JOURNAL OF WATER AND LAND DEVELOPMENT
J. Water Land Dev. 2012, No. 17 (VII–XII): 69–76
PL ISSN 1429–7426
Available (PDF): www.itep.edu.pl/wydawnictwo; http://versita.com/jwld/

Received 01.10.2012
Reviewed 08.11.2012
Accepted 12.11.2012
A – study design
B – data collection
C – statistical analysis
D – data interpretation
E – manuscript preparation
F – literature search

Physiographic factors affecting the stratigraphy of peat deposits in the Lower Basin of the Biebrza River

Henryk JAROS ABCDEF

Białystok University of Technology, Faculty of Basic Building Construction and Building Physics. Wiejska str. 45E, 15-351 Białystok, Poland, e-mail: henrykjaros@poczta.onet.pl

For citation: Jaros H. 2012. Physiographic factors affecting the stratigraphy of peat deposits in the Lower Basin of the Biebrza River. Journal of Water and Land Development. No. 17 p. 69–76

Abstract

Analyses of water conditions in the Lower Basin of the Biebrza River and deposit stratigraphy were conducted in cross-sections through the valley, where geodetic measurements were also made. Peat type in particular layers of the soil profile was determined in selected cross-sections at 100 m intervals. The Lower Basin of the Biebrza River is diverse with regard to the type of water supply to a peatbog, the shape of the bio-accumulative basin's bottom and the slope of peatbog surface along and across the valley. These factors resulted in the development of different habitats in the peatbog.

Northern part of the Lower Basin, between the main road in the village Osowiec and the inflows of the Kosódka and Wissa rivers to the Biebrza River, is a narrow valley supplied mainly with overflowing water of the Biebrza River. Habitats and hydrogenic deposits of this area developed in relation to the type and layout of mineral substratum and to the duration and depth of seasonal flooding.

North-west part is mainly supplied by ground water from the adjacent upland. Peat layers, developed on ground waters flowing out from the upland, markedly slope toward the bed of the Biebrza River. Considerable fluctuations of the ground water level can be observed there and most frequently the sites are periodically drying. Part of the valley, from the inflows of the Kosódka and Wissa rivers down to the Biebrza and Narew River confluence, is mainly supplied with underground waters from upland.

Key words: *cross-section, difference in elevation, natural slope of the ground, plant community, water inflow*

INTRODUCTION

Habitats with water-related plant communities develop in river valleys [OŚWIT 1991]. Habitats diversify depending on the relation between soil moisture and oxygen conditions, the appearance and duration of seasonal floods and on the water and soil trophic status. Prevalence of a particular factor over the others decides upon the development of a certain habitat type [OKRUSZKO 1991]. Bogging process takes place under condition of anaerobiosis. Aerobic – anaerobic system with siltation develops in seasonally flooded areas. On elevated areas more distant from the river bed, aerobiosis is accompanied by humification. The areas with hydrogenic deposits of various moisture develop there, such as silted and muddy lakes overgrowing by plants. Seasonally flooded areas are supplied with waters rich in dissolved mineral compounds and this is the factor decisive for the development of certain plant communities and types of peat [OKRUSZKO 1988].

Upland, depending on the type of deposits and their stratigraphy, supplies the valley with waters [BANASZUK 2004]. Wet, moist and periodically dry sites develop during the supply of deposit with gravitation waters from the upland. At permanently high level of ground waters, wet, moist, periodically dry and infiltration sites may develop. The river water determines the development of particular habitats alongside the river bed. The range of its impact depends on the river regime and its hydrological and hydrographical parameters [BYCZKOWSKI 2004]. Infiltration wet, moist, periodically dry and infiltration dry sites will develop in the zone of river flooding. The shape of mineral substratum under peat deposit as well as the layout of peatbog surface and slopes of the ground along and across the valley determine the development of plant communities and consequently, the type of peat [WASSEN *et al.* 2002]. Ground slopes enforce water flow or its stagnation in certain areas. They also decide upon the movement of rainfall water that supplies fragments of the area or flows down to the recipient [JAROS 2004a, b]. Diversified layout of mineral substratum under peat deposit decides upon the development of local standing waters or makes underground water from the upland flow under a deposit toward the recipient, supplying it with various intensity [STREEFKERK, CASPARIE 1992].

METHODS

The studies on the stratigraphy of peat deposit in the Lower Basin of the Biebrza River were carried out in 26 cross-sections throughout the valley established by the Institute of Land Reclamation and Grassland Farming (IMUZ) with geodetic measurements of the ground surface and determination of plant communities. The author carried out the study on deposit stratigraphy by drilling in sites at 100 m intervals down to the bed of the basin's bottom. The peat type was determined with a macroscopic method – according to the norm [PN-G-02500:1985]. In case of difficulties with the classification of a peat type, samples were taken and the peat type was determined by a microscopic method [TOBOLSKI 2000].

Local slopes of the ground and their elevation were determined for larger homogenous areas. Geodetic materials prepared by IMUZ were used to calculate land slopes. The analysis of slopes at the valley's edges and near the Bebrza River's bed was significant for the determination of areas that could be supplied with surface waters during spring floods.

Transversal and longitudinal slopes of the land indicate water movement on peat surface, which affects oxygen conditions of peatbog and the development of plant communities that reflect habitat conditions. The results were described for selected characteristic cross-sections, illustrating the stratigraphy and water supply in larger areas of the valley (Fig. 1).

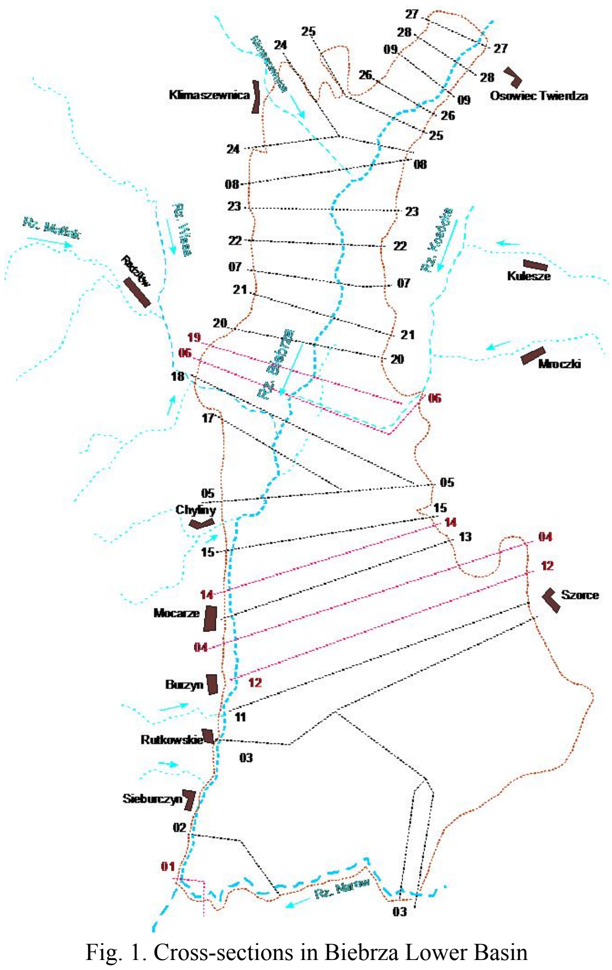

Fig. 1. Cross-sections in Biebrza Lower Basin

RESULTS

Northern part of the Lower Basin located near the Białystok–Grajewo road, close to the village of Osowiec is supplied with waters of the Biebrza River and of the Rudzki Canal (cross-section No. 1). During spring and autumn the overflowing waters of both rivers result in large flooding. The land surface is strongly diversified by erosion-accumulation activity. It is hard to establish the slopes of the ground because of their frequent and significant variation in values and directions. They vary from 0.02% to 0.03%. Differences in elevation (Rh) between the edges of ground hollows filled with hydrogenic deposits are not big in selected parts of the cross-section and vary from 0.1 m to 0.5 m. Significant denivelations can be observed in the area of the basin. Particular hollows filled with hydrogenic deposits can be found at different altitudes. This area is mainly covered by communities of *Caricetum gracilis* (Fig. 2).

There are shallow hydrogenic, silt and silted mucky, deposits 20–50 cm thick in this area (Fig. 2). Noteworthy, thin layers of the deposits are parallel to the ground surface which is a proof of a highly dynamic moisturising of the area. Shallow hydrogenic deposits are covered by incidentally flooded drying sites (ZC), flooded dry sites (ZD) and flooded, periodically dry sites (ZCD). The supply of underground waters from the upland is visible in the cross-section No. 4 in a river-bank part of the valley. This is reflected in the development of wedge-shaped peat layers that start from the valley edges and gradually disappear toward the river (Fig. 3). Steep land slopes (0.15–0.16%) and differences in elevation (from 0.9 m to 1.5 m) prove the input of waters from surrounding areas to this deposit. Central part of the valley presented in the cross-section No. 4 is subjected to strong flooding impact of the Biebrza River. However, steep slopes of the land cause a rapid water runoff and large fluctuations of ground water levels. Silt deposits develop under such moisture-air conditions.

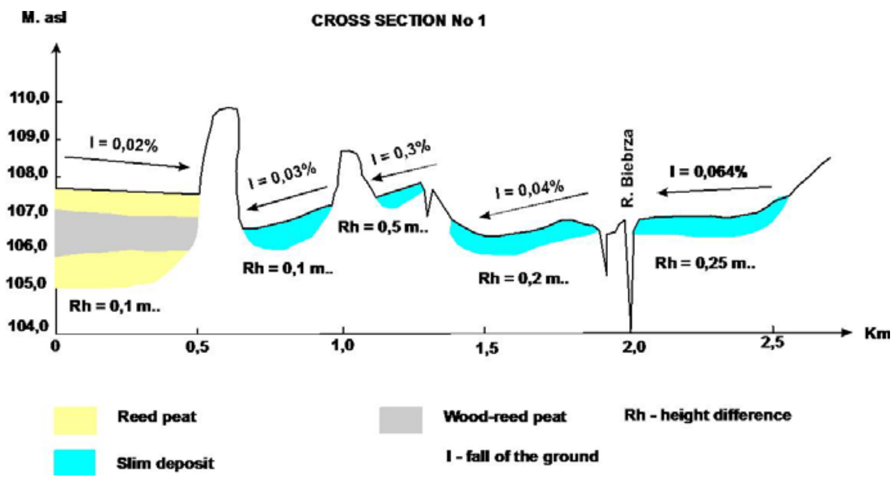

Fig. 2. Cross section no. 1

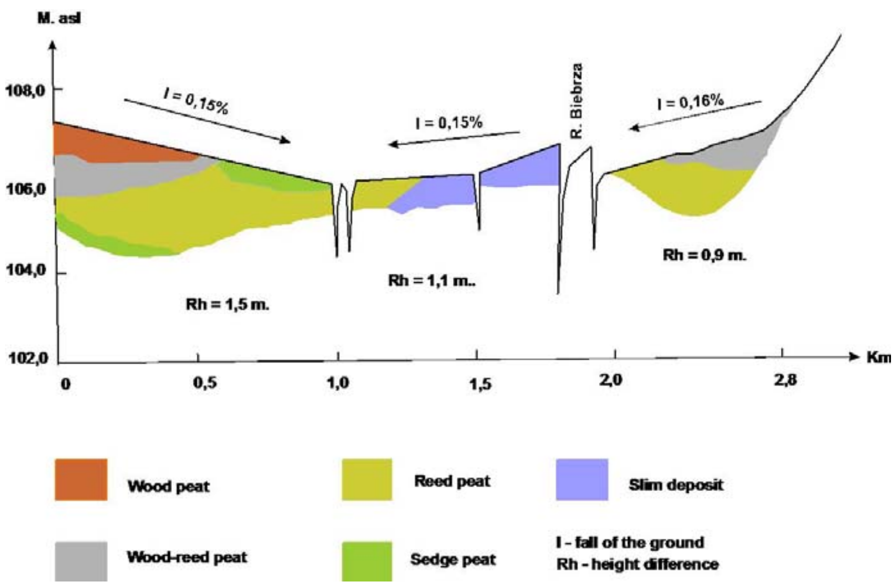

Fig. 3. Cross section no. 4

Fluviogenic supply can be observed exclusively in the cross-section No. 6. A small local supply of a narrow strip of hydrogenic soils with surface runoff is visible in the eastern part of the valley at the bottom of a mineral scarp. Peat deposit in its main mass is homogenous with a small slope of the ground (from 0.06% to 0.3%) directed toward the river-bed. The difference in elevation (Rh) in some areas is about 1 m.

Local hollows of mineral substratum are filled with organic deposits that create flat, almost horizontal surface of layers building the soil profile and levelling the peatbog surface. This is a characteristic feature of flooded marshes. An average thickness of peats is 1 m. Diversified ground surface can be observed in the region of the Klimaszewnica River. This results from a network of drainage ditches built earlier and still pending the process of sedimentation and peat thickening. The peat thickness in this area is diversified accordingly. In areas with thicker peat deposits and more intensive water supply there are potential wet flooded habitats (WB) while shallower soils form potential flooded dry sites (WC). The area is overgrown by *Magnocaricion* and *Phragmition* communities (Fig. 4).

The area presented in the cross-section No. 12 is characterised by a variety of peat types, that appear at different depths of soil profile and in particular land hollows in the cross-section through the valley. The stratigraphic deposit structure is diversified and, therefore, it is difficult to definitely determine the historical changes of water conditions of the area and the type of surface and underground water supply. In western part from the upland side, a supply with underground waters can be observed at a distance of 1000 m. Its impact is visible in characteristic wedge-shaped peat layers in the deposit. From the river side it is overlapped by the development of peat deposits characteristic for fluviogenic supply. This is a zone of peat developed as a result of combined soligenic and

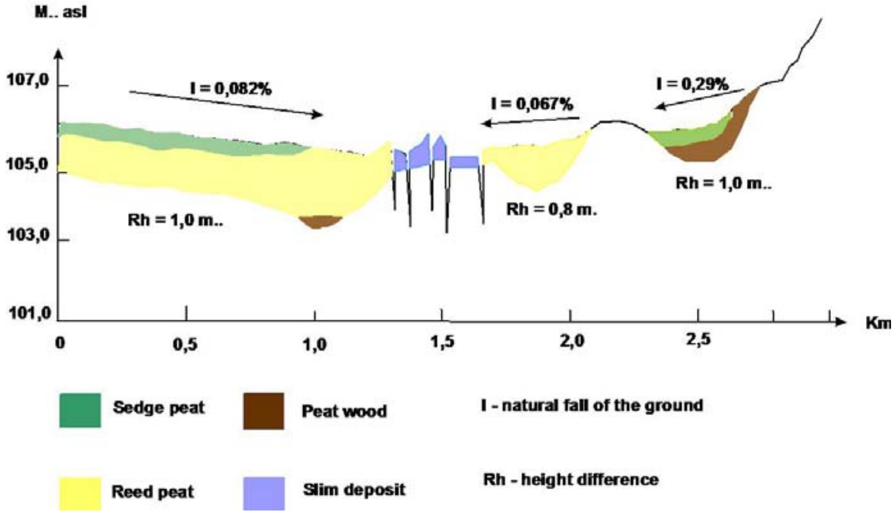

Fig. 4. Cross section no. 6

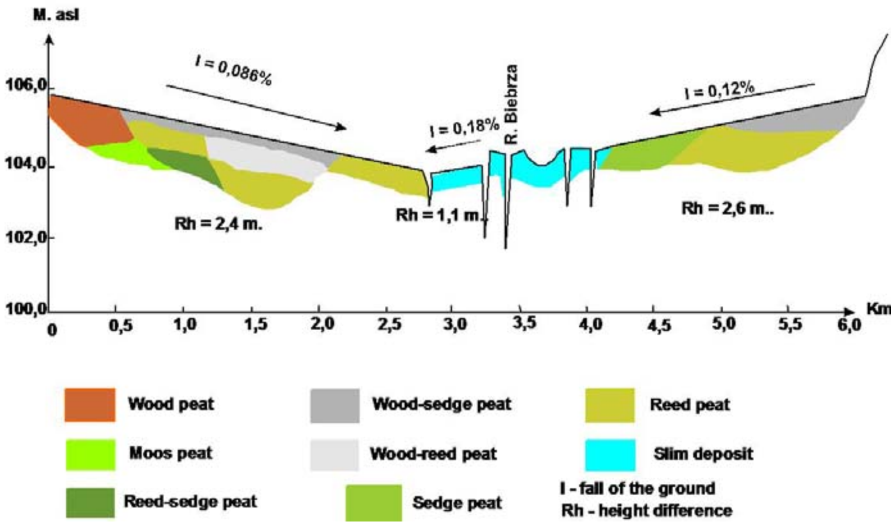

Fig. 5. Cross section no. 12

fluviogenic supply. In the vicinity of the river the fluviogenic supply caused the development of one type of peat (Fig. 5). The area of old river-beds is covered by silt deposits.

In this part of peat deposit there is a small slope of the ground (0.09% to 0.18%) that suggests a possibility of fluviogenic water supply. This type of water supplyis not, however, possible across the entire width of the valley, which is evidenced by differences in elevation (Rh) from 1.1 m to 2.6 m. Probably, this is a combined system of both types of water supply. The deposit thickness varies from 1 to 1.5 m. The east part of the valley is also difficult for a definite classification. The impact of ground waters from the upland and a visible influence of the Biebrza flooding can be observed there.

It is also difficult to unequivocally classify the eastern part of the valley. The impact of ground waters from the upland is visible there together with a clear influence of the Biebrza overflows. The land slope in the river-bed zone is about 0.035% suggesting possible supply of this area with river waters. The thickness of peat and other hydrogenic deposits is slightly thinner there and varies from 0.5 m to 1.5 m. Potential flooded periodically dry (ZBC) and dry (ZD) sites developed there. In part of the valley supplied by ground waters from the upland, effluent drying sites (WC) and effluent periodically dry sites (WCD) developed. This area is covered by plants of the alliance *Alnion glutinosae* in the edge part of the valley and by the associations of *Magnocaricion*, *Phragmition* and *Caricion Canescenti fuscae*.

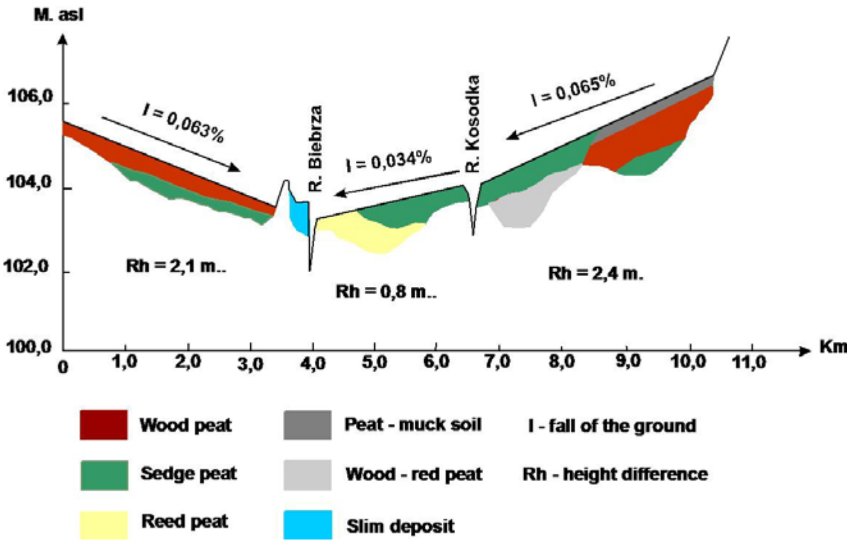

Fig. 6. Cross-section no. 14

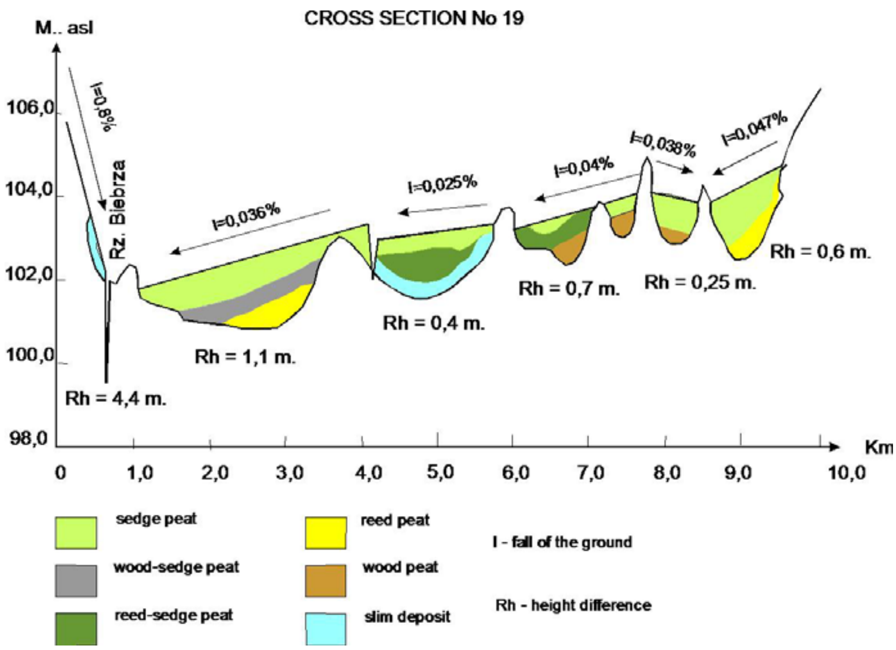

Fig. 7. Cross section no. 19

Hydro-ecological conditions similar to those described in the cross-section No. 12 appear also in the cross-section No. 14. In the eastern part, one can observe a clear supply with waters from the upland reflected in stratigraphy and a steep slope of the ground (about 0.065%). The deposit stratigraphy in this part of the valley shows that the Kosodka River crossing the area exerts no significant effect on the development of particular peat types. The decisive factors are water supply from the upland and slopes of the ground. The Kosodka River is only a transmitter for underground water flow and exerts no impact on the deposit stratigraphy.

Peat deposit in the region of the cross-section No. 19 consists of a series of individual ground hollows filled with hydrogenic deposits. These are peatbogs of small thickness separated from each other by shallows or elevations of mineral soils. The overall land slope in that part of peatbog is diverse and in its eastern part there is a slope falling in opposite direction to the general slope of the valley. The eastern part of the deposit is visible in a form of two ground hollows filled mainly with sedge peat that appears within nearly the whole thickness of the soil profile. At the deposit's bottom of this part of the peatbog, there is wood peat and reed peat of small thickness. This part of the deposit is clearly different from the remaining part. The next four ground hollows toward the Biebrza River show the features of underground water supplies. This is reflected in a leaning structure of peat layers, parallel to the ground surface. The impact of the Biebrza River on the development of this part of peatbog is very little and can affect only the area adjacent to the river-bed. Such an influence can be observed during wet years, when flooding of the Biebrza River is large and deep (Fig. 7).

DISCUSSION

The Lower Basin of the Biebrza Valley is diversified with respect to the types of water supply within wetland sites. It results from shape and size of the valley, from the layout of substratum under the bottom of peat deposit, the layout and slopes of the ground surface and from supplies with overflows of the Biebrza River and with underground waters from the upland. Northern part of the basin, from the main road in Osowiec to the inflows of the Kosódka and Wissa rivers to the Biebrza River, is a narrow valley mainly supplied by overflowing water of the Biebrza River. The water, site conditions and the layout of land is characterised by the cross-section No. 1. The development of hydrogenic deposits depends on the Biebrza River waters.

Supplying the edges of the valley with underground waters can be seen in cross-section No. 4. It takes place in the eastern and western parts of the valley. The river overflows do not appear in these areas due to significant slopes of the ground (about 0.15%) and the differences in elevation exceeding 1 m. Changing inflow causes the fluctuations of underground water level and site moisture. Central part of the valley is influenced by the Biebrza water supplies and by those from higher areas.

Near the discharge of the Klimaszewica River, the difference in elevations (Rh) in the western part of the valley is 1m, therefore, the whole area can be flooded during larger floods (cross-section No. 6). A soligenic supply can be seen in the eastern part of the valley, in the area adjacent to the upland. The narrow land strip adjacent to the Biebrza river-bed is affected by river waters. Limnetic siltation, silt-covered lands and silt deposits develop there in old river-beds and waterholes. In the valley part represented by the cross-section No. 12, the valley is 6 km wide, while in the cross-section No. 14 its width exceeds 10 km and gradually expands towards the southern end of the basin.

In part of the valley presented in cross-sections No. 12 and 14, the supply of peat deposit with waters from the upland is clearly visible. The river impact on the development of hydrogenic deposits manifests itself only in the narrow land strip along the Biebrza River. Differences in elevation (Rh) between the area near the river-bed and the valley edges are between 2 and 3 m, therefore, flooding with the Biebrza waters is impossible there.

Southern part of the Lower Basin of the Biebrza River is diversified with respect to stratigraphy, land slopes and is not a homogeneous complex of peat deposits. It consists of a number of land hollows, filled with hydrogenic deposits, separated from each other by local land elevations. The supply of peat deposits with waters from the upland can be seen in the whole width of the valley. This is reflected in a layout of peat layers in land hollows and in the location of particular troughs filled with peat in relation to each other and to the ordinate of the Biebrza River.

CONCLUSIONS

1. The Biebrza River flooding shapes water conditions in the narrow, northern part of the basin mainly filled with shallow silt deposits of substratum diverse in the layout and ground slopes frequently directed from the river-bed toward the valley.

2. The Biebrza waters shape water conditions in areas near the river bed down to the confluence of the Biebrza and the Narew River. The river waters affect the narrow land strip adjacent to the river-bed, old river-beds and waterholes. Siltations, silt-covered lands and silt deposits developed there.

3. In central part of the basin, peat deposit is supplied mainly with waters from the upland. This is reflected in wedge-shaped layout of peat layers, whose thickness gradually decrease and disappear.

Steep slopes of the ground directed toward the Biebrza river-bed are situated in this part of the valley. Local ground hollows under the deposit bottom are usually filled with different types of peat, which results from periodical isolation of stagnant water bodies that promote the development of different peat forming communities.

4. Parts of the area characterised by small slopes of the ground surface have relatively flat mineral substratum with mixed type of supply with waters coming from the upland and surface waters retained from overflows and precipitations.

5. Soligenous supply of wetland sites prevail in the southern part of the Lower Basin down to the confluence of the Biebrza and Narew rivers. This part of peatbog is characterised by numerous local hollows of peat substratum that create a number of peat deposits separated by small local dry-ground forests or just being filled with organic deposits.

REFERENCES

BANASZUK H. 2004. Geologia i geomorfologia Kotliny Biebrzańskiej. W: Kotlina Biebrzańska i Biebrzański Park Narodowy: aktualny stan, walory, zagrożenia i potrzeby czynnej ochrony środowiska. Monografia przyrodnicza [Geology and geomorphology of the Biebrza Valley. In: The Biebrza Valley and the Biebrza National Park. Biological monograph]. Ed. H. Banaszuk. Białystok. Wydaw. Ekonomia i Środowisko.

BYCZKOWSKI A., FAL B. 2004. Wody Kotliny Biebrzańskiej. W: Kotlina Biebrzańska i Biebrzański Park Narodowy: aktualny stan, walory, zagrożenia i potrzeby czynnej ochrony środowiska. Monografia przyrodnicza [Waters of the Biebrza Valley. In: The Biebrza Valley and the Biebrza National Park. Biological monograph]. Ed. H. Banaszuk. Białystok. Wydaw. Ekonomia i Środowisko p. 113–182.

JAROS H. 2004a. Gleby hydrogeniczne w Basenie Biebrzy Dolnej. W: Kotlina Biebrzańska i Biebrzański Park Narodowy: aktualny stan, walory, zagrożenia i potrzeby czynnej ochrony środowiska. Monografia przyrodnicza [Hydrogenic soils in the Lower Biebrza Basin. In: The Biebrza Valley and the Biebrza National Park. Biological monograph]. Ed. H. Banaszuk. Białystok. Wydaw. Ekonomia i Środowisko p. 286–292.

JAROS H. 2004b. Hydrogeniczne siedliska glebotwórcze w Basenie Dolnej Biebrzy. W: Kotlina Biebrzańska i Biebrzański Park Narodowy: aktualny stan, walory, zagrożenia i potrzeby czynnej ochrony środowiska. Monografia przyrodnicza [Hydrogenic soil-forming habitats in the Basin of the Lower Biebrza River. In: The Biebrza Valley and the Biebrza National Park. Biological monograph]. Ed. H. Banaszuk. Białystok. Wydaw. Ekonomia i Środowisko p. 308–313.

MATUSZKIEWICZ W. 2001. Przewodnik do oznaczania zbiorowisk roślinnych Polski [A guide for the determination of plant communities of Poland]. Warszawa. Wydaw. Nauk. PWN. ISBN 83-01-13520-4 pp. 536.

OKRUSZKO H. 1988. Zasady podziału gleb hydrogenicznych na rodzaje oraz łączenie rodzajów w kompleksy [Principles of the division of hydrogenic soils into kinds and coupling kinds in complexes]. Roczniki Gleboznawcze. T. 39. Z. 1 p. 127–152.

OKRUSZKO H. 1991. Rodzaje mokradeł w Pradolinie Biebrzy [Types of wetlands in the Biebrza Valley]. Zeszyty Problemowe Postępów Nauk Rolniczych. Z. 372 p. 163–184.

OŚWIT J. 1968. Zonal arrangement of plant communities as a reproduction of water conditions in the lower Biebrza River Valley. Zeszyty Problemowe Postępów Nauk Rolniczych. Z. 83 p. 217–232.

OŚWIT J. 1991. Budowa, geneza i rozwój torfowisk pradolinnych Biebrzy [Structure, origin and development of peatbogs in the Biebrza Valley]. Zeszyty Problemowe Postępów Nauk Rolniczych. Z. 372 p. 185–218.

PN-G-02500: 1985. Oznaczenie gatunku torfu [Polish norm, determination of peat type]. Warszawa. PKNiJ.

STREEFKERK J.G., CASPARIE W.A. 1992. The hydrology of bog ecosystems. Wydaw. Staatsbosbeheer 2nd ed.

TOBOLSKI K. 2000. Przewodnik do oznaczania torfów i osadów jeziornych [A guide for the determination of peat and lake sediments]. Warszawa. Wydaw. Nauk. PWN. ISBN 8301132159 pp. 508.

WASSEN M.J., BLEUTEN W., BOOTSMA M.C. 2002a. Linking hydrology to ecology: Biebrza as a geographical reference. Annals of Warsaw Agricultural University. Vol. 33 p. 27–47.

WASSEN M.J., PEETERS W.H.M., OLDE VENTERINK H. 2002b. Patterns in vegetation, hydrology and nutrient availability in an undisturbed river floodplain in Poland. Plant Ecology. Vol. 165 p. 27–43.

Henryk JAROS

Czynniki fizjograficzne wpływające na stratygrafię złoża torfu w Dolnym Basenie Doliny Biebrzy

STRESZCZENIE

Słowa kluczowe: *dopływ wód, naturalny spadek terenu, przekrój poprzeczny, różnica wysokości, zbiorowisko roślinne*

Analizę warunków wodnych w Dolnym Basenie Doliny Biebrzy i stratygrafii złoża przeprowadzono na przekrojach poprzecznych przez dolinę, na których wykonane zostały także pomiary geodezyjne. Na wytyczonych przekrojach wykonano oznaczenia rodzaju torfów występujących w poszczególnych warstwach profilu glebowego w punktach odległych od siebie o ok. 100 m. Dolny Basen Doliny Biebrzy jest zróżnicowany pod względem rodzajów zasilania torfowiska wodami, ukształtowania dna spągu basenu bioakumulacyjnego i spad-

ków powierzchni torfowiska wzdłuż i w poprzek doliny. Czynniki te powodują wykształcenie różnych siedlisk na torfowisku.

Część północna Basenu Dolnego, od trasy komunikacyjnej w Osowcu do ujścia rzek Kosódka i Wissa do Biebrzy, jest wąską doliną, którą zasilają głównie wylewające wody Biebrzy. Siedliska i utwory hydrogeniczne tego terenu wykształciły się zależnie od rodzaju i ukształtowania mineralnego podłoża oraz czasu trwania i głębokości zalewu.

W części północno-zachodniej dominuje zasilanie wodami podziemnymi z przyległej wysoczyzny. Warstwy torfu wytworzonego na wypływających z wysoczyzny wodach podziemnych posiadają znaczne spadki, skierowane do koryta Biebrzy. Występują tu znaczne wahania poziomów wody gruntowej i są to najczęściej siedliska okresowo przesychające. Na odcinku doliny, od ujścia Kosódki i Wissy do Biebrzy do połączenia Biebrzy i Narwi, przeważa zasilanie wodami podziemnymi z wysoczyzny.