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FUNCTIONING OF MEADOW ECOSYSTEMS IN RIVER PIWONIA VALLEY 40 YEARS AFTER ITS MELIORATION

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Summary. The paper was aimed at evaluating the functioning of meadow ecosystem, air and water system, as well as soil transformations in river Piwonia valley 40 years after its melioration. The research was based on hydro-geological studies carried out in 1974 and 2005 as well as upon water system in dry years 1976 and 2002. The study was conducted in Polesie Lubelskie (Sosnowica) on grasslands meliorated and managed in 1963–1965 that have been improperly performed. Change of water system, together with intensification of agricultural production, and then giving up the land management contributed to formation of other habitat components. As a consequence of melioration, land surface was lowered, organic matter got mineralised, as well as soil volume density and ash content increased and porosity decreased. The influence of improper land management under optimum soil moisture conditions led to disappearance of many valuable grass species and succession of *Deschampsietum caespitosae* associations with great percentage of weeds, decrease of yielding and simplification of botanical composition of meadow sward.

Key words: water systems, soil degradation, plant yielding, plant communities

INTRODUCTION

Grasslands occupy about 4 million hectares in Poland, making 22% of grassland area (13% of country area), i.e. much less than in other European countries [Nazaruk and Pawluśkiewicz 2001]. For ages, meadows and pastures have been the source of cheap and ecological fodder for ruminants. Unfortunately, the decrease of dairy and meat production in farms caused the grasslands to become out of performance. Observed negligence referring to conservation and exploitation of melioration systems along with still decreasing level of pratotechnics leads to yields size decrease [Jankowska and Zastawny 2003,

Kozłowska 2004]. Spreading of wasteland area is the consequence, which leads to sward degradation and periodical drying or flooding of the terrain [Nyc 2001]. Polish accession to European Union and incorporation of agricultural and environmental programs resulted in the change of farmers attitude to land management. At present, mainly due to subsidies, great percentage of those wastelands is performed as semi-natural single-cut meadows.

In Lublin region, among 167 000 ha of meliorated grasslands (52% of area), only 38 000 ha were properly managed in 2006. Despite the fact that 49 000 ha of meadows and pastures are adapted for melioration, it was made on only 10% of the area [Statistical 2006], which means that 80% of meliorated grasslands was abandoned, mainly on inaccessible post-bog areas.

Intensification of agricultural production on small area led to introduction of chemicals (powdered bones, growth regulators) for cattle breeding. These substances were aimed at accelerating the production cycle, but instead it caused environment pollution and bovine spongiform encephalopathy (BSE) occurrence. Therefore, producing fodder on the base of grasslands can be observed in Western Europe, and fodder conservation in the form of silage and silage-hay made from meadow grasses finds a growing interest [Nazaruk and Pawluśkiewicz 2001, Jankowska and Zastawny 2003].

MATERIAL AND METHODS

The present study was aimed at evaluating the functioning of meadow ecosystem, air and water system, as well as soil transformations occurring in river Piwonia valley 40 years after its melioration. It was based on hydro-geological studies including the extent of land surface lowering and stratographic structure of Sosnowica cross-section as a result of levelling and probing made in 1974 and 2005, as well as studies upon water system in dry years 1976 and 2002 [Szajda 1980]. The study was carried out in Western Polesie, in the locality of Sosnowica, on grasslands meliorated and managed in 1963–1965 that are at present improperly performed (Fig. 1). Examinations included:

– analysis of water system changes (water surface, soil moisture content),
– soil measurements (volume density, specific density, pF curve),
– stratographic measurements (levelling and soil profile),
– analysis of yielding from control plots and fertilised in 2002,
– analysis of meteorological conditions (precipitations and temperatures).

The determinations were performed applying the following methods:

– ground and surface water levels – measured in relation to terrain level in specialized piesometric wells,
– soil moisture content – dryer-gravimetric method for samples collected from plants root layer (0–30 cm),
– specific density – pycnometry,

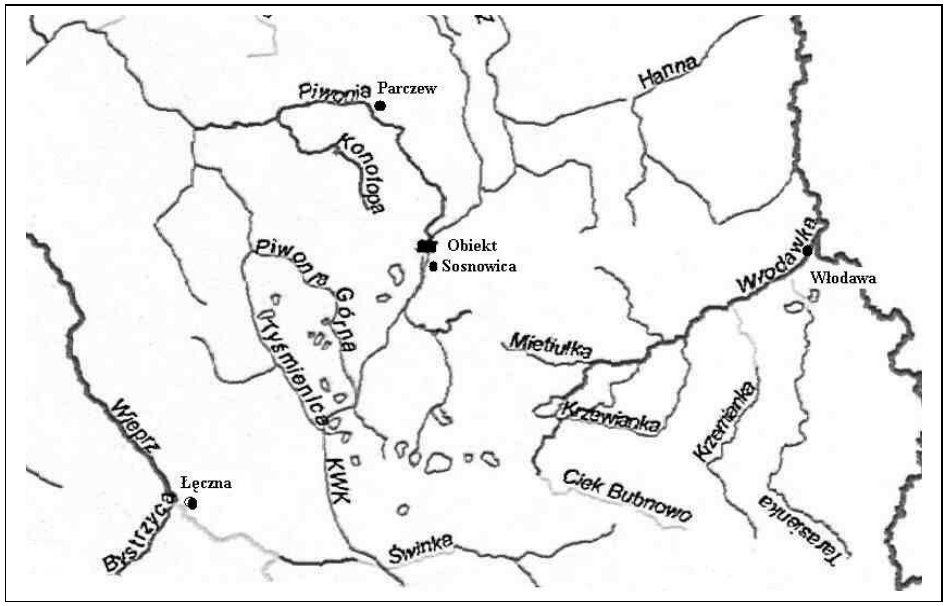

Fig. 1. Location of the object of examinations relating to the hydrographical network Polesie

– volume density – drying samples of 250 cm^3 capacity,
– points at pF curve – using high-pressure chambers,
– ash content – combusting at 550°C [Zawadzki 1973].

Selected indices of meteorological drought during vegetation period were used to characterize climatic conditions of Polesie Lubelskie [Szajda *et al*. 2007]. The evaluation revealed that vegetation period 1976 was characterised by the largest sum of days with no precipitation, while 2002 was distinguished by strong drought in May-September [Łabędzki and Leśny 2008].

Detailed characteristics of the studied object, location of studied cross-section and levelling-soil profile were presented in earlier publications [Szajda 1980, Grzywna 2005, Grzywna and Szajda 2006]. Here, it should be worth mentioning that left fragment of the object is performed as 2-cut meadow belonging to Department of Grassland Sciences and Green Shaping, Agriculture University of Lublin [Baryła 2001]. Right side of studied object is performed as semi-natural single-cut meadows or it is not performed at all. Analysed cross-section is located in river Piwonia valley between Wieprz-Krzna Canal and fish pond Hetman. That fragment of the valley is filled with mursh-peat soils at different stage of conversion, and mineral-mursh soils can be found only near Coal Mine. Maximum thickness of peat forms in Sosnowica cross-section was measured at the close neighbourhood of the river; it amounts to 4.7 m [Grzywna 2005].

RESULTS AND DISCUSSION

Climatic conditions, water systems, type of soil cover, and phyto-sociological conditions affect the functioning of meadow ecosystems. The water system in Sosnowica cross-section is shaped by interdependence of water levels in Wieprz-Krzna Canal, river Piwonia, and fish pond Hetman. In addition, those conditions were modified by a system of melioration ditches that had not been conserved for 20 years.

Change of water system and intensification of agricultural production, and then giving up the land management, contributed to the creation of other habitat components [Baryła 2001, Nyc 2001]. Land surface lowering, mineralisation of peat matter and simplification of floristic composition occurred as a consequence of melioration. The rate of ongoing degradation processes depends on stratographic structure, soil properties, air and water systems, as well as the level of pratotechnics [Jurczuk 2000].

Studies conducted in 2005 revealed that medium-murshed MtII peat forms of 15 cm thickness and characterised by medium-grainy structure dominated in the analysed cross-section. Mean thickness of peat layer of 114 ha total area and built of sedge and reed peats is 2.1 m [Borowiec 1990].

Conversion of anaerobic into aerobic processes occurred due to water removal from peat area, which led to increase of peat decomposition, and then its transformation into hydrophobic mursh. Lowering of peat layer and change of soil structure and properties resulted from converting it from accumulation to recession stage [Jurczuk 2000].

In 1974–2005, peat in Sosnowica cross-section was lowered by 21 cm, on average. The rate of lowering in that area depends on subsoil thickness and moisture conditions [Grzywna and Szajda 2006]. Maximum lowering (27 cm) was recorded at the point where thickness is 3.8 m and drainage interaction of the river is apparent.

Changes of physical and water properties as well as soil mineralisation are directly associated with ground lowering. Analysis of data from Table 1 reveals that specific and volume densities – along with ash content – increased, whereas soil porosity decreased. The most dramatic change occurred in relation to ash content (50% increase).

That increase resulted from soil mineralisation and nitrogen and carbon compounds release. Change of ash content and soil physical properties was a consequence peat drying and lowering. It involved change of soil structure from fibrous to amorphous, and then grainy [Okruszko and Piaścik 1990]. Soil properties change and formation of medium-grainy mursh contributed to soil taxonomy change. At initial stage, the soil was classified as MtIbc, while it was transformed into MtIIcc in 31 years.

Table 1. Changes of physical properties of 0–30 cm soil layer at point No. 4

Year	Specific density	Volume density	Total porosity	pF = 2.7	Ash content
	$Mg \cdot m^{-3}$	$Mg \cdot m^{-3}$	$kg \cdot kg^{-1}$	%	%
1974	1,44	0,22	87,6	50	16
2005	1,51	0,31	84,3	47	24
Change	+0,07	+0,09	-2,7	-3	+8

Besides changes in physical properties and stratographic structure of a soil, also moisture content changes take place. Two main retention indices were applied to assess those conditions: ground water level and moisture content in root zone of the soil. Therefore, analysis of water system changes dynamics in 1976 and 2002 was performed (Fig. 2 and 3). Presented data indicate that optimum soil moisture occurred at the beginning of the vegetation period, where moisture content reached 78–79%, and ground water level was at the depth of 26–38 cm. After water outflow into the river and melioration ditches, sudden lowering of ground water level and associated decrease of soil moisture content was observed. Maximum depth of water level was recorded at the end of June 1976 (92 cm), with the lowest soil moisture content at the end of July (54%) – Fig. 2.

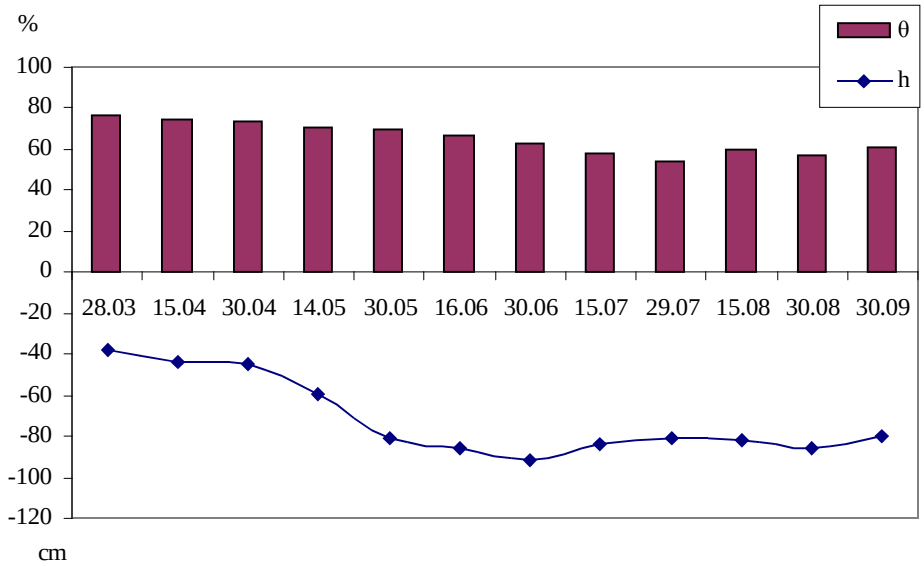

Fig. 2. Changes of ground water level and soil moisture content MtIbc in 1976

Then, slight improvement of water system conditions took place, and the level of water surface decreased to 82 cm. Referring to 2002, the lowest water

level was found in mid June (74 cm), and the lowest soil moisture content – at the

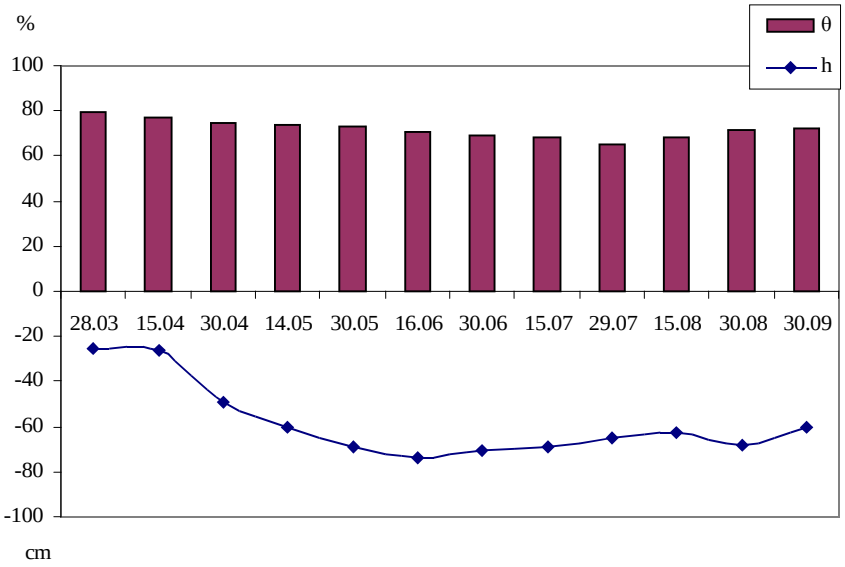

Fig. 3. Changes of ground water level and soil moisture content MtIIcc in 2002

end of July (64%) – Fig. 3. Both in 1976 and 2002, the humidity was higher than permissible corresponding to pF = 2.7 and amounting to 50% in 1976 and 47% of volume in 2002. System of hydrological conditions in 1976 and 2002 depended on the amount and distribution of atmospheric precipitations. Deeper water levels in 1976 as compared to 2002 were a result of different intensity of meteorological drought. In 1976, meteorological drought caused the appearance of soil and hydrological droughts, while only the soil drought occurred in 2002 [Szajda *et al*. 2007, Łabędzki and Leśny 2008].

Appropriately managed meadows are both a source of convenient fodder and they protect organic soils against degradation [Kozłowska 2004]. Condition of grasslands can be easily evaluated by means of botanical composition of meadow sward and size of achieved yields analysis. Therefore, phyto-sociological records were taken from experimental plots of 10 m^2 area each, as well as yielding of the meadow in control and fertilised combinations was recorded in 2002. Fertilisation was applied at the rate of 70 kg N, 50 kg P_2O_5, 90 kg K_2O, and 10 kg MgO, harvesting 2 hay cuts. Mean yield achieved from control plots situated on waste area was 22 dt·ha^{-1} from the first and 20 dt·ha^{-1} from the second cut, which gave total hay yield of 42 dt·ha^{-1}. It increased due to fertilisation by 50% up to 63 dt·ha^{-1}. Thus, it revealed that achieved hay yield depended on fertilisation applied, level of ground water, and botanical composition of meadow sward. As a conclusion: giving up mineral fertilisation is the main reason for bad condition of grasslands.

Botanical composition of plant communities on studied cross-section was

determined by anthropopression. In spring 1965, meadows were sown with grass mixture: *Festuca pratensis*, *Festuca rubra*, *Phleum pratensis*, *Trifolium pratense*, *Dactylis glomerata*, *Poa pratensis*, *Lotus corniculatus*, *Agrostis alba* [Baryła 2001]. An intensive meadow performance was conducted until mid of 80's on that area. Giving up the management later led to unfavourable changes in species composition. Valuable tall grasses disappeared from the communities, to be replaced by *Alopecurus pratensis* and nitrogen-vulnerable weeds such as *Urtica dioica* and *Anthriscus sylvestris* [Kryszak *et al*. 2004]. In early 1985, conservation of melioration devices, fertilisation, and nursery operations were reduced with subsequent giving up of the meadow cutting. Changes in management led to degradation of plant communities and succession of *Holocetum lanati*, *Deschamsietum caespitosae*, and *Juncetum effuse* associations. The widest expansion was shown by very poor (floristically) communities of *Deschamsietum caeaspitosa* with great percentage of weeds.

Melioration activity including building the Wieprz-Krzna Canal and system of melioration ditches in 60's caused fundamental changes in peat water system. In the Łęczna-Włodawa Lakeland over 73% wetlands was drained [Chmielewski 2001]. A significant lowering of water surface level contributed to the break of bogging processes and the beginning of biochemical transformations. Peat layers with no water are subjected to irreversible contraction and concentration of peat matter. Surface soil layers with no water lift get lowered. At the same time, a change in soil structure takes place, with resulting change of its physicochemical properties.

Peat in Sosnowica cross-section was lowered at the rate of 7 mm annually due to dehydration. Thus, it involved changes of soil physical features. Analysis of soil 0–30 cm layer revealed that specific and volume densities as well as ash content increased, while porosity decreased. The greatest changes (50% increase of ash content) were the consequence of soil mineralisation.

It was found that peat dehydration caused unfavourable mineralisation and murshing processes, leading to changes in soil water system. Worsening of water system was most apparent in the aspect of soil porosity decrease and decrease of water content accessible for plants (pF = 2.7). Deeper water level in 1976 in relation to 2002 was a result of different intensity of meteorological droughts. In 1976, meteorological drought caused the appearance of soil and hydrological droughts, while only the soil drought occurred in 2002 [Szajda *et al*. 2007, Łabędzki and Leśny 2008]. Weaker at present dynamics of water level oscillations mainly results from poor technical condition of melioration ditches that, not conserved, are overgrown with plants.

Plant communities were another habitat component that was analysed. Performed analyses revealed that uniform communities of *Holocetum lanati*, *Deschamsietum caespitosae*, and *Juncetum effusi* appeared on waste part of the object. Thus, total hay yield from control plots was 42 $dt \cdot ha^{-1}$, whereas on intensively performed meadows it amounted to 120 $dt \cdot ha^{-1}$ [Jankowska and Za-

stawny 2003]. Moreover, the hay was characterised by very poor nutritive value resulting from large content of weeds and short grass species. Giving up mineral fertilisation is the main reason for bad condition of grasslands.

In spite of economic abandonment of the use of meadows on the examined object, phenomena of denaturalisation of wetland restoration did not appear. This fact results from periodical exaggerated lowering of the mirror of groundwater to the depth of the over 70 cm. As a result of this phenomenon, a demotion followed, both of the ecological and of the production advantages. Hence the need for agricultural-environmental programs that will link the requirements of balanced farming harmoniously with local re-naturalisation of wetlands and enrichment biodiversity.

CONCLUSIONS

All performed analyses permitted the formulation of the following conclusions:

1. Water management on peats should tend to balanced development of those areas by creating air and water conditions favourable for agricultural production as well as maintaining and protecting natural resources.

2. Due to the area dehydration, peat was lowered at the rate of 7 mm annually, with associated changes in soil physical properties. Thus, specific and volume densities and ash content increased, while porosity decreased.

3. Changes of pratotechnics level, mainly intensity of performance, contributed to disappearance of valuable grass species and succession of *Deschamsietum caespitosae* associations with considerable percentage of weeds.

4. Influence of improper performance of meadow ecosystems under conditions of satisfactory plant supply with water was indicated by lower yields and simplification of botanical composition of meadow sward. Protecting these areas against devastation is naturally, economically, and ecologically justified.

5. In spite of economic abandonment of the use of meadows on the examined object, the phenomena of denaturalisation of wetland restoration did not appear. Hence the need for agricultural-environmental programs that will link the requirements of balanced farming harmoniously with local re-naturalisation of wetlands and enrichment biodiversity.

REFERENCES

Baryła R., 2001. Changes of meadow sward species composition in post-bog habitat (synthesis of 30-year studies carried out in Sosnowica (Wieprz-Krzna Canal region) (in Polish). Annales UMCS, sec. E, 56, 65–76.

Borowiec S., 1990. Peat areas of Lublin region (in Polish). LTN.

Chmielewski T.J. 2001. Łęczna-Włodawa Lakeland: transformation of landscape ecological structure and the rules of spatial management. Monographs of the Environmental Engineering Committee, Polish Academy of Sciences in Lublin, vol. 4, pp. 146.

Grzywna A., 2005. Air and water systems as well as yielding of meliorated meadows in river Piwonia valley (in Polish). Acta Agrophysica, 5 (2), 283–290.

Grzywna A., Szajda J., 2006. Transformations due to melioration in organic soils of river Piwonia valley (in Polish). Soil Sci. Annals, 42, 1/2, 93–98.

Jankowska-Huflejt H., Zastawny J., 2003. Opportunities to improve the efficiency of grassland utilization in Poland (in Polish). Wiad. Mel. Łąk., 3, 160–163.

Jurczuk S., 2000. Influence of water system regulation on lowering and mineralisation of organic soils (in Polish). Bibl. Wiad. IMUZ, 96, 120.

Kozłowska T., 2004. Condition and opportunities to improve meliorated and wasted grasslands (in Polish). Wiad. Mel. Łąk., 4, 186–190.

Kryszak A., Grynia M., Kryszak J., 2004. Important directions of meadow succession on anthropogenically transformed areas in river Barycz valley (in Polish). Soil Sci. Annals, 40, 2, 259–268.

Łabędzki L, Leśny J., 2008. Effects of drought in agriculture – present and predicted associated with global climatic changes (in Polish). Wiad. Mel. Łak., 1, 7–9.

Nazaruk M., Pawluśkiewicz B., 2001. Meadow and pasture as a source of ecological and cheap fodder for cattle (in Polish). Wiad. Mel. Łąk., 2, 67–71.

Nyc K., 2001. Ecological importance of water management on grasslands (in Polish). Wiad. Mel. Łąk., 3, 106–110.

Okruszko H., Piaścik H., 1990. Characteristics of hydrogenic soils (in Polish). ART Olsztyn.

Statistical Annals of Main Statistical Office. 2006. Environment Protection.

Szajda J., 1980. Elaboration of method for irrigation predicting under conditions of shallow ground water level (in Polish). Manuscript, IMUZ Lublin, pp. 50.

Zawadzki S., 1973. Laboratory determination of retention ability of soil forms (in Polish). Wiad. IMUZ, 11, 2, 11–31.

FUNKCJONOWANIE EKOSYSTEMÓW ŁĄKOWYCH W DOLINIE RZEKI PIWONII 40 LAT PO JEJ ODWODNIENIU

Streszczenie. Celem pracy jest ocena funkcjonowania ekosystemu łąkowego, stosunków powietrzno-wodnych i zachodzących przemian glebowych w dolinie rzeki Piwonia 40 lat po jej odwodnieniu. Podstawę pracy stanowią badania hydrogeologiczne przeprowadzone w latach 1974 i 2005 oraz stosunków wodnych w suchych latach 1976 i 2002 na Polesiu Lubelskim w Sosnowicy, na użytkach zielonych zmeliorowanych i zagospodarowanych w latach 1963–1965, a obecnie niewłaściwie użytkowanych. Zmiana stosunków wodnych oraz intensyfikacja produkcji, a następnie zaniechanie użytkowania przyczyniały się do kształtowania innych komponentów siedliska. W następstwie odwodnienia nastąpiło osiadanie powierzchni terenu, mineralizacja masy organicznej oraz wzrost gęstości objętościowej i popielności oraz zmniejszenie porowatości gleb. Wpływ niewłaściwego użytkowania w warunkach optymalnego uwilgotnienia gleby przyczynił się do zanikania wartościowych gatunków traw i sukcesji asocjacji *Deschampsietum caespitosae* ze znacznym udziałem chwastów oraz spadkiem plonowania i uproszczeniem składu botanicznego runi łąkowej.

Słowa kluczowe: stosunki wodne, degradacja gleb, plonowanie roślin, zbiorowiska roślinne