ANALYSIS OF WATER CONDITIONS IN THE NAREW VALLEY

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Abstract: Unfavourable transformations of organic soils and wetland vegetation observed in the Narew valley within the Narew National Park lead to the impoverishment of valuable natural features, protection of which was the main reason of the park's establishment. Primary cause of these changes is seen mainly in the alteration of hydrologic regime and in the lowering of ground water levels following human activity. Here we analyse the variability of water flows in the Narew at water gauge in Suraż (at the border of the Narew National Park), ground water tables and meteorological conditions. Years 1969-1981 were extremely wet. Statistical analyses did not show, however, significant changes in water flows during the period of 50 years (1951-2002). Instead, substantial decline of ground waters was observed in the valley, which might originate from enhanced evapotranspiration, higher temperatures in spring, smaller and shorter snow precipitations or erosion of riverbed. The results indicate that the reasons for observed degradation of hydrogenic sites are complex and resultant of many natural and anthropogenic agents. Unequivocal determination of the reasons requires complex studies, long-term natural monitoring and constant measurements of surface and ground water levels.

INTRODUCTION

Unfavourable transformations of organic soils and wetland vegetation which lead to the impoverishment of natural values of riparian sites is observed in many river valleys [Actual…, 1999]. These processes are usually associated with drying of soils due to decreased water flow in a river or a decline of surface and ground water levels resulting from various anthropogenic activities [SZEWCZYK *et al*., 2003]. Degradation of hydrogenic sites is observed even in parts of river valleys where no draining measures have been undertaken.

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The upper Narew valley is an example of such a site, particularly the stretch protected within the borders of the Narew National Park (NPN). Studies carried out within the framework of nature protection plan for NPN [Protection…, 2002] and other research studies [Actual…, 2002; BANASZUK, 1996] document in details the areas of distinct mineralization of peatlands and transformation of the vegetation cover. Particularly unfavourable is overgrowing of the valley with common reed and shrubs.

Some specialists associate it with changes in hydrologic regime caused by the construction of Siemianówka dam reservoir and by the Narew regulation downstream the Narew National Park [Actual..., 1999; SZEWCZYK *et al*., 2003]. Results of hydrological analyses based on long term (since 1950) gauge measurements do not show stable trends of decreasing water flow nor the restriction of spring floods [SZYMCZAK, MIODUSZEWSKI, 2003; CYGAN *et al*., 2003]. On the contrary, some analyses show constant, observed since the seventies, increasing of low flows in rivers of north-eastern Poland [BYCZKOWSKI, MANDES, 1996]. Moreover, it is difficult to demonstrate that dam reservoir Siemianówka exerts negative impact on water flow within the Park [CYGAN *et al*., 2003] due to large increment of the catchment area between the reservoir and water gauge in Suraż.

Excessive drying of hydrogenic sites may undoubtedly bring the loss of natural values of the valley, which should be protected by the national park. The reasons for observed changes are, however, not satisfactorily documented. Analyses of available records on ground water tables and selected meteorological parameters that might affect water relations in the valley have been attempted in order to explain the phenomenon.

HYDROLOGICAL CHARACTERISTICS OF THE NAREW

Hydrological regime of the upper Narew is characterised by deep low waters in summer months and high water flows followed by floods in the valley in spring. Disturbance of this regime, particularly restriction of floods may negatively affect hydrogenic sites.

Analysis of water flow variability in the Narew is based on long term daily measurements of water stages at the water gauge Suraż which is included in the hydrological monitoring network of the Institute of Meteorology and Water Management (IMGW). The gauge is situated at the upper border of the Narew National Park (fig. 1) thus it represents water volume entering the park.

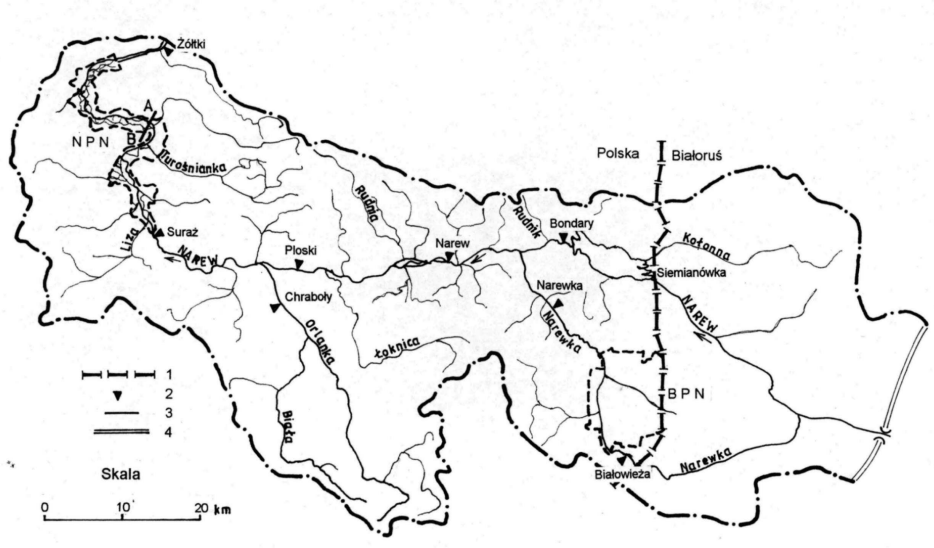

Fig. 1. Hydrographic network of the Upper Narew; NPN – Narew National Park, BPN – Białowieża National Park, 1 – state border, 2 – water level gauge, 3 – cross-section Wólka Waniewska – Kolonia Topilec, 4 – regulated part of the Narew river

No long term hydrologic records are available from the Narew National Park so the analysis was based on data from the profile in Suraż. Results of this analysis clearly show that, apart from maximum values, all analysed statistical characteristics of daily flows had an increasing tendency for the 50 years period [Water management..., 2002; SZYMCZAK, MIODUSZEWSKI, 2003]. The trend was approximated for selected periods of 1951-1970, 1970-1983, 1983-2000. Presented tendencies estimated from data on particular hydrological years (fig. 2) show that the results differ from those based on the entire 50-years period. It is clearly visible that years 1969-1984 were extremely wet while recent period (1985-2000) was dry and similar to that of 1951-1964. The effect of dam reservoir constructed in 1990 and filled to its full capacity in 1992 [CYGAN *et al*., 2003] can not be seen.

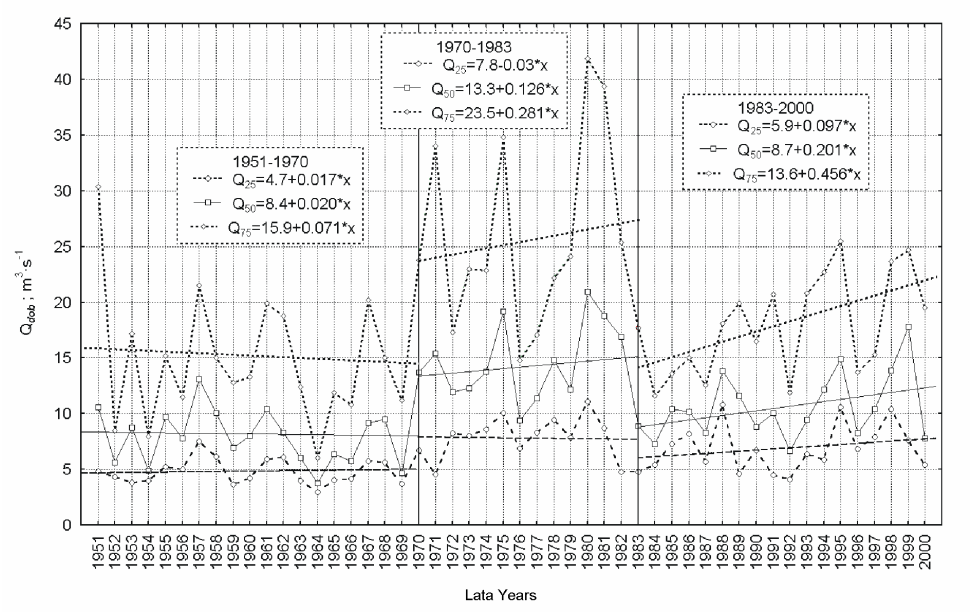

Fig. 2. The changes of discharge in the Narew river, gauge Suraż

High waters of appropriate discharge result in floods in the Narew valley. The number of days when flows are higher than the bankfull discharge were determined for the channel cross-section at the Suraż gauge. The figures may differ at other cross-sections but the character of changes remains similar. The number of such days in particular years of the 1951-2000 period is shown in fig. 3. There were marked differences in flood duration between particular years but the longest floods occurred in years 1969-1983. Recently (1984-2000) flood duration has been similar to that of the years 1951-1968.

Analyses of water flow at the Suraż water gauge during the last 50 years do not allow to conclude on unfavourable long term trends in hydrological regime. Three distinctly different periods of water flows can be distinguished.

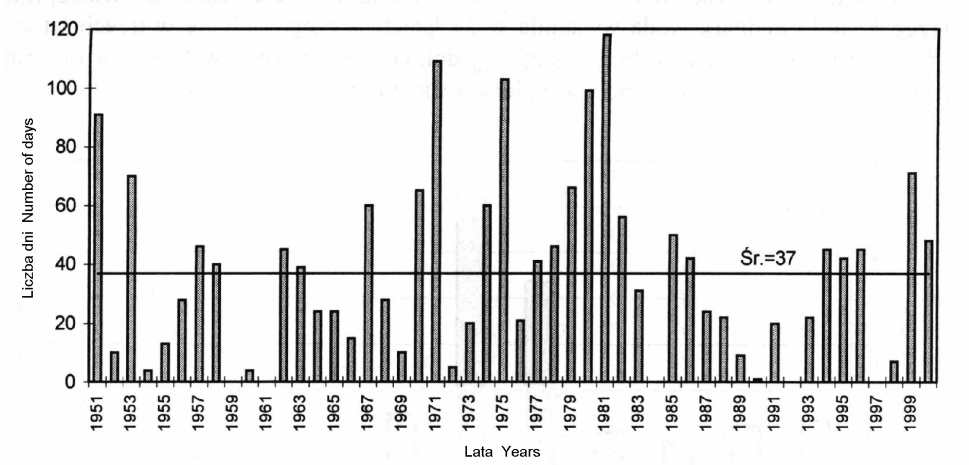

Fig. 3. Flood duration in the valley in particular years

High water stages and long term floods were recorded in 1969-1983. In the last 20 years flows have been significantly lower and similar to those of 1951-1968. Lower flows after 1980 have also been observed in other rivers of north-eastern Poland including the Biebrza [BYCZKOWSKI, MANDES, 1996; Hydrological..., 2002]. Having this in mind, observed decrease of water flow in the Narew in the last 20 years can hardly be explained by river regulation made in 1986 or by construction of the dam reservoir Siemianówka in 1992.

ANALYSIS OF ATMOSPHERIC CONDITIONS

Analysis of atmospheric conditions was based on data from meteorological station in Białystok, the one closest to the Narew valley. The analysis does not show any marked climatic changes in the last 50 years in both precipitation and temperature. Water relations in the valley may largely depend on snow retention, usually not considered in climatic analyses. The thickness of snow cover in particular years was determined upon standard measurements of the IMGW. As an authoritative thickness of the snow cover was taken that at the end of winter. The number of days between snow melt and May 1st of each year was also determined. Results of these analyses demonstrate that winters become less snowy and therefore water reserves stored in snow are smaller. Snow melting date was also observed to occur earlier (Fig. 4.).

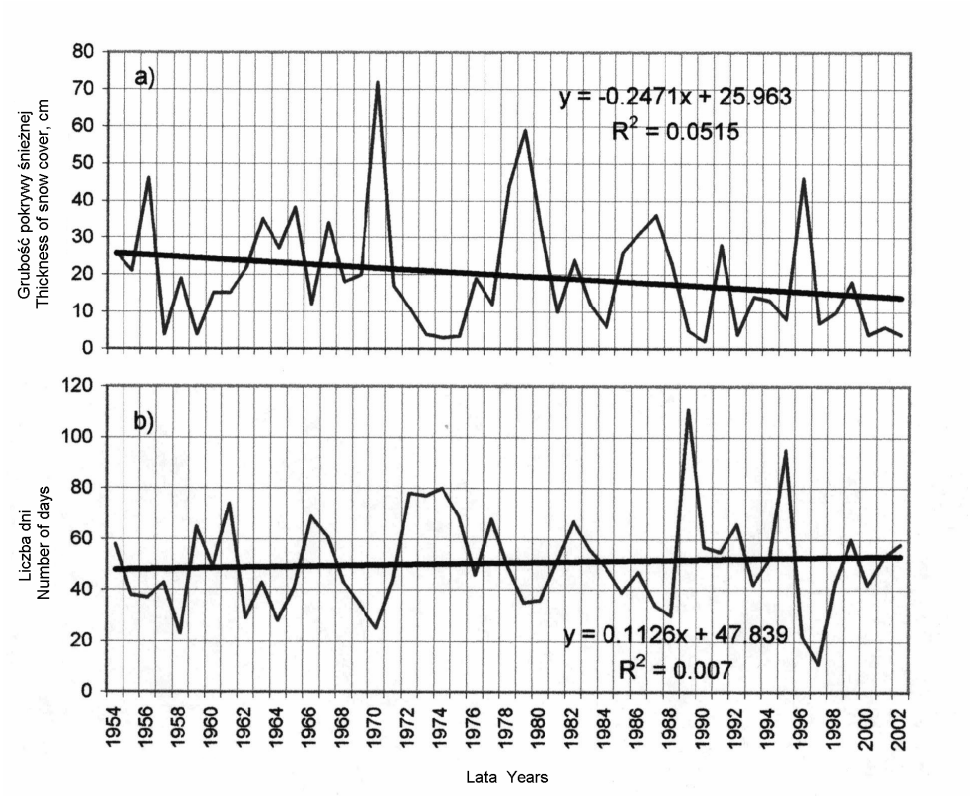

Fig. 4. The changes of snow cover in spring; a – thickness of snow cover, b – the number of days since snow melt till the 1st of May

Analysis of precipitation (P) and potential evapotranspiration (E) in April calculated with the Penman's equation showed a clear tendency of increasing both in this month (fig. 5). The difference between evapotranspiration and precipitation E – P did not, however, change.

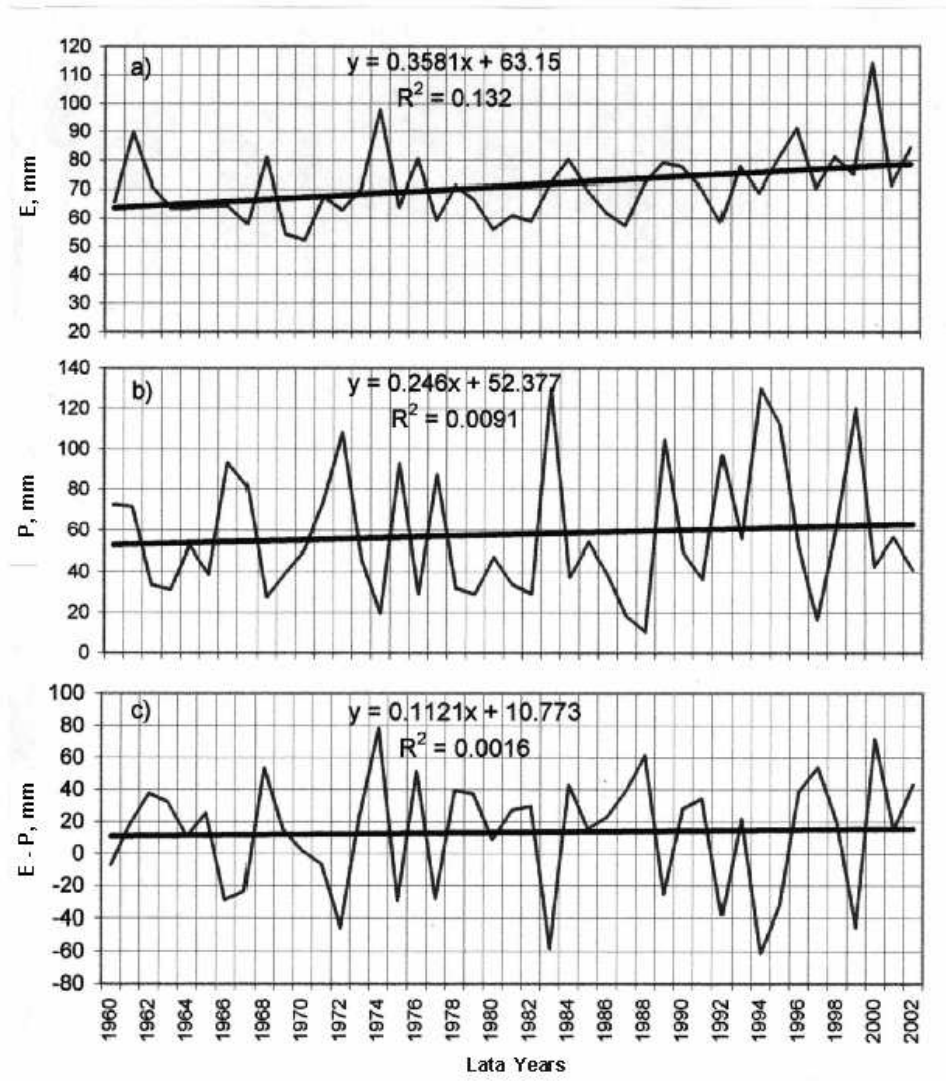

Fig. 5. Precipitation and evapotranspiration in April: a) potential evapotranspiration, b) precipitation, c) precipitation deficit.

Having these analyses in mind, one may speculate that changes in precipitation and potential evapotranspiration in spring do not exert any significant effect on observed transformations of water relations in the valley. Much smaller snow retention and earlier snow melting result, however, in that water remains shorter on the peatland surface, vegetation season starts earlier and that's why the ground water table in summer tends to decline. This hypothesis is true providing the water standing on surface is brought not only by the river floods but on part of the area is also an effect of snow melting and large precipitation in spring. It is a very probable

assumption. Areas where water standing on the ground surface in spring originates mainly from snow melting were estimated e.g. in the Biebrza valley [Hydrological…, 2002].

SURFACE AND GROUND WATER STAGES

It has been assumed that moisture in the valley during the vegetation period depends largely on water tables in spring. Analysis of mean water tables in the Narew in the period of snow disappearance showed an increasing tendency which might be caused by the earlier snow melting (fig. 6). Water tables in the river during the first ten days of May were found to decline markedly. It proves faster discharge of spring waters from the valley which in turn is a resultant of decreasing snow cover thickness and its earlier disappearance. Faster outflow of spring waters may be also a consequence of constructing ditches even the shallow ones.

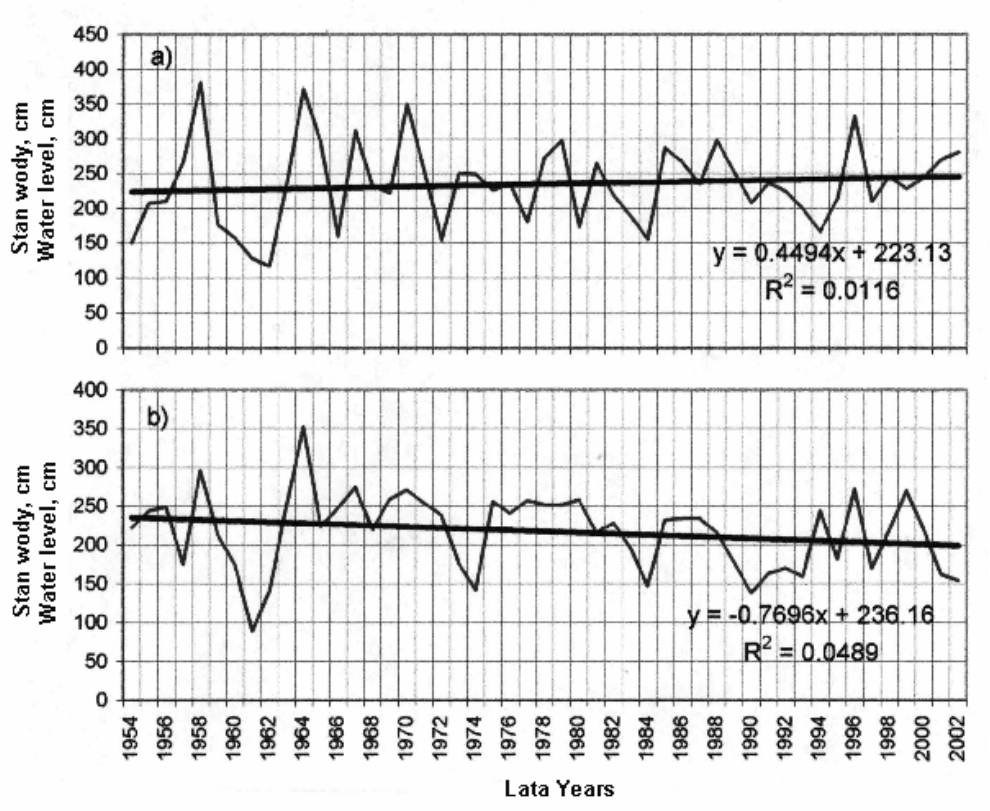

Fig. 6. Water level at the gauge Suraż: a) on the day of snow disappearance, b) in the first decade of May

Detailed characteristics of the ground water variability in the valley is difficult because of a lack of long term measurements. In the river valley within the Narew National Park the only periodical records of water tables are available from the cross-section Wólka Waniewska – Kolonia Topilec (fig. 1) and include those:

- made by dr T. Churski (IMUZ) between 1969 and 1979 in several wells twice a month during the whole year (including the period when the valley was flooded by spring waters);
- made by the team of the Narew National Park since 2000 twice a month but only in the summer when the sampling point is accessible;
- carried out during one and a half year in 2001-2002 with automatic pressure recording D-Diver station; records were taken four times a day also during high flows.

Results from the years 1969-1979 show that waters remained long on the ground surface. In the Topilec cross-section almost whole valley was inundated for over 6 months a year while flooding in the years 2002-2003 lasted less then four months. Flooding periods markedly shortened. It is noteworthy, however, that the years 1969-1979 were extremely wet. Water flows in the Narew were exceptionally high in those years (fig. 2).
Ground water tables at the cross-section Wólka Waniewska – Kolonia Topilec and surface water levels at the water gauge in Suraż were analysed to evaluate the relationships between both types of waters. Three piezometers situated in central part of the valley close to each other were selected for this analysis and measurements were carried out in three periods: 1 – years 1969-1979, 2 – year 2001, 3 – year 2002. Averaged relationships between ground water table depth and water stages for these periods significantly differed (fig. 7). In the years 1969-1979 ground water tables remained much higher then they do now at similar river water stages at Suraż. Ground water levels in the first series of measurements (1969-1979) did not drop beneath 0.6 m below the surface while now (2000-2002) they fall in the summer to 1.2 m below ground at the very similar river water levels as previously. It thus appears, that significant changes had to occur in the valley that modified the relationships between surface and ground water levels.

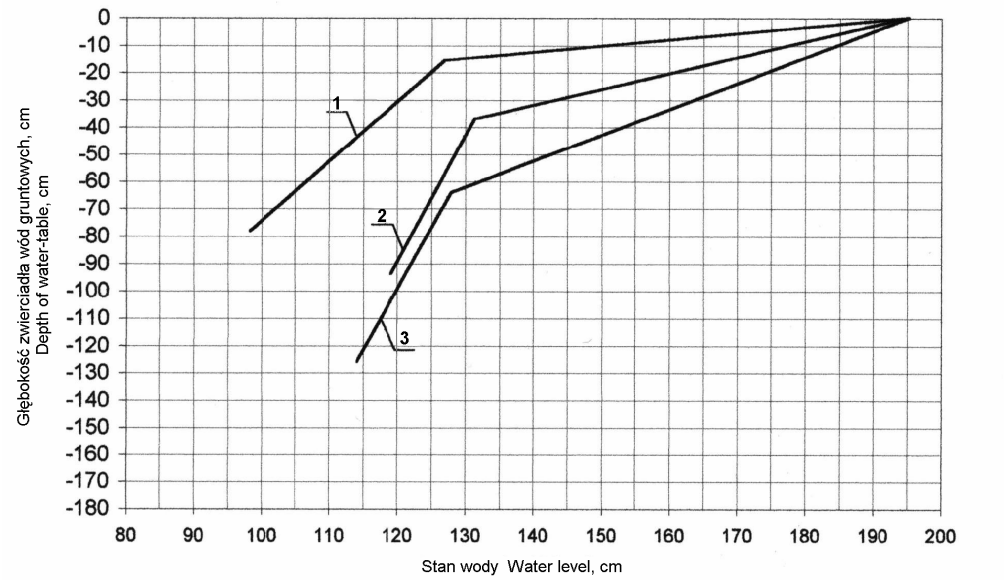

Fig. 7. The relationship between surface water levels at the gauge Suraż and groundwater tables: 1 – years 1969-1979, 2 – year 2001, 3 – year 2002

DISCUSSION

Presented analyses and measurements show evident changes of water relations in the Narew valley. Analysis of the long term (50 years gauge records) trends did not confirm any permanent decline of water flows in the river but show that the years 1969-1979 were extremely wet. The highest flows and the longest periods of water stagnation on the ground surface took place in those years. Much smaller water flows have occurred in the recent 20 years but similarly low flows were noted before 1969. Therefore, it seems that changes of water flow in the river could not be responsible for observed drying up the valley. Regulation of the Narew (1984) below the Narew National Park and construction of the Siemianówka dam reservoir (1992) only slightly affected hydrological regime of the river within the park borders. Some effect on ground water tables and on moisture content in the valley could be expected from observed climatic changes. The latter means thinner snow cover and earlier snow disappearance. Water layer that remains on the ground comes from high water stages in the river but also from snow melting. Lack of snow or its earlier disappearance result in drying up the valley and thus in decreasing water resources available for plants during the vegetation season.
Noteworthy were significant changes in ground and surface water relationships between the period 1969-1979 and 2000-2002. At the same water levels in the river (water gauge Suraż) ground waters decline now much deeper than before. Several possible reasons for that are discussed below.

1. Increased actual evapotranspiration of wetland vegetation. That is quite probable reason since succession of reeds and shrubs, the plants being

more efficient in transpiration than sedges, is observed on large areas of the valley. Some effect on evapotranspiration (through increased biomass production) may be due to increased trophic status of habitats caused by e.g. atmospheric nitrogen loads or nitrogen inputs from decomposed peat.

2. Decline of water levels in the river as a consequence of erosion of riverbed within the Narew National Park while the river channel at Suraż remained unchanged. No evidence for such processes is available.
3. Decline of water levels in the river as a result of decreasing hydraulic roughness of the channel. That is very probable since remarkable reduction of water transparency (and thus of higher plants growth) has been observed recently in the main river channel [Protection…, 2002]. Macrophytes overgrowing banks and bottom of a river may largely impede water flow and elevate water table. A lack of vegetation makes lower water levels at the same water flows. Noteworthy, water gauge at Suraż has been situated in a compact river channel (a bridge) where plant growth was always limited by depth and water velocity. Therefore, no changes caused by the disappearance of vegetation, otherwise possible in wider parts of the valley (National Park), did occur there.

CONCLUSIONS

Observed transformations of vegetation and degradation of peat soils distinctly evidence for the proceeding dry up of the valley within the borders of the Narew National Park. Explaining the alteration of water relations is difficult since changes could have several reasons. Results of analyses demonstrate that water status of hydrogenic sites could be affected by:

- climatic changes in spring, particularly by the decrease of snow cover thickness and earlier disappearance of snow cover;
- increased evapotranspiration due to reed and shrub succession and greater soil fertility;
- decline of water level in the river due to limited growth of aquatic plants in the river channel that followed a decrease in water transparency;
- natural cyclic changes of water flows in the river (wet years 1969-1979), consequently water flows in the river were higher in those years and floods lasted longer than in the last 20 years or in years preceding the wet period;
- some other unknown changes in the basin of the Narew river.

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