www.czasopisma.pan.pl PAN POLSKA AKADEMIA NAUK www.journals.pan.pl

Teka Kom. Ochr. Kszt. Środ. Przyr. – OL PAN, 2016, 13, 130–137

SHALLOW GROUNDWATERS OF THE POLESIE NATIONAL PARK IN THE PERIOD FOLLOWING INTENSIFIED RAINFALL ALIMENTATION

Marek Turczyński, Katarzyna Mięsiak-Wójcik, Joanna Sposób, Stanisław Chmiel, Sławomir Głowacki, Justyna Janusz-Emerla

Department of Hydrology, Maria Curie-Skłodowska University, Kraśnicka av. 2 cd, 20-718 Lublin
e-mail: turmar@poczta.umcs.lublin.pl, katarzyna.miesiakwojcik@poczta.umcs.lublin.pl, joanna.sposob@poczta.umcs.lublin.pl, stanislaw.chmiel@poczta.umcs.lublin.pl, slawek.glowacki@poczta.umcs.lublin.pl, justyna.janusz@poczta.umcs.lublin.pl

Abstract. The paper presents the characteristics of shallow groundwaters of the Polesie National Park – one of five national parks in Poland, where main subjects of protection are water-peatland ecosystems. Its functioning depends on the state of water resources. Data from field mapping at the turn of July and August 2013 used for the analysis show untypically high location of groundwaters in the summer period. Such a situation was caused by abundant atmospheric alimentation that occurred in spring and early summer of the analysed year.

Key words: Polesie National Park, groundwaters, hydrogenic areas

INTRODUCTION

The Polesie National Park is located in the eastern part of the Lublin voivodship. In accordance with the physiographic division of the Lublin voivodship by A. Chałubińska and T. Wilgat [1954], a major part of the study area is located in the Łęczna-Włodawa Lake District, constituting a part of the Polesie Lubelskie region. Only its southern areas belong to the Chełm Hills region, included in the Lublin Upland [Wilgat 1961]. In hydrographic terms, the area of the Park is located in the catchment of the Vistula River, in the zone of the 2nd order watershed separating catchments of the Wieprz and Bug River [Map of Hydrographic Division of Poland 1 : 10 000]. According to the Hydrogeological Atlas of Poland [Paczyński 1995], the discussed area is located within the IX Lublin-Podlasie hydrogeological region.

www.czasopisma.pan.pl PAN POLSKA AKADEMIA NAUK www.journals.pan.pl

The conditions of occurrence and circulation of water in catchments of the Polesie National Park are determined by particular components of the natural environment, with the geological structure, land relief, and climatic conditions representing the highest importance [Michalczyk *et al*. 2004, Kulik and Baryła 2010, Michalczyk *et al*. 2010].

The climatic conditions of the area are usually determined by the polar-marine air masses bringing cooling and precipitation in summer. Approximately 140 cloudy days, 44 sunny days, and 140 days with precipitation occur on average in a year, including approximately 90 days with precipitation equal or higher than 1 mm. Summer precipitation predominates in a year over winter precipitation. It constitutes approximately 40% of total precipitation. Approximately 15% of the amount of atmospheric alimentation is accounted for snowfall, developing snow cover persisting for 72–77 days in a year [Kaszewski 2002]. Annual precipitation totals are variable, but in the area of the Park they do not exceed 575 mm. The highest values are recorded in the northern part of the analysed area in the vicinity of Pieszowola (573 mm), and the lowest in Garbatówka (521 mm). The highest precipitation occurs in July (77–82 mm), and the lowest in January and February (25–32 mm).

Mean annual air temperature for the Polesie National Park amounts to 7.3°C, and its annual amplitude reaches almost 23°C. It is among the highest values in Poland, and suggests a high degree of continentalism [Kaszewski 2002]. Potential evapotranspiration from meadow areas exceeds 600 mm in the vegetative season, and that from higher-located areas is estimated for 450 mm.

The inconsiderable hypsometric diversity of the Park, its geological structure, and weak drainage system determine shallow occurrence of groundwaters. The first aquifer is particularly composed of sandy and organic formations (peats, gyttjas) with underlying impermeable or weakly permeable loams, silts, and glacial tills. In areas of shallow occurrence of Cretaceous formations, impermeable layers are constituted by marl insertion. In a major part of the Park, located in the area of the Holocene accumulation plain, the water table is located at a depth of not less than 1 m [Wilgat *et al*. 1984]. Within denudation plains, the thickness of the aeration zone amounts to 2–3 m. Only in the highest located parts of the Park, within denudation monadrocks, the depth of occurrence of groundwaters exceeds 5 m (max. of approximately 12–14 m). The groundwaters are predominantly unconfined. Their confined character was only recorded in areas of deeper occurrence (waters of the Cretaceous aquifer) [Michalczyk *et al*. 2003a, 2004, 2010].

The analysis of groundwater table fluctuations in the Polesie National Park shows evident seasonal rhythm. At the beginning of the hydrological year, in the autumn period, considerable decreases of the water level below average are observed, related to the exhaustion of water resources in the period of intensified evapotranspiration in summer. An increase in retention is recorded from

www.czasopisma.pan.pl PAN POLSKA AKADEMIA NAUK www.journals.pan.pl

April to May, when the highest levels of groundwaters are observed. Their rapid decrease occurs in the following months, maintained until the autumn minimum. Intensive rainfall occurring in the summer period can temporarily inhibit the decreasing tendency [Michalczyk *et al*. 2004].

The surface water network of the Polesie National Park is developed by rivers (Piwonia, Piwonia Górna, Piwonia Dolna, Włodawka, Mietiułka, and Bobryk), melioration ditches and conducting canals, lakes (Łukie, Karaśne, Moszne, and Długie), ponds (Pieszowolskie and Bruskie), and peat-pits. Melioration works conducted in the Polesie region for several centuries, and intensified over the last hundred years (system of the Wieprz-Krzna Canal) resulted in a strong transformation of the poor natural fluvial network, and multiple deepening and straightening of river channels [Michalczyk *et al*. 1993, 2002]. An important element of the water network of the Park is also constituted by permanent and temporary wetlands which frequently determine the functioning of rivers [Michalczyk *et al*. 2003b]. The largest of such compact areas include: Bubnów Swamp, Staw Swamp, Durne Swamp, and Orłowskie Peatland.

The objective of the paper is to present the location of the shallow groundwater table in the Polesie National Park in the period of untypically high alimentation of the groundwater resources.

MATERIAL AND METHODS

The analysis of groundwater resources was performed based on measurements of dug wells (depth to the groundwater table and to the bottom) in the Park. Field mapping at the turn of July and August 2013 covered registration of 200 control points. The research was conducted in the period of relatively untypical as for the summer season, high location of the groundwater table. It was caused by very abundant atmospheric alimentation in the months preceding the field mapping, namely in May and June. The precipitation total for the two months in 2013 amounted to 237 mm, whereas the two-month mean from the period 2005–2013 amounted to 162 mm [www.tutiempo.net/en/Climate/WLODAWA].

Based on well measurements, maps of the state of groundwaters were prepared at a scale of 1 : 10000: groundwater table contour map presenting the development of groundwater table, and hydroisobath (groundwater table depth) map presenting the thickness of the aeration zone. The map provided the basis for the determination of the direction of flow of groundwaters, and designation of their watersheds. The hydroisobath map permitted among others the identification of potential threats related to drying of peatland areas.

www.czasopisma.pan.pl PAN POLSKA AKADEMIA NAUK www.journals.pan.pl

RESULTS AND DISCUSSION

Results of the research conducted in the Polesie National Park showed that the groundwater table of the first exploited aquifer corresponds with the topographic surface. The area is distinguished by very shallow occurrence of groundwaters. In the Park, the contribution of areas saturated with water, covered by a hydroisobath of 1 m, amounts to almost 90% (Table 1, Fig. 1). Areas with groundwaters occurring at a depth higher than 1 m occupy 10.168 km^2 (13.4% of the area of the Park) in the northern part of the Park, and 2.195 km^2 (10% of the area of the Park) in its southern part.

Table 1. The share of shallow groundwaters in the area of Polesie National Park in summer season 2013

Areas/parts of Park	Northern		Southern	
	km^2	%	km^2	%
Area surrounded by groundwater depth contour 0–1 m together with surface waters	65.493	86.6	19.747	90.0
Area surrounded by groundwater depth contour > 1 m	7.486	9.9	1.147	5.2
Area surrounded by groundwater depth contour > 2 m	2.682	3.5	1.048	4.8
Total area	75.661	100	21.942	100

Source: own authors' work based on field research

Groundwaters in the northern part of the Park are characterised by variable manner of occurrence. In the area of the southern slope of Garb Włodawski, the first usable aquifer occurs in the Quaternary deposits. Water is accumulated in various sands and gravels, and retained on weakly permeable or impermeable loams and silts. Waters with shallow occurrence and hypodermic character, susceptible to the impact of atmospheric factors and supply of all pollutants, were recorded at the foot of Garb Włodawski, as well as on deluvial formations, and in its plateau parts – on shallow impermeable layers.

The surface area of hydrogenic areas – stagnant waters and wetlands in the northern part of the Park – amounts to 75.661 km^2 (Table 1), and wetlands in which groundwaters show shallow occurrence (up to 1 m depth) occupy as much as 86% of its area (Fig. 1). The maximum depth reached 4.85 m, at an inconsiderable mean depth of 0.409 m. In the Park, the altitudes of the groundwater table varied from 163.56 m to 187.30 m a.s.l., and the mean altitude amounted to 168.69 m a.s.l. The average decrease in water level equalled 0.59° (1.02%).

The south-eastern part of the Park includes an area of outcrops and shallow Cretaceous deposits (Upper Cretaceous marls and chalk). The mean depth of occurrence of water table was 0.398 m. Moreover, in peatland Bubnów and Staw in the measurement period, marshes and flooded areas were maintained covering an area of 10.563 km^2. The maximum depths to groundwaters (10–12 m b.g.l.) were

www.czasopisma.pan.pl PAN POLSKA AKADEMIA NAUK www.journals.pan.pl

characteristic of the elevations of the southern boundary of this part of the Park and its buffer zone. In the municipalities of Wielkopole and Tarnów, located within the Chełm Hills, dug wells retain groundwaters at depths of more than 10 m, whereas in small distances from land culminations, the depth of the usable aquifer decreases to a depth of below 2 m. This is caused by the shallow occurrence of impermeable marls.

The groundwaters of the south-eastern part of the Park occur at an average altitude of 176.69 m a.s.l., i.e. almost 8 m higher than in the northern part. The highest recorded location of the groundwater table was 194.19 m (Fig. 2), and the lowest 172.35 m. The mean slope of the water table amounts to 0.62° (1.08%).

In periods of considerable surplus of water, flat wetland areas are flooded. In the summer period 2013, the total area of flooded wetlands in the Park amounted to 12.56 km^2. Almost half of the area of the southern part of the Park (47%) was covered by a layer of stagnant water (Bubnów Swamp 8.02 km^2, Staw Swamp 2.33 km^2).

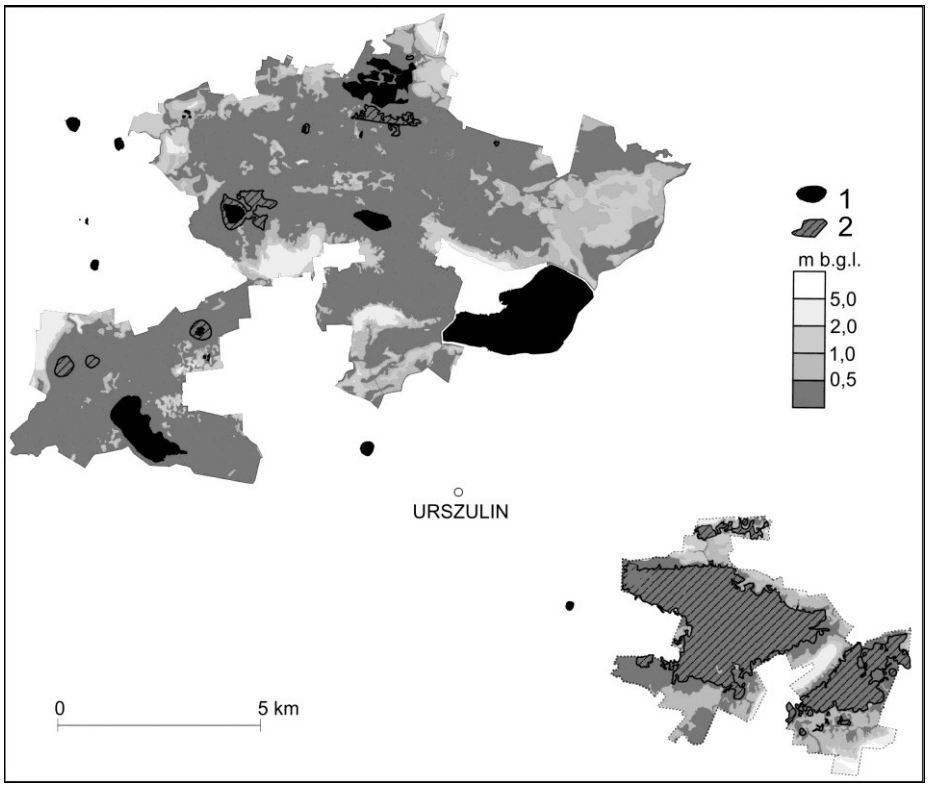

Fig. 1. Map of groundwater table depth in Polesie National Park (July–August 2013). Own authors' work based on filed research. Explanations: 1. standing water bodies, 2. inundated areas

www.czasopisma.pan.pl PAN POLSKA AKADEMIA NAUK www.journals.pan.pl

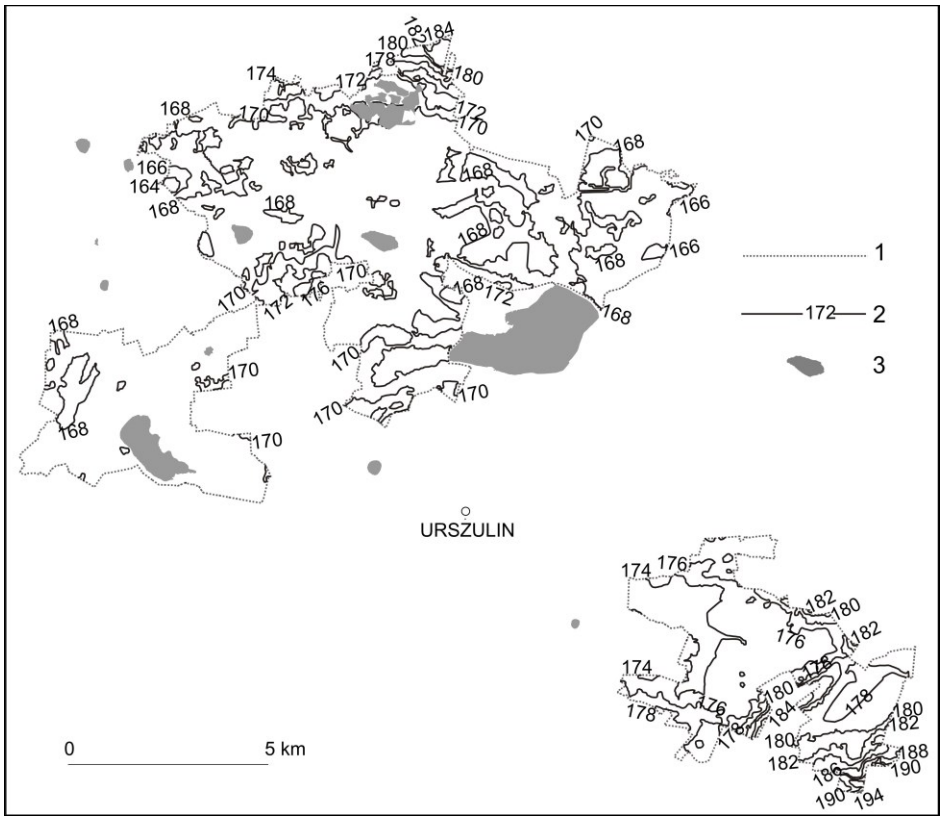

Fig. 2. Groundwater contour map of Polesie National Park (July–August 2013). Own authors' work based on filed research. Explanations: 1. border of Polesie National Park, 2. groundwater contours (every 2 m), 3. standing water bodies

The Łęczna-Włodawa Lake District is distinguished by a very low number of natural groundwater outflows to the land surface – springs. Due to this, small outflows recorded during mapping in August 2013 in the Polesie National Park in the villages of Karczunek (5 springs) and Wojciechów (1 spring) deserve particular attention and protection. They are Quaternary springs with low efficiency (approximately 1.5 $dm^3 \cdot s^{-1}$). Information obtained during interviews with the local community suggests the presence of a higher number of springs in the area, but due to ceasing of their exploitation, the outflows were overgrown by bushes, and become inaccessible in the period of abundant vegetation growth.

CONCLUSION

The water resources of the Polesie National Park are of key importance for the functioning of its ecosystems. They determine its environmental and land-

www.czasopisma.pan.pl PAN POLSKA AKADEMIA NAUK www.journals.pan.pl

scape attractiveness. The preservation of water resources is one of the basic objectives of protection in the Park.

The field research conducted in summer 2013, permitting the spatial analysis of the location of the groundwater table, showed the specific parameters of the hydrosphere of the Polesie National Park. A major part of the Park (more than 85%) is occupied by areas in which the depth to the groundwater table is lower than 1 m. This favours the preservation of the natural values of water-peatland ecosystems. It should be emphasised, however, that the analysed hydrographic situation is untypical. In the summer period, the usually observed stages of groundwaters are not high, and the analysed situation was a result of abundant atmospheric alimentation in spring and early summer 2013. The research also showed a considerable division of the area of the Polesie National Park (northern and south-eastern part). It is evidenced by the differences in altitudes of location of water tables between them, reaching approximately 8 m.

The area of the Łęczna-Włodawa Lake District is characterised by a low number of natural groundwater outflows to the land surface – springs. Therefore, small outflows encountered in the Polesie National Park in the villages of Karczunek and Wojciechów deserve particular attention and protection.

Due to the very shallow location of the groundwater table, it is important to pay attention to potential and actual sources of pollutants of groundwaters. In areas where environmental attractiveness is dependent on natural water quality, any manifestations of pollution are exceptionally unfavourable. They contribute to an increase in the level of eutrophication of waters in lakes and rivers, and cause changes in the habitat conditions of peatlands.

REFERENCES

Chałubińska A., Wilgat T., 1954. Podział fizjograficzny województwa lubelskiego, w: Przewodnik V Ogólnopolskiego Zjazdu PTG. Lublin, 3–44.

Kaszewski B.M., 2002. Klimat Polesia Lubelskiego i jego zmiany. Acta Agrophys. 66, 21–48.

Kulik M., Baryła R., 2010. Changes of groundwaters level at „Krasnoryki" meadow site in the Poleski Park Narodowy. Teka Kom. Ochr. Kszt. Środ. Przyr. 7, 184–191.

Mapa podziału hydrograficznego Polski 1 : 10 000. KZGW, IMGW-PIB.

Michalczyk Z., Bartoszewski S., Chmiel S., Dawidek J., Głowacki S., Turczyński M., 2002. Zasoby wodne Poleskiego Parku Narodowego, w: S. Radwan (ed.), Poleski Park Narodowy. Monografia przyrodnicza. MORPOL, Lublin, 55–71.

Michalczyk Z., Bartoszewski S., Głowacki S., Turczyński M., 1993. Wody Poleskiego Parku Narodowego. Ekobios 1, 1–24.

Michalczyk Z., Chmiel S., Turczyński M., 2003a. Dynamika stanów wody powierzchniowej i podziemnej. Acta Agrophys. 91, 53–63.

Michalczyk Z., Chmiel S., Turczyński M., 2003b. Stosunki wodne w obszarze funkcjonalnym Poleskiego Parku Narodowego. Acta Agrophys. 91, 26–67.

www.czasopisma.pan.pl PAN POLSKA AKADEMIA NAUK www.journals.pan.pl

Michalczyk Z., Głowacki S., Różycki A., 2004. Dynamika zwierciadła wód w Poleskim Parku narodowym, w: R. Dobrowolski, S. Terpiłowski (red.), Stan i zmiany środowiska geograficznego wybranych regionów wschodniej Polski. Wyd. UMCS, Lublin, 183–188.

Michalczyk Z., Głowacki S., Sposób J., 2010. Dynamics of the groundwater table in Polesie National Park. Teka Kom. Ochr. Kszt. Środ. Przyr. 7, 251–259.

Paczyński B. (red.), 1995. Atlas hydrogeologiczny Polski. Wyd. PIG, Warszawa.

Wilgat T. (red.), 1961. Polesie Lubelskie. Wyd. Lubelskie, Lublin.

Wilgat T., Michalczyk Z., Paszczyk J., 1984. Płytkie wody podziemne w obszarze związanym z centralnym rejonem Lubelskiego Zagłębia Węglowego. Wyd. UMCS, Lublin, 1–71.

www.tutiempo.net/en/Climate/WLODAWA.

PŁYTKIE WODY PODZIEMNE POLESKIEGO PARKU NARODOWEGO W OKRESIE PO WZMOŻONYM ZASILANIU DESZCZOWYM

Streszczenie. W pracy przedstawiono charakterystykę płytkich wód podziemnych Poleskiego Parku Narodowego – jednego z pięciu w Polsce, w których głównym przedmiotem ochrony są ekosystemy wodno-torfowiskowe, a funkcjonowanie uzależnione jest od stanu zasobów wodnych. Wykorzystane do analizy dane z kartowania terenowego na przełomie lipca i sierpnia 2013 r. pokazują nietypowe, wysokie położenie wód podziemnych w okresie letnim. Sytuacja ta spowodowana została obfitym zasilaniem atmosferycznym wiosną i wczesnym latem analizowanego roku.

Słowa kluczowe: Poleski Park Narodowy, wody podziemne, obszary hydrogeniczne