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DYNAMICS OF GROUNDWATER TABLE IN POLESIE NATIONAL PARK

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Summary. The Polesie National Park is an area of unique natural and landscape values in the Europe. Water conditions, existence of marshes, wetlands, lakes and storage reservoirs, and mainly shallowly occurring ground waters, are the most important factors influencing the specific features of the Polesie landscape [Wilgat 1963]. The paper presents the results of measurements of the groundwater level in the area of Polesie National Park in 1991–2008. The results of the study show that precipitation is the main factor determining the changes of the groundwater level, which is visible in similar rhythm of changes of the first groundwater table level. Seasonal and annual changes, corresponding to years of lower and higher precipitation values, are also visible in the rhythm of changes. The amplitude of changes of the groundwater table depends on the depth of the unsaturated zone in the area of observation wells. The natural rhythm of groundwater table changes can be disturbed by human impact, connected with the exploitation of ground waters, also from confined aquifers, with the digging of drainage systems, and with the existence of peat-holes.

Key words: Polesie National Park, dynamics of groundwater level

INTRODUCTION

The Polesie National Park, with an area of 9647.73 hectares, is situated in the central part of the Łęczna-Włodawa Lake District, subregion of the Lublin Polesie. This is an area of small groundwater resources and low river outflow. Shallowly occurring ground waters, huge areas of permanent or periodical wetlands, and many lakes and reservoirs have left a stamp on the landscape [Wilgat 1954, Michalczyk *et al*. 2003]. Water conditions, mainly those related with the occurrence and retention of ground waters, determine the attractiveness and natural values of that area. Those conditions, above all the depth of groundwater occurrence and the dynamics of water resources, change due to the land use.

The main purpose of the study presented in this paper was analysis of changes of groundwater table location, based on measurements taken in test wells, started just after the foundation of the Polesie National Park.

STUDY AREA

The Polesie National Park is situated in a slightly diverse flat area, in the zone of the second order watershed between the basins of the rivers Wieprz Bug. The area is situated at an elevation of 160–175 m above sea level, and in the zone of Garb Włodawski in the northern part even at 185–190 m. Gradients are small, and in the vast plains do not exceed 1‰. In the lower parts of terrain, fed by precipitation and ground waters, hydrophilic plants developed, the decay of which has led to the formation of peat beds, sometimes of significant thickness [Wilgat 1954, Harasimiuk and Wojtanowicz 1998].

Lithologically diversified Quaternary deposits of the thickness from several to 60 m are found at the bedrock of the study area. Those deposits, overlying marls of the Upper Cretaceous, are characterised by varied permeability and water retention capacity. At the bottom of Quaternary deposits there are waste-rock silts, clays, and series of sands covered by limnic loams and silts, and sands, gravels, and spreads of boulder clay. Surface deposits are formed by vistulian fluvial-flood and lacustrine sediments and Holocene mineral-organic alluvia and peats. Monotonous surface relief is a specific feature of the Park. The largest area is occupied by two levels of accumulation plains. The lower level is covered by wetlands, build of Holocene deposits of water and organic accumulation, the higher one – by sands, loams, and silts of water accumulation. Higher areas are covered by denudation plains on glacial sediments or on shallowly occurring Cretaceous layers, however in the highest part of the area denudation mountains with shallowly occurring Cretaceous marls are dominant.

The area of Lublin Polesie, also the area of the Polesie National Park, is characterised by low precipitation rate, 550 mm per year, and high values of transpiration. Potential evapotranspiration in meadows in the growing season exceeds 600 mm [Szajda 1989]. Terrain transpiration from the higher areas can be estimated at 450 mm. In the spring and summer seasons values of transpiration exceed the rate of precipitation, which results in lowering of the shallow groundwater table [Michalczyk 1998].

MATERIAL AND METHODS

With regard to significance of water conditions in the functioning of the natural environment of Polesie, just after the foundation of the Polesie National Park in May, 1990, a system of monitoring of surface and ground waters was developed by the Department of Hydrography of Maria Curie-Skłodowska Uni-

versity. Measurements and observations, conducted by employees of the Polesie National Park, started in November, 1990 [Michalczyk *et al*. 2004]. The scope and method of monitoring changed in the last two decades. Since the end of 2008 measurements in dig wells have been stopped, and the present system of monitoring uses 28 observation wells (piezometers), seven of them with automatic limnimeters. Several limnimeters document the hydraulic head of deeper water-bearing beds.

The assessment of dynamics of the groundwater table in the Polesie National Park was based on measures of groundwater table in 11 dig wells, located in various parts of the Park (Fig. 2) in the years 1991–2008. Regardless of the implemented and modernised system of monitoring, measurements of rivers, lakes and ground waters were conducted and changes of the range of wetlands and marshes were analysed. The results of the researches have been presented in many papers describing characteristics of water conditions of the Polesie National Park and the Polesie region [Michalczyk *et al.* 2003, 2004, Chmielewski 2009].

RESULTS

Shallow ground waters in the area of the Polesie National Park occur mainly in porous Quaternary sediments, and locally in pore-fissured rocks of Upper Cretaceous. In Quaternary rocks there are several water-bearing beds, hydraulically connected. They form one series of aquifers, commonly used for supplying rural households. The water-bearing bed of the first aquifer is usually formed in sands, often with dusty and muddy layers and peats. The bottom of the water-bearing bed is formed in lithologically diversified Quaternary deposits (silts, loams, boulder clays), and in the area of Wola Wereszczyńska, Załucze and Urszulin – chalky rocks or their waste-mantle. Shallow groundwaters, as well as waters of Cretaceous multiaquifer formation in the zone of denudation mountains, are characterised by open water table. In places where Cretaceous rocks occur deeper, ground waters of that formation have confined feature. Between valleys, groundwater table is usually situated below the Quaternary groundwater table, but in the river valleys and depressions – above or on the same height as the Quaternary one [Michalczyk *et al*. 2003, 2004, Hydrographic Map… 2006]. Groundwater table occurs very shallowly (Fig. 1) and the unsaturated zone does not reach 2 m on most of the area of the Park. Seepage conditions of water to the first water-bearing horizon differ, despite the thin layer of the unsaturated zone.

About 1/3 of the Polesie National Park area is covered by deposits of average and good conditions of water retention: sands and gravels, eolian and fluvial sands with loams, while on the surface of the remaining area there are boulder clays, silts and loams, alluvia and peats of poor water retention capacity. The depth of occurrence of the groundwater table changes seasonally and corresponds to the dominant parts of the surface relief. In the zone of Holocene accumu-

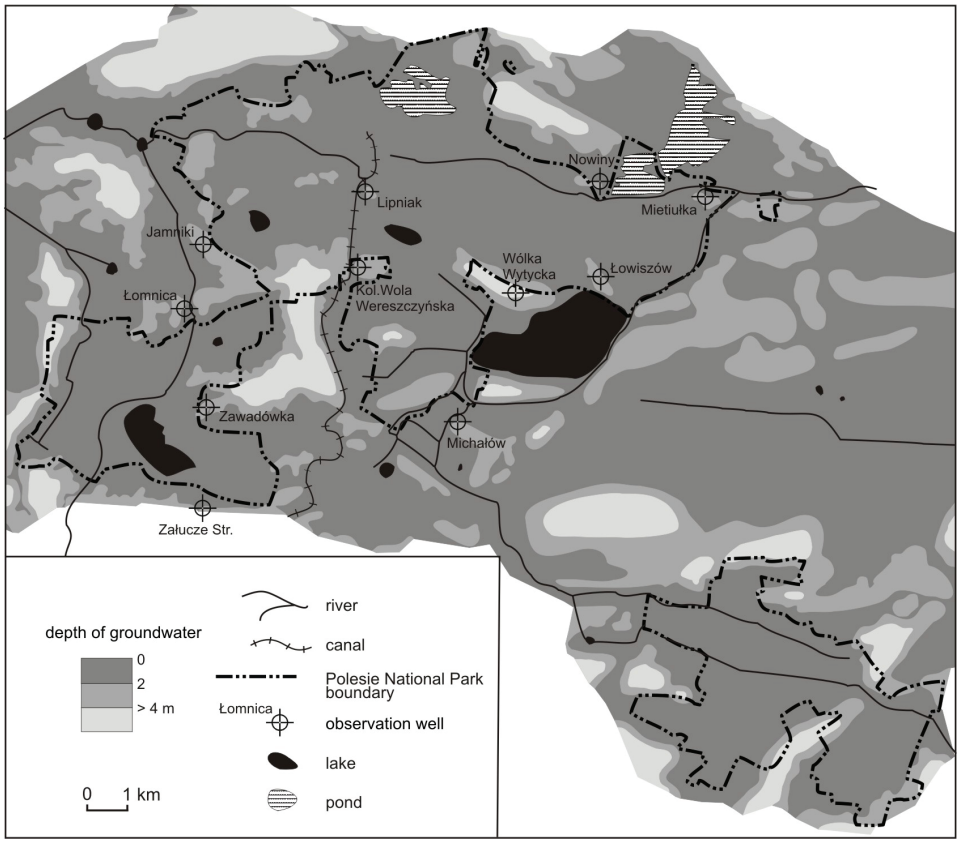

Fig. 1. Depth of occurrence of the groundwater table in the Polesie National Park and location of groundwater observation wells

lation plain (outside the build-up areas), ground waters occur on the depth of several centimetres, even in the periods of the long-term droughts. These are natural conditions for the occurrence of permanent wetlands and marshes [Borowiec 1990]. Deeper, ground waters are maintained in the areas of upper Pleistocene accumulation level and within denudation plains, where rural settlements have developed. In the zone of denudation mountains the depth of water occurrence usually exceeds 5 m, in Garb Włodawski region and the highest relic mountains of the Cretaceous bedrock the thickness of the unsaturated zone slightly exceeds 10 m. Groundwater table is characterised by small hydraulic gradient, which plays a significant role in slow groundwater flow and small drainage range of natural watercourses and draining ditches [Wilgat *et al.* 1983].

The average monthly values of groundwater levels in three observation wells are presented on the Fig. 2. Monthly sums of precipitation for the observation station of the Institute of Meteorology and Water Management in Włodawa [http://www.tutiempo] are also presented in the chart. Monthly values of precipitation change from several to over 150 mm (Fig. 2). In the years 1991–2008

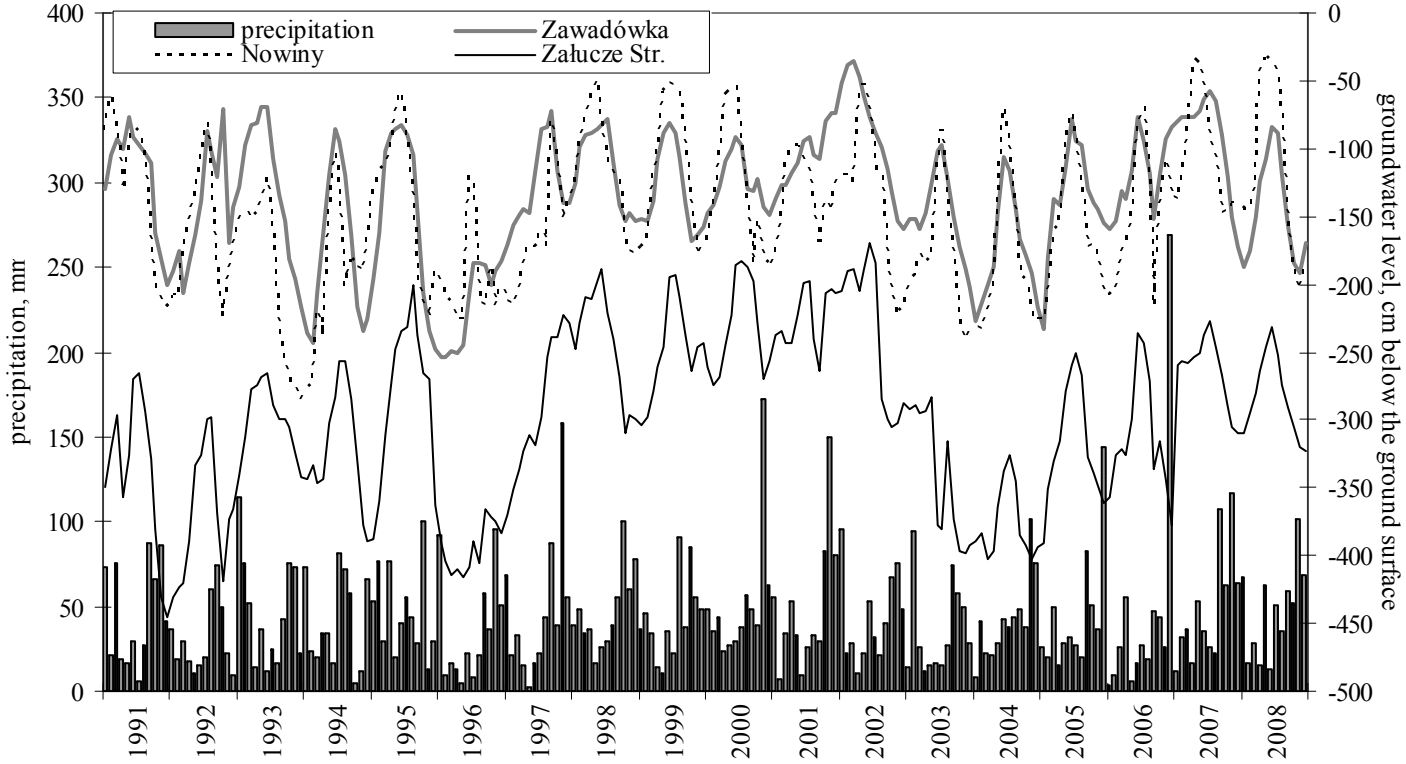

Fig. 2. Monthly values of precipitation and average groundwater levels in the Polesie National Park

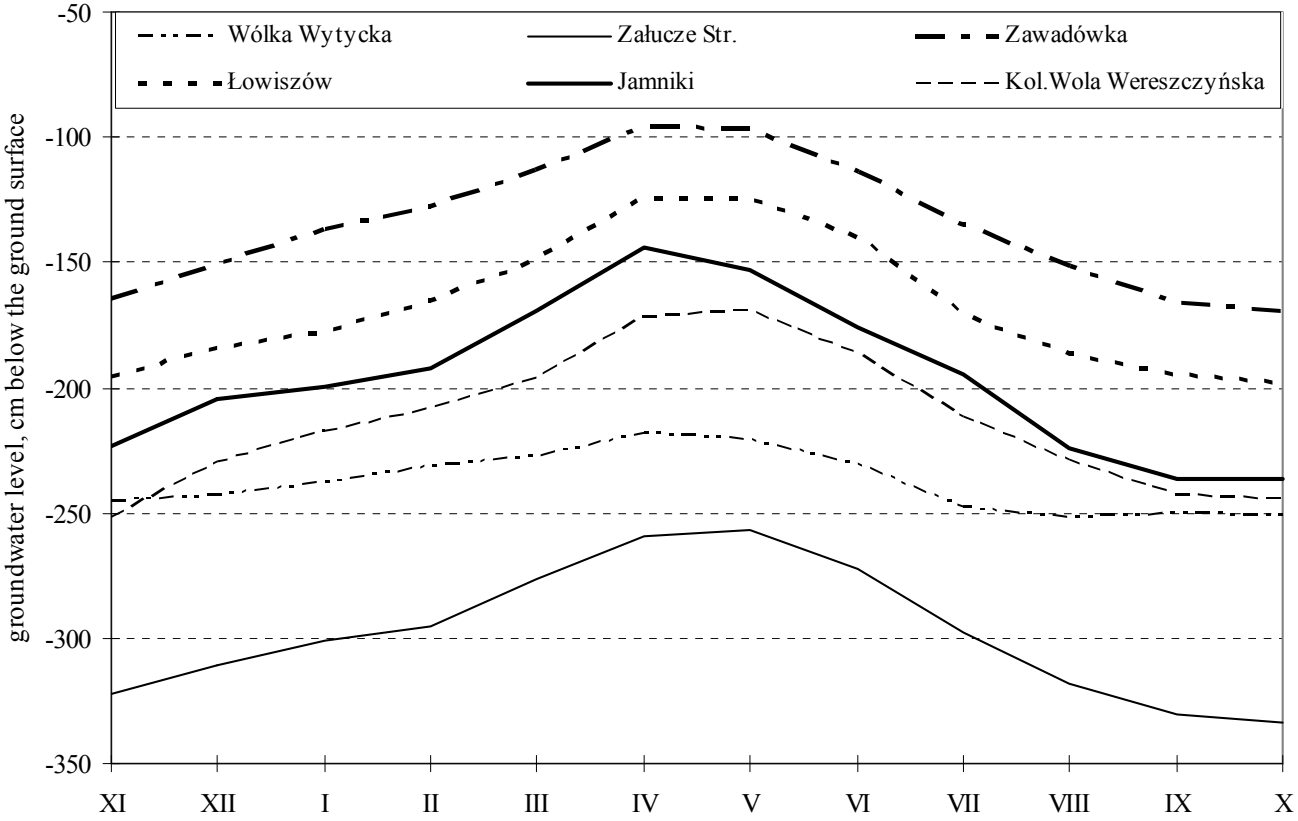

Fig. 3. Seasonal changes of groundwater levels

a slight increasing tendency of precipitation and water levels was observed, but without statistical significance. Seasonal and annual changeability, referring to precipitation feeding is visible in the rhythm of changes. The lowest location of groundwater table was observed in 1991/1992, 1996 and 2003/2004. However, the highest water resources were recorded in the years 2002 and 2007, which is directly related with high precipitation. In the lowest, uninhabited areas of the Park, the amplitude of groundwater table changes is only several centimetres, in the zone of denudation plains its value increases to 2 m, and under the hilly areas it reaches 2.5–3.5 m. The analysis showed that the amplitude of groundwater table level changes is related to the thickness of the unsaturated zone, and thus to the location of the observation wells, because groundwater table occurs at less than 1 m in the spring period almost in all of the wells.

Seasonal changeability of groundwater levels is very distinct, as it is in other parts of the Lublin Polesie [Wilgat *et al*. 1983]. Despite the high dynamics of groundwater levels, regular variation for average values is observed. In the years 1991–2008 minimum groundwater levels most often occurred in the autumn season, and maximum mainly in April and May (Fig. 3). Continental rhythm of groundwater levels changes, with maximum values in the spring season (thawing snow) and summer minimum values (drought) is characteristic for all analysed observation wells.

Table 1. Characteristic groundwater levels in 1991–2008

Groundwater observation well	Groundwater level, cm below ground surface			Amplitude of changes, cm
	Average	Minimum	Maximum	
Jamniki	190	338	43	295
Kol. Wola Wereszczyńska	212	396	60	336
Lipniak	194	303	50	253
Łomnica	276	450	103	347
Łowiszów	168	292	58	234
Michałów	131	231	23	208
Mietiułka	121	191	47	144
Nowiny	150	285	32	253
Wólka Wytycka	238	293	170	123
Załucze	298	445	169	276
Zawadówka	135	253	35	218

In the years 1991–2008 the highest amplitude of groundwater table changes was observed in Łomnica and Kolonia Woli Wereszczyńskiej – over 330 cm (Tab. 1). In the same period the slightest differences were monitored in Wólka Wytycka – somewhat over 120 cm. The diversity of the changes of groundwater table amplitude results from the depth of its occurrence, conditioned by surface relief. In the lower part of the study area groundwater table occurs shallowly. The highest changes of groundwater table are observed under the hills where the unsaturated zone is thicker.

CONCLUSION

The location of groundwater table in the area of the Polesie National Park is mainly conditioned by geological structure, surface relief and atmospheric feeding. The rhythm of levels of the first groundwater table is similar in all observation wells, which indicates the important role of precipitation in water dynamics. Seasonal and annual changes, referring to series of years of low and high precipitation, are distinct in the rhythm of variation. In the annual rhythm the highest groundwater levels and the lowest fluctuation are noted in the spring season, however, the highest changeability of groundwater levels is observed in the autumn period. Groundwater levels increase of different value is monitored every spring.

The lowest location of groundwater table was observed in 1991/1992, 1996 and 2003/2004, and the changes reached even over 300 cm. The amplitude of groundwater table level changes refers to the thickness of the unsaturated zone, thus to the location of the observation wells. In the lowest areas of the Park, the amplitude of groundwater table changes is only several centimetres, in the zone of denudation plains its value increases to 2 m, and under the hilly areas the changes reach 2.5–3.5 m.

Human impact, such as the exploitation of ground waters, also from the confined aquifers, the digging of drainage systems, and the existence of peatholes, have led to a lowering of the location of groundwater table and to higher water dynamics.

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DYNAMIKA ZWIERCIADŁA WODY PODZIEMNEJ W POLESKIM PARKU NARODOWYM

Streszczenie. Poleski Park Narodowy jest obszarem o unikatowych w skali europejskiej walorach przyrodniczych i krajobrazowych. Czynnikiem warunkującym specyficzne cechy krajobrazu poleskiego są stosunki wodne, przede wszystkim bagna, mokradła, jeziora i zbiorniki wodne [Wilgat 1963]. W pracy przedstawiono wyniki pomiarów położenia zwierciadła wód podziemnych na terenie Poleskiego Parku Narodowego w latach 1991–2008. Wyniki badań pokazują, iż o zmianach położenia zwierciadła wód podziemnych decyduje przede wszystkim zasilanie atmosferyczne, czego przejawem jest podobny rytm wahań stanów wód pierwszego zwierciadła. W rytmie wahań bardzo czytelne są wahania sezonowe oraz roczne, nawiązujące do wystąpienia serii lat o niskich i wysokich opadach. Amplituda wahań zwierciadła wody zależy od miąższości strefy aeracji, wynikającej z położenia stacji pomiarowej. Naturalny rytm wahań zwierciadła wód podziemnych może zostać zakłócony poprzez zabiegi antropogeniczne związane z eksploatacją wód podziemnych, w tym również z poziomów naporowych, kopanie rowów odwadniających oraz istnienie dołów po eksploatacji torfu.

Słowa kluczowe: Poleski Park Narodowy, dynamika zwierciadła wód podziemnych