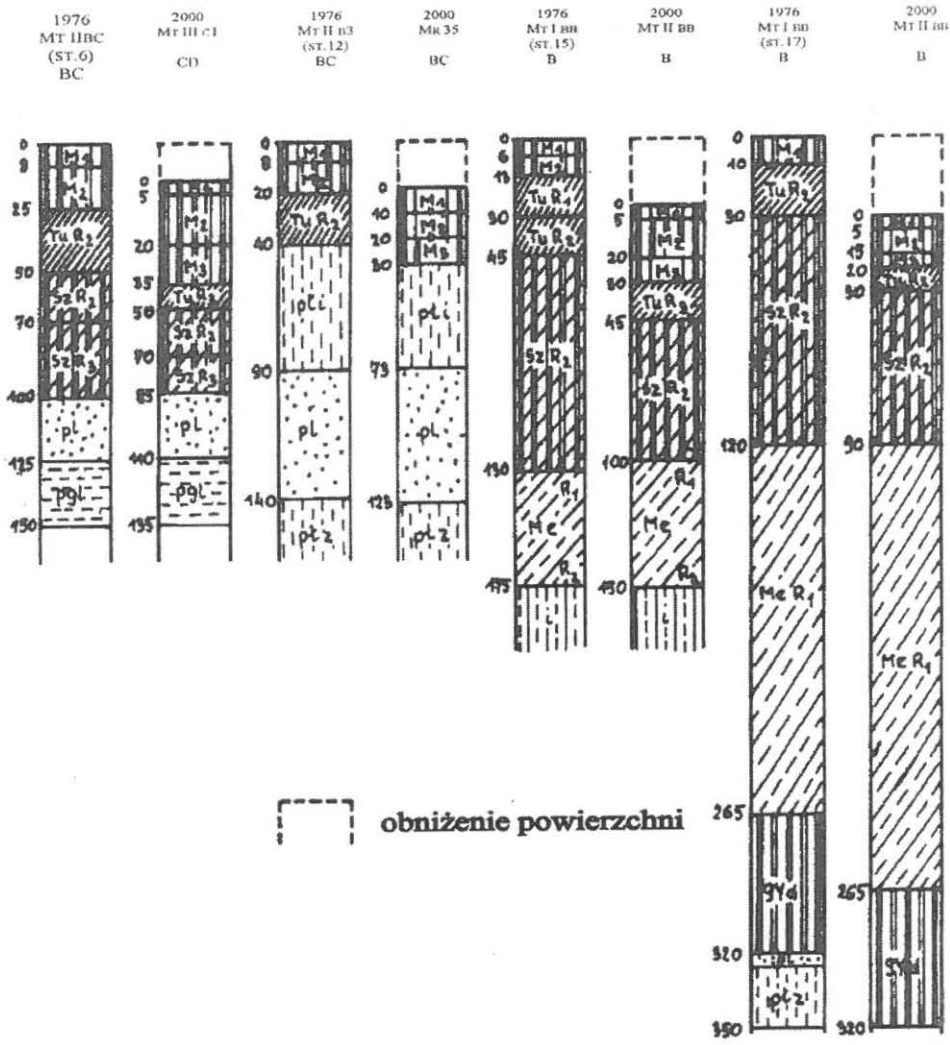

Fig. 1. Morphological characteristics of intensively dehydrated soils MtIIbc (loc.16) in Zbójno and MtIIb3 (loc.12), MtIbb (loc.15), Mt1bb (loc.17) in Zienki in the period 1976-2000

moss peat in its profile. This type of peat after draining show a high susceptibility to subsidence which agrees with the results of other authors [6]. In Piwonia Górna I, moderate draining resulted in a lowering of the deep soil surface MtIIbb by 43 cm with slight changes in its morphology. The changes consisted only in a slight deepening of the peat moorshing zone in the profile. Whereas poorly moorshified deep soil MtIbc in the peatland in Piwonia Uhnin (profile 4) underwent considerable

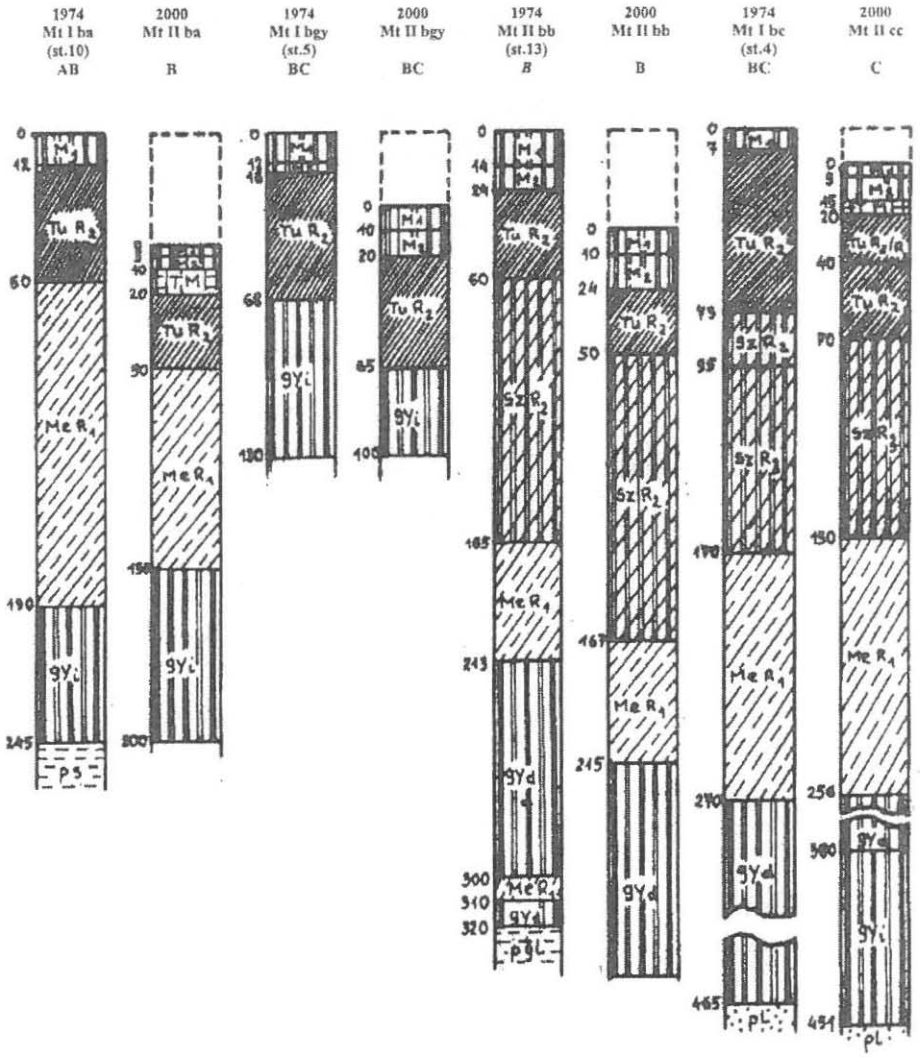

Fig. 2. Morphological characteristics of moderately dehydrated soils MtIba (loc.10) and MtIbgy (loc.5) in Tyśmienica III Krasne, MtIIbb (loc.13) in Piwonia Górna I, Mt1bc (loc. 4) in Piwonia Uhnin in the period 1974-2000.

transformation. It was transformed into a moderately moorshified soil MtIIcc, and its surface lowered by 14 cm due to mineralisation and subsidence (Fig. 2).

Soil in Zielawa IV Hołowno, i.e., peat-moorsh moderately moorshified formed from strongly decomposed peat (MtIIcc) preserved its initial taxonomic characteristics recorded in 1974, but its thickness decreased by 20 cm.

EVALUATION OF CHANGES IN THE SOILS PHYSICAL PROPERTIES

When evaluating physical soil changes, two basic parameters determining the direct and indirect compaction of organic soil mass, i.e., bulk density (G_o) and total porosity (P_o), which correlate with density negatively at the level of high significance have been taken into consideration [3]. Both values are the most visible indices of transformations which take place in the drained peat mass undergoing moorshing process. The third parameter which can be used for the description of changes taking place in the post-bog peat soils, is ash content in moorsh. Numerous studies showed that the phenomenon of the lowering of peat thickness conditioned by the on-going mineralisation of the organic soil mass is always accompanied by an increase of the ash content in the surface layer of the soil profile [9].

Data presented in Table 1 showing both the compactness of the soils studied and their porosity and ash content univocally show that the moorsh mass in the subsurface layer of the soils studied underwent significant changes in the course of the last twenty five years. It is reflected in the increase of the ash content in the moorsh formations creating a sub-sod level (M_2) ranging from 2.6 to 14.4% (Table 1) and a considerable increase in the bulk density of these formations. In intensively drained soils, the bulk density increased in the range between 12 and 28%, whereas in moderately drained soils, between 8 and 35% (Table 1). Taking into consideration the fact that in the middle of the seventies, the bulk density of the soil formation in the sub-sod layer (5-10 cm) was relatively high in most of the soils studied, because it usually exceeded 0.20 g cm^{-3}, it could be assumed that the decession phase of these soils relating to the moorshing process had been initiated long before melioration started.

EVALUATION OF CHANGES IN THE HUMIDITY CONDITIONS ON THE PEATLANDS OF THE LUBLIN POLESIE

In the decession phase of development, peat soils become gradually shallower due to subsidence and mineralisation, and evolve towards mineral-organic soils at first, and later towards mineral soils. Soil units change their taxonomic characteristics and their belongings to the prognostic soil-moisture complexes (PS-MC) and form sites with an increasing susceptibility to drying out in the above process. And the rate of this process is mainly related to the draining depth. Changes in water conditions and transformations that peat soils undergo after drainage are

Table 1. Changes of ash content, bulk density and total porosity of organic soil formations in chosen profiles of peat-moorsh soils in Lublin Polesie in the period of the last 25 years

No.	Melioration object Type of soil at the beginning and the end of the study	Soil layer (cm)	Ash content (% d.m.)		Bulk density (g cm^{-3})		Total porosity (vol. %)	
			1974	2000	1974	2000	1974	2000
1	Zbójno (profil 4)	5-10	18.5*	22.7	0.23*	0.29	85.8*	82.1
	MtIbc → MtIIcc	20-25	12.0	11.4	0.17	0.21	89.5	87.0
		35-40	11.6	16.6	0.17	0.19	89.5	88.3
		60-65	10.8	11.1	0.15	0.16	90.7	90.1
2	Zbójno (profil 6)	5-10	14.8*	17.4	0.19*	0.27	88.3*	83.3
	MtIIbc → MtIIIc1	15-20	16.1	14.7	0.19	0.28	88.3	82.7
		23-28	12.6	14.6	0.19	0.25	88.3	84.6
		55-60	12.7	37.5	0.15	0.22	90.7	88.0
3	Zienki (profil 12)	5-10	21.4*	27.6	0.24*	0.29	85.2*	84.1
	MtIIb3 → Mr33	15-20	18.6	22.7	0.26	0.27	83.9	83.3
4	Zienki (profil 15)	5-10	18.1*	21.8	0.25*	0.28	84.6*	82.7
	MtIbb → MtIIbb	15-20	16.6	16.3	0.25	0.28	84.6	82.7
		30-35	10.5	11.4	0.16	0.22	90.1	86.4
		60-65	10.6	10.8	0.15	0.14	90.7	91.3
5	Zienki (profil 17)	5-10	19.3*	23.5	0.24*	0.29	85.2*	82.1
	MtIbb → MtIIba	15-20	21.7	17.1	0.17	0.26	89.5	93.9
		25-30	10.0	11.8	0.12	0.18	92.6	88.9
		60-65	10.4	9.8	0.13	0.14	92.0	91.3
6	Tyśmienica III - Krasne	5-10	20.0	29.9	0.26	0.32	83.9	82.5
	(profil 5)	15-20	17.3	20.4	0.15	0.23	90.7	85.8
	MtIbgy → MtIIbgy	40-45	8.8	15.5	0.11	0.15	93.2	90.7
7	Tyśmienica III - Krasne	5-10	26.4	34.6	0.20	0.27	89.1	85.2
	(profil 10)	15-20	13.1	14.3	0.16	0.21	90.1	87.0
	MtIba → MtIIba	25-30	8.8	9.8	0.13	0.14	92.0	91.3
		35-40	7.8	9.1	0.12	0.15	92.6	90.7
		55-60	8.4	10.1	0.13	0.13	92.0	92.0
8	Piwonia Górna I	5-10	17.9	20.8	0.26	0.28	84.0	82.7
	(profil 13)	20-25	12.3	14.3	0.15	0.19	90.7	88.3
	MtIIbb → MtIIbb	55-60	7.8	9.5	0.11	0.11	93.2	93.2
9	Piwonia-Uhnin (profil 4)	8-13	20.0	34.4	0.30	0.37	87.5	79.6
	MtIbc → MtIIcc	20-25	11.0	13.4	0.14	0.18	91.3	88.9
		50-55	13.1	11.6	0.13	0.12	92.0	92.6
10	Zielawa IV - Hołowno	5-10	18.1	32.0	0.31	0.38	80.9	79.2
	(profil 1) MtIIcc→MtIIcc	25-30	11.8	15.8	0.16	0.21	90.1	87.0
		55-60	12.7	36.8	0.16	0.25	90.1	86.3

*Studies performed in 1976

reflected by the gradual transfer of these soils from the complexes with excessive or moderate moistening to complexes forming drying or dry sites.

The basis for the evaluation of humidity conditions in the peatlands studied was the recognition of the soil type and the PS-MC to which they belong [1,2,8]. Results of such recognition unambiguously showed (Figs 1 and 2), that both draining and the agricultural use of peatlands resulted in changes in the soils which occur in them and the soil-moisture complexes formed by these soils. These changes were largest in the most intensively drained location in Zbójno where the MtIbc soil in the last twenty five years passed from potentially periodically drying soil-moisture complex *BC* to drying one *C*, and the MtIIbc soil from *BC* complex to potentially periodically dry soil-moisture complex *CD*. On the other hand two deep soils of Zienki (profiles 15 and 17) remained in the potentially moist soil-moisture complex (*B*). Also the site of the shallow MtIIb3 soil (Zienki, profile 12) remained in the same *BC* complex, despite the transfer of the soil into the group of mineral moorsh soils (Fig. 1).

In conditions of moderate draining, the soil of MtIba in Tyśmienica III Krasne (profile 10) was transferred from the potentially periodically wet soil-moisture complex *AB* to moist one (*B*) and the soil MtIbgy (profile 5) remained in the potentially drying soil-moisture complex *BC*. Also in Piwonia Górna I (profile 13), moisture conditions of the site formed by the MtIIbb soil did not undergo changes. The soil remained in the potentially moist soil-moisture complex (*B*). The MtIbc soils in the location of Piwonia Uhnin, on the other hand, changed from the potentially periodically drying soil-water complex *BC* (Fig.2) into potentially drying soil-moisture complex *C* (Fig. 2). The MtIIcc soil occurring in the peatland in Zielawa IV Hołowno (profile 1) which preserved its absolutely unchanged taxonomic characteristics in the last twenty five years, remained in the potentially drying complex *C*. Preservation of post-bog peat soils for longer periods of time within the same moisture-soil complexes which reflects a lack of clear changes in profile structure, is undoubtedly the result of the quite favourable water conditions of these soils.

CONCLUSIONS

The following conclusions can be drawn from a comparison of the actual soil conditions of the peatlands chosen in the Lublin Polesie with the same conditions recorded in the middle of the seventies of the last century, i.e., directly after or

within a few years after melioration and the commencement of the agricultural use of these soils:

1. The basic factors determining the rate of changes and transformations of the post-bog soils under grassland were: draining depth, type of peat forming peat deposits, and degree of peat decomposition.

2. In the last twenty five years, the process of moorshing generated by drainage and the phenomena of subsidence and mineralisation of the peat mass connected with it resulted in a lowering of the soils surface by 15 to 45 cm and an increase in the ash content and bulk density of the sub-surface soil layer by, respectively, 2.6 to 14.4% and 8 to 35%.

3. The moorshing zone which deepens due to intensive peat draining changes the morphology of the soil profile and taxonomy of the soil units distinguished according to the range of this zone. Hence site conditions and types of prognostic moisture-soil complexes created by these soils change.

4. Moderately moorshing deep soils utilised as meadows in conditions of moderate draining as a rule do not change its moorshing status.

5. Relatively high values of bulk density in the surface layer of the soils studied, exceeding 0.20 g cm^{-3}, characteristic of moorshing formations, unambiguously show that the above soils had been included in the process of moorshing long before melioration. This should be related to the periodical peatland drying in the places where these soils occurred. Undoubtedly, these were partially dried peatlands in which high levels of ground water were dominant. It can be proved by the very shallow range of peat moorshing restricted to the surface layer of the soil profile only.

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OCENA ZMIAN WARUNKÓW GLEBOWYCH NA TORFOWISKACH POLESIA LUBELSKIEGO WSKUTEK ICH ODWODNIENIA

J. Gawlik, J. Szajda

Zakład Ochrony Przyrody Obszarów Wiejskich, Instytut Melioracji Użytków Zielonych
Falenty, 05-090 Raszyn, Polska

S t r e s z c z e n i e. W pracy przedstawiono ocenę zmian warunków glebowych jakie nastąpiły na torfowiskach Polesia Lubelskiego w okresie ostatniego ćwierćwiecza wskutek ich odwodnienia i rolniczego zagospodarowania. Stwierdzono, że w okresie tym wskutek osiadania i mineralizacji torfu powierzchnia badanych gleb obniżyła się od 15 do 45 cm. W poziomach stropowych gleb zwiększyła się popielność i stan zagęszczenia masy murszowej odpowiednio o 2.6-14.4 i 8-35%. Jednocześnie pogłębiająca się strefa zmurszenia torfu spowodowała przejście gleb z pierwszego stadium zmurszenia (MtI) do stadium drugiego, tj. do gleb średnio zmurszałych (MtII), a ze średnio zmurszałych do gleb silnie zmurszałych (MtIII), bądź nawet z MtI do MtIII. Odzwierciedleniem tych zmian były z kolei zmiany tworzonych przez te gleby rodzajów prognostycznych kompleksów wilgotnościowo-glebowych (PKWG. Wyraziło się to stopniowym przechodzeniem badanych gleb z kompleksów tworzących siedliska okresowo mokre (*AB*) lub wilgotne (*B*) do kompleksów okresowo posusznych (*BC*), posusznych (*C*) lub okresowo suchych (*CD*).

S ł o w a k l u c z o w e: gleby torfowo-murszowe, proces murszenia, przeobrażenia gleb torfowych, następstwa degradacji torfów