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Chapter 12

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Changes of Physico-water Properties of Soils and Species Composition of Plant Communities on the Post-bog Meadows in Supraśl Górna Valley

1. Introduction

Lowland bogs located in the river valleys, which were supplied by flowing waters (Dembek, Oświt 1992), were not agriculturally used on account of stable or periodic over- wetting. The development of animal production in Poland in the second half of XX th century revealed the need of production of high-valued bulky feed and adjustment the large area of lowland bogs to establishment of meadows and pastures. These goals were mainly reached by draining of fluvioglacial lowland bogs with the use of the system of open ditches and the management of semi-natural boggy habitat by sowing with arable grass mixtures. In previous century, in Poland there was meliorated and managed over 75% of lowland bogs surface. These investments have enabled to obtain additional area of meadows and pastures and considerable development of cattle-breeding (Kiryluk 2007). The largest meliorated areas of lowland bogs are situated on he north-east part of Poland: Wizna Swamp, Kuwasy Swamp, Tyniewicze Swamp, Brzozówka Swamp, but also on Lubelskie Region and West Pomerania.

Excessive drainage of meliorated peat bogs but also not always well-working melioration systems of infiltration irrigation, were the reasons of differentiated changes in post-bog habitats. In the first period of post-bog meadows management, the volume of hay production reached the level of 6-10 t $\cdot$ha $^{-1}$. It was possible thanks to high availability of mineral nitrogen for grasses and other meadow plants, which was released as the result of mineralisation of drained peat (Gotkiewicz et al. 1996). During next years of post-bog meadows management, there was observed the instability of their cropping and even decreasing trends of plant biomass production (Okruszko 1991). This process was mainly caused by the changes of physical properties of peat-muck soils (Bieniek et al. 2006, Szymanowski 1987), the decrease of their retention abilities but also the changes in species composition of artificially established plant community. Dependently on the intensiveness of drainage and the way of use, the changes in meadows post-bog habitats had features of drying or swamping (Kiryluk 2009).

Mineralisation, mucking of peat but also decrease of water capacity, have caused reducing of species diversity of plants communities, lowering of their productivity and natural values of these habitats (Grzegorczyk et al. 2000; Trąba, Wolański 1999). This problem occurs, to the large extend, in many years after melioration and appears on the most of muck objects in Poland, but also in countries of Western Europe. Last years in Poland there were made many attempts to stop the degradation process of meliorated post-bog habitats by improvement of drainage systems (Jurczuk 2004, Szajda, Olszta 2002). There were done many works on meadow re-management of peat, on which synanthropisation and impoverishment of plant communities was observed (Hopkins et al. 1995, Łyszczarz, Dembek 2010).

The changes in the soil-water post-bog habitat and their results in phytocenosis were researched in the period of 1986-2010 on the post-bog object of Supraśl Górna, situated in the upper river stretch of Supraśl in Podlaskie vivodeship.

The aim of this research work is the analysis of basic physico-water properties of muck-peat soils and the changes in plant communities in post-bog plant habitats, but also the presentation of main reasons causing degradation processes in these ecosystems.

2. Habitat conditions and reserch methodology

The changes of habitat conditions and plant communities were investigated on the meadow object of Supraśl Górna in the stretch of 79+465 to 93+800 km on the River Supraśl (Fig. 1). In the records of melioration supplies, this complex is marked as G-2 and covers the area of 1100 ha of post-bog meadows. Peat drainage and melioration supplies were made in the period of 1978-1980 and post-melioration management was conducted in 1980-1983 (Ekspertyza 1982).

Irrigation on this object is done in the extensive way, from the own sources of the River Dzierniakówka (the tributary of Supraśl), because the proposed irrigation system from the main stream, which means the river Supraśl, was not done. Currently, melioration ditches are deep, do not possess the proper bad fall and have not effective drainage-irrigation functions. In the longer precipitation-free periods, ditches do not drive water and the nearby areas are strongly over-dried, but after the period of high rainfall, the gravitation water outflow through melioration system is impossible and the conditions of over-wetting come into being.

On the basis of plant communities diversity, location of ground water-table and soil sounding, there were marked 10 research points (Fig. 1).

In this work, there were analysed research results from three points with the numbers 3, 5 and 8, which are differentiated by the thickness of peat deposits.

From the particular genetic levels of peat-muck soils there were taken soil samples to the graduated cylinders with the capacity of 100 cm^3, in which there were determined bulk density and ash content of soils. These properties are substantial in order to assess the changes occurring in the post-bog soils (Szymanowski 1987).

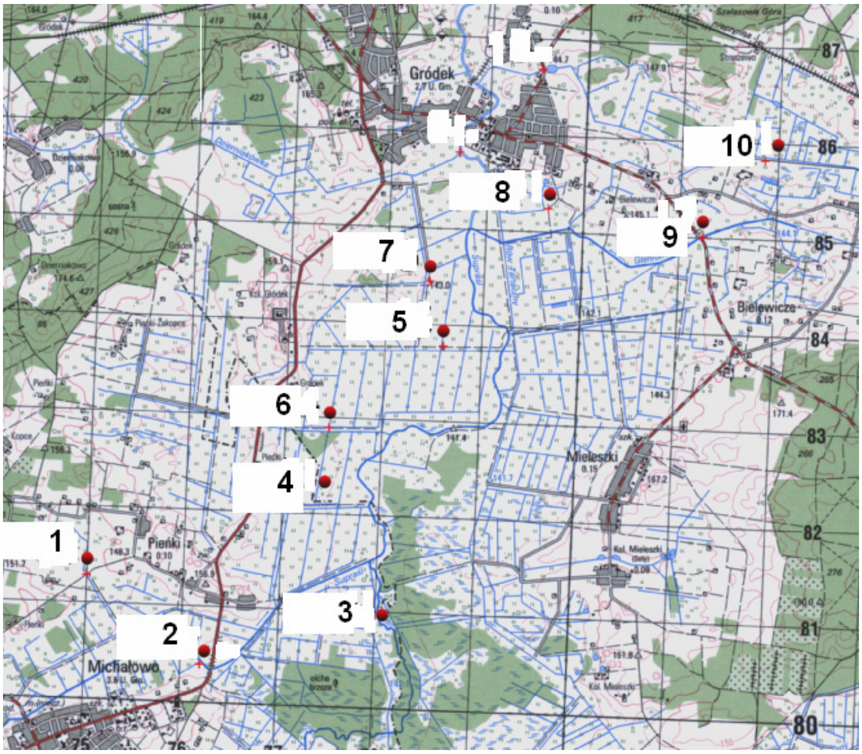

Fig. 1.Map of Supraśl Górna object with marked research points © A. Kiryluk

Soil bulk density was determined in samples taken to the graduated cylinders with the capacity of 100 cm^3, without disturbance of natural soil structure. The samples were dried to constant mass in the temperature of 105°C. Ash content of peat was determined by the annealing in the temperature of 550°C.

The first researches of soil properties in this object were conducted in 1987, so 7-8 years after melioration, which means after advanced process of soil mucking but also after forming of artificial plant communities which were set up in result of meadow post-melioration. Afterwards, the researches were repeated in the same points in 2006 and 2010 with the use of the same methodology.

The floristic researches were conducted on the plant patch with the surface of 100 m^2 in 1986, 2006 and 2010. There was determined the percentage content of particular species in community within an accuracy of 1%. The species which amounted less than 1% were marked with the simple "+". In floristic tables species were classified to: grasses, papillonaceous, herbs and weeds, cyperaceous and juncaceous.

3. Reserch results and discussion

3.1. Morphological structure of analysed soils

On the basis of soil pits, analysed soils were characterised and classified as peat-muck type.

The research point 3 (Table 1) was situated in the post-bog habitat on deep peat-muck soil. More beneficial wetting conditions and good species composition of plant communities allowed on the intensive use of meadows in this habitat.

In the habitat of post-bog meadows on the medium-deep peat-muck soil there was located research point number 5 (Table 2). Habitat conditions and floristic composition of plant community allowed on the medium-intensive use.

Table 1

Structure of soil profile in research point 3

Diagnostic level	Level depth	Type of soil material
Mt	0-30 cm	Humus muck (Z_2)
Otnisz R_2	31-69 cm	Rush peat, grey, medium-decayed
Otnisz R_1	70-130 cm	Rush peat, grey, poorly decayed
below	130	poorly decayed peat
Sytematics soil unit:	IV B1.a, deep peat-muck soil Mt II ba, formed from poorly decayed peat , prognostic soil-moisture complex - wet (PKWG-B)	
Way of habitat use	Post-bog meadow, intensively used	

Table 2

Structure of soil profile in research point 5

Diagnostic level	Level depth	Type of soil material
Mt	0–27 cm	Humus muck (Z_2)
Otnisz R_2	28–75 cm	Rush peat, grey, medium-decayed
Otnisz R_1	76-100 cm	Rush peat, brown poorly
below	100 cm	Loose sand
Sytematics soil unit:	IVB1.a, medium- deep peat-muck soil MtIIbb**,** formed from medium-decayed peat, prognostic soil-moisture complex periodically dried (PKWG-BC).	
Way of habitat use	Post-bog meadow, medium-intensively used	

In the habitat of post-bog meadows on shallow peat soil with the thickness of 60 cm, there was located research point number 8. Poor floristic composition of habitat allowed on the extensive one hay-growing use of post-bog meadows.

Table 3

Structure of soil profile in research point 8

Diagnostic level	Level depth	Type of soil material
Mt	0-28 cm	Humus muck (Z_2) (Z_2)
Otnisz R_2	29-60 cm	alder peat, grey, medium-decayed
below	60 cm	Loose sand
Sytematics soil unit:	IVB1.a, shallow peat-muck soil MtIIc 60pl , prognostic complex dried (PKWG-C).	
Way of habitat use	Post-bog meadow, extensively used	

3.2 Ground waters on analysed object

In 10 points on analysed object there was measured water-table of research pints. On the Figure 2 there are shown mean ground water-table levels in these points in vegetation period of 1986, 2006 and 2010.

After 20 years, the levels of ground water on analysed object fell of about 20 cm on average, while after 2006 there were observed the tendencies of ground waters rising, which can be substantiate by lower water outflow (Phot. 1).

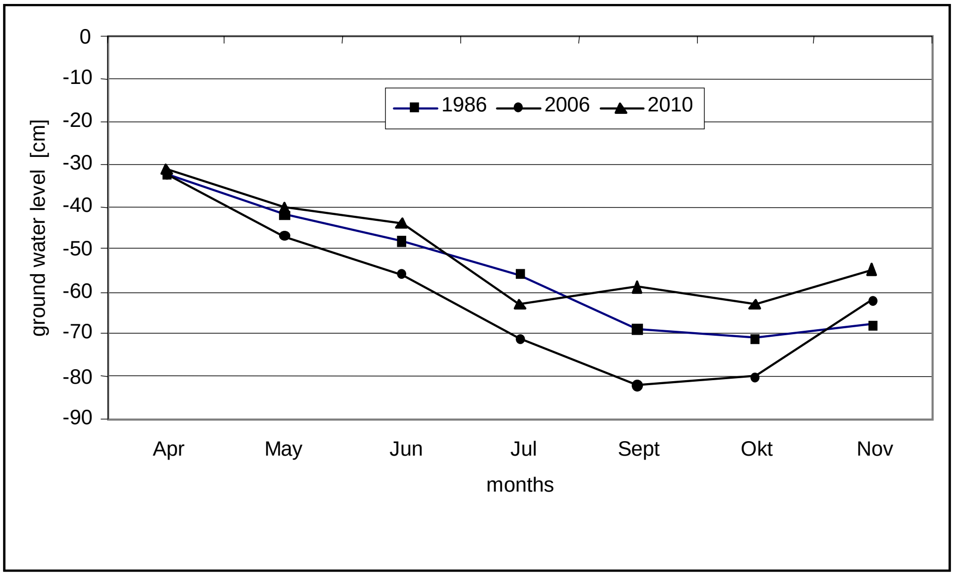

Fig. 2. Mean ground water levels on the Supraśl Górna object in vegetation months

Phot. 1. The lack of water outflow in ditches is the reason of over-wetting of ground
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Another reason of ground water rising and its maintenance near the surface of meadows on the most area of meliorated post-bog object, was also dysfunctional system of drainage-irrigation ditches (Phot. 2).

Phot. 2. Non-conserved melioration ditch does not act drainage-irrigation functions on the object
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The course of water-table in vegetation period indicates that ground waters were mainly formed under the influence of rainwater and, in narrower scope, under the influence of infiltrated irrigation. In the period from June to October, ground waters lowered into the depth of 50 cm that is why they could have been less available or unavailable for plats roots in peat-muck conditions with the mucking degree of Mt II (Szajda, Olszta 2002).

3.3. Changes of bulk density of peat-muck soils

Mean bulk density of analysed soil amounted 0,247 g $\cdot cm^{-3}$, and the range of this parameter fluctuated between 0,154 to 0,413 g $\cdot cm^{-3}$. After 20-year-period in each research point and on all genetic levels, there were observed changes of mass density and increase of bulk density (Table 4). The highest bulk density which reached 0,413 g $\cdot cm^{-3}$ was stated on the M_1 muck level in peat-muck soil in 2010 and the smallest, which amounted 0,154 g $\cdot cm^{-3}$, on the T_2 peat level in deep peat-muck soil in 1986. The density rising of peat mass on the top soil layers is a typical process for many post-bog objects and is mainly a result of intensive mucking of peat (Chrzanowski, Szuniewicz 2002, Gotkiewicz et al. 1996). The conditions which caused peat mineralisation and its density in analysed habitats were: periodic lack of water in root layer (mainly on M_1 level) and hydrophobic character of muck, which is proved by the researches of Bieniek et al. (2006). The changes of physical properties of post-bog soils are influenced by the way of meadows use (Kiryluk 2007).

Table 4

Bulk density of peat-muck soils, g$\cdot cm^{-3}$

Genetic horizon	Mt IIbb deep peat-muck soil, medium-mucked			Mt IIbb 100 pl medium deep peat-muck soil medium-mucked			MtII c 60 pl shallow peat-muck soil, medium-mucked		
	Year 1986	Year 2006	Year 2010	Year 1986	Year 2006	Year 2010	Year 1986	Year 2006	Year 2010
M_1	0,274	0,279	0,281	0,269	0,275	0,274	0,375	0,412	0,413
M_2	0,210	0,205	0,203	0,250	0,270	0,268	0,361	0,377	0,375
T_1	0,175	0,188	0,187	0,193	0,205	0,203	0,180	0,216	0,215
T_2	0,154	0,161	0,163	0,174	0,194	0,194	–	–	-

3.4. Changes of ash content of peat-muck soils

The average ash content in analysed peat-muck soils amounted 20% (Table 5). The highest ash content, which reached 37,5 %, was stated in shallow peat-muck soil MtII c 60pl on the $T_{1,}$ peat level which could have been caused by the processes of silting and carrying of mineral material on the stage of fluvioglacial peatbog forming, but also in the time of periodic overflow.

High ash content on this genetic level can not be the result of mineralisation and chemical changes of peat mass. High ash content, reaching over 20%, appeared in all analysed soils on the M_2 muck level. In the period of 20 years, on this level there was observed the rising of ash content in soils in each of three analysed points. Similar ash content was stated on out of crop post-bog object of Siódmiak (Bieniek et al. 2006). Moreover, these researches indicate on unbeneficial influence of intensive use on the other properties of post-bog soils. Except of physico-chemical changes within soil profile, the ash content increase is influenced by the way of use of post-bog habitats (Chrzanowski, Szuniewicz 2002, Jurczuk 2004).

Table 5

Ash content of peat-muck soils on the Supraśl Górna object % a.s.m.

Genetic horizon	Mt IIbb deep peat-muck soil, medium-muck			Mt IIbb 100 pl medium –deep peat-muck soil medium-muck			MtII c 60 pl Shallow peat-muck soil, medium-muck		
	Year 1986	Year 2006	Year 2010	Year 1986	Year 2006	Year 2010	Year 1986	Year 2006	Year 2010
M_1	17,4	17,1	17,3	16,6	18.6	18,5	23,6	25,6	25.3
M_2	19,9	20,0	19,8	24,0	26,8	26,5	20,1	21,8	21,6
T_1	13,7	13,9	13,5	13,8	15,0	15,2	37,0	37,5	37,0
T_2	11,2	12,3	12,2	17,0	17,3	17,0	–	–	-

3.5. Floristic composition of meadow plant communities on the object in the period of 1986-2010

Floristic researches of plant communities conducted in the same habitat from 1986 have allowed to determine the trends of changes in succession of post-bog flora. (Table 6). The analysis of plant communities composition has shown the most substantial changes which means lowering of species diversity in shallow habitats of post-bog soils, while in habitat of deep soils the number of species has risen.

In habitats of deep, medium-deep and medium-mucked peat-muck soils (research points 3 and 5) the most frequent species in meadow communities were: *Alopecurus pratensis* L., *Phalaris arundinacea* L. These species formed the volume of biomass production in these habitats, because they covered stable, well-sodden post- bog meadows. In habitat of deep peat-muck soils, the changes of communities floristic composition were slight and the number of species increased by 6 after 20 years.

Table 6

Species composition of meadow plant communities in the period of 1986 -2010 (species share in %)

Species	Point 3			Point 5			Point 8		
	1986	2006	2010	1986	2006	2010	1986	2006	2010
Grasses									
Agrostis gigantea Roth	11	8	12	6	4	8	3	1	2
Alopecurus pratensis L.	15	17	18	16	15	20	12	8	10
Anthoxanthum odoratum L.s.str.	2	3	4	2	4	5	6	5	6
Deschampsia caespitosa (L.) P. Beauv.	1	2	5	3	5	6	4	4	5
Festuca arundinacea Schreb.	5	6	4	5	7	4	6	2	1
Festuca pratensis Huds.	3	2	2	3	6	5	7	5	3
Festuca rubra L. s. str.	–	–	-	1	3	4	14	16	14
Glyceria fluitans (L.) R. Br.	3	2	5	2	2	3	+	+	-
Glyceria maxima (Hartm.) Holmb.	2	2	3	2	3	4	1	1	2
Holcus lanatus L.	–	–	-	–	3	2	8	7	6
Molinia caerulea (L.) Moench s. str.	4	2	2	3	1	1	+	+	+
Phalaris arundinacea L.	17	14	18	12	11	12	4	4	5
Phragmites australis (Cav.)Trin.ex Steud.	6	4	3	2	1	2	1	1	2
Poa palustris L.	8	4	5	6	1	1	1	+	+
Poa pratensis L.s. str.	5	5	4	5	7	5	14	17	18
Herbs and weeds									
Achillea ptarmica L.	+	+	+	+	+	+	–	–	–
Caltha palustris L.	+	2	1	+	–	–	–	–	–
Cardamine pratensis L.s.str.	–	3	2	+	–	–	–	–	–
Cardaminopsis arenosa (L.) Hayek	–	–	-	–	1	–	6	14	12
Cirsium palustre (L.) Scop.	–	+	+	–	–	–	–	–	–
Comarum palustre L.	+	+	1	–	–	–	–	–	–
Dactylorhiza maculata (L.)Soó	+	+	+	+	–	–	–	–	–
Lychnis flos-cuculi L.	4	2	1	4	2	1	2	2	3
Epilobium palustre L.	+	+	+	–	–	–	–	–	–
Epipactis palustris (L.) Crantz	+	+	+	–	–	–	–	–	–
Filipendula ulmaria (L.) Maxim	3	2	1	5	2	1	3	4	3
Geranium palustre L.	+	1	+	+	+	+	–	–	–
Geum rivale L.	1	1	+	1	1	1	–	–	–
Lysimachia vulgaris L.	+	1	+	+	–	–	–	–	–
Lythrum salicaria L.	+	1	+	2	2	2	+	+	+
Menyanthes trifoliata L.	+	1	1	+	–	–	–	–	–
Polygonum bistorta L.	2	3	2	3	2	2	–	–	–
Ranunculus repens L.	2	2	2	4	2	1	+	–	–
Rumex obtusifolius L.	–	+	+	+	+	+	–	–	–
Senecio paludosus L.	–	+	+	+	–	–	–	–	–
Stellaria graminea L.	+	+	1	2	3		+	–	–
Urtica dioica L.	–	3	1	6	8	6	8	9	8
Valeriana officinalis L.	+	–		–	–	–	–	–	
Cyperaceae and Juncaceae									
Carex nigra Reichard	2	1	1	3	2	2	–	–	–
Carex riparia Curtis	1	1	+	+	+	+	–	–	–
Juncus effusus L.	–	+	+	+	+	+	–	–	–
Scirpus sylvaticus L.	1	2	1	2	2	2	–	–	–
Papillonaceous									
Lathyrus palustris L.	1	1	–	+	+	+	–	–	–
Lotus uliginosus Schkuhr	1	1	–	+	+	+	–	–	–
Trifolium hybridum L.	–	1	–	+	+	+	–	–	–
Total	100	100	100	100	100	100	100	100	100
Number of species	35	41	38	38	34	32	22	20	19

In research point 5 in habitat of medium-deep peat-muck soils, which was characterized by quite beneficial wetting conditions, there maintained: *Alopecurus pratensis* L. and *Phalaris arundinacea* L., but also the share of *Festuca pratensis* Huds.,and *Poa pratensis* L.s. str. increased. The number of species in habitat lowered by 4 to 2006 and by 6 in 2010. In the community, there occurred among others *Holcus lanatus* L. and *Urtica dioica* L., which could have proven the initiation of habitat drying process.

On shallow peat-muck soils (research point 8) the community was mainly formed by *Poa pratensis* L.s.str and *Festuca rubra* L.s.str. The little share in the community had *Alopecurus pratensis* L. Almost 30% of plant communities in this habitat made dicotyledonous weeds: *Cardaminopsis arenosa* (L.) Hayek and *Urtica dioica* L., which had xerophilous properties. Similarly, on the economic and natural account, unbeneficial changes in meadow habitats on excessively dried organic-carbon soils were stated by Trąba and Wolański (1999).

The limiting of degradation of agriculturally valuable meadow communities on the peat-muck soils is a very difficult task (Grzegorczyk et al. 2000), and in case of advanced changes, it is rather impossible to achieve (Hopkins et al. 1995, Ramseier 2000). The issue of the problem is that the degradation of plant communities is observed on large meliorated meadow objects in Poland, and the main reasons of this process are: abandonment of their reasonable use and the lack of effective irrigation in the vegetation period.

4. Conclusions

1. On post-bog object of Supraśl Górna in the period of 1986-2010 there were stated the changes in soil-water conditions and the changes in meadow plant communities.
2. The most substantial changes were observed in habitat of shallow peat-muck soils MtIIc which means the increase of peat bulk density and ash content.
3. There were stated less considerable changes of physico-water properties of medium-deep and deep peat-muck soils.
4. In plant communities in habitat of medium-deep and deep peat-muck soils, there was stated higher species diversity of plant communities than in the habitat of shallow peat-muck soils. Plant communities in these habitats were characterized by stability and high biomass productivity.
5. In the period of 2006-2010, in the result of maintenance of quite shallow ground water-table, there was observed the rising of hygrophilous species share in plant communities, which could be the manifestation of another swamping process of post-bog habitats.

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