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CHANGES OF WATER RELATIONS IN THE MIDDLE NAREW VALLEY (1968-1988)

In the period 1986-1988, under the International Remote Sensing Experiment TELEGEO-87, large-scale investigations were conducted in the middle Narew valley west of Białystok (Fig.1) in order to determine a dynamic variability of the geographical environment of NE Poland (Olędzki 1989, 1990).

The southern part of the area under investigation, due to its unique environmental value, is a partly protected area within the Narew Landscape Park. In the northern part of the investigated land, soil reclamation work was conducted in the late 1970s, which largely drained the bottom of the Narew valley. This has provided a chance to carry out interesting comparative studies on change of water relations in the two parts of the valley caused by human activity. At the same time, it should be noted that due to the character of the natural environment of this terrain (geological structure, type of relief, hydrogeography, plant cover), the area may be considered to be representative of NE Poland and of the vast areas of Belarus and Lithuania.

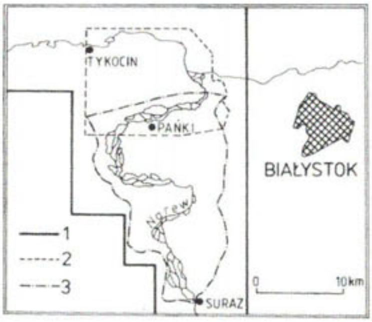

Fig.1. Location of investigated area: 1 — boundaries of investigated area, 2 — boundaries of reclaimed soil, 3 — boundaries of the Narew Landscape Park

This paper presents some considerations regarding selected elements of hydrosphere, including groundwater as well as land with increased humidity, such as morass areas, permanent marshes and periodic marshes.

A preliminary assessment of changes of the depth of occurrence of the first level of groundwater has been based on the analysis of the average annual depth levels of groundwater in three measuring wells of the Institute of Meteorology and Water Management (IMGW) (Fig.2): at Tykocin, on the land reclaimed in the years 1975 — 1981; at Pańki — in the area protected under the Narew Landscape Park, and at Suraż — to the south of the area under protection. Dynamic variability of depth of occurrence of the first level of groundwater corresponds to the variability of precipitation (Fig.3). Changes of the level of groundwater are usually transferred by one year in relation to the precipitation values.

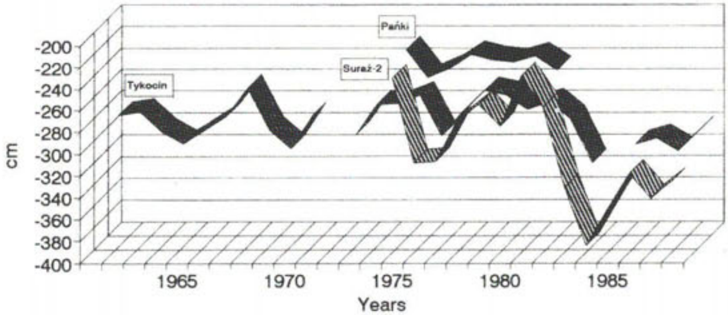

Fig.2. Changes of the first groundwater level in 1961-1988, based on data from measuring wells of the IMGW at Tykocin, Pańki and Suraż (after the IMGW data)

At Tykocin, oscillations of the first level depth of groundwater in the years 1961-1988 amounted to 69 cm, the average for that period being 296 cm. After 1982, that is after the land reclamation was completed, the highest level (304 cm) of groundwater was recorded in 1988, only slightly exceeding the lowest levels of the 1960s and 1970s. This may be explained in the first place by land reclamation, and — second — small amount of precipitation in the 1980s.

At Pańki the oscillations of the first level depth of groundwater are smaller. In the years 1975-1982 it ranged in the interval of 25 cm, the average value being 228 cm. Thus, groundwater was relatively shallow here throughout the period under investigation. This fact has been confirmed by the satellite photos, which indicates that it is a storage area.

At Suraż the dynamic variability of occurrence of the first level of groundwater is the highest. In the years 1975-1988 its oscillations amounted to 156 cm, the average value being

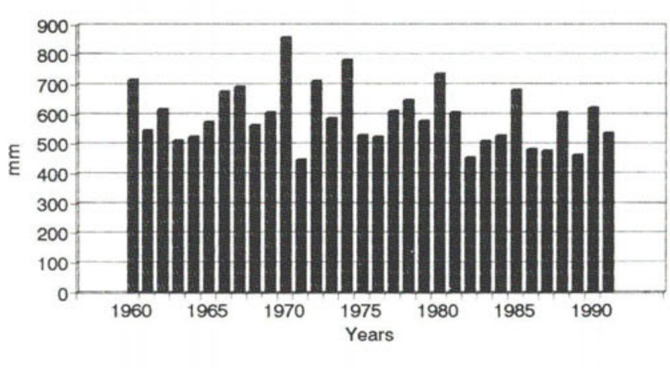

Fig.3. Annual precipitation totals in Białystok in the years 1960-1991 (after Statistical Yearbooks of the CSO, 1960-1991)

298 cm. In this area, after 1981, too, the depth of occurrence of the first level of groundwater was rapidly falling. These considerable oscillations of the table of the first level of groundwater are most probably due to the fact that the land from Suraż up the Narew valley has also been reclaimed and an excess of water (if any) is quickly drained off to an absorptive "primary" area of the Narew Landscape Park. But the steadily decreasing depth of these waters in the analyzed well may be the effect of soil reclamation to the north of the Landscape Park. Thus, the area of the Park is acting like a sponge rapidly taking away water from the area situated in the upper Narew catchment, partly retaining it and slowing down its runoff to the reclaimed part of the valley in the north of the area under investigation.

This preliminary analysis leads to the following conclusions:

1. Groundwater of the first water-bearing level within the area under investigation shows considerable and spatially differentiated oscillations of depth of its occurrence. The rhythm of these oscillations seems to correspond to variability of atmospheric precipitation, while the tendency of steady decrease of the groundwater table is bound up with land reclamation and with the decreasing precipitation amount in the 1980s.

2. The level of occurrence of groundwater on unreclaimed land within the confines of the Narew Landscape Park is more stable and these waters are more shallow. It is the water storage area.

3. The reclamation of the northern part of the area under investigation, coupled with decreasing precipitation, caused the lowering of the groundwater table in this part of the valley and enforced — due to advantageous hydrographic circumstances — a quicker runoff of groundwater also from the bottom of non-reclaimed part of the valley as well as from the upland surrounding the valley. A high potential absorption capacity of unreclaimed land intensified the "drawing off" of groundwater from the upper Narew valley up-stream of Suraż.

Attempts were made to confirm the conclusions from the observation of the above-mentioned wells by use of spatial analysis of changes in depth of occurrence of the first aquifer in the northern reclaimed part of the valley.

To achieve this purpose, two maps of hydroisobaths made in May 1981 and July 1988 were compared. In both cases, those were the years of the highest — in this area — groundwater levels in relation to the neighbouring years. As a result of the comparison of the two maps, a map of differences in depth of occurrence of the first level of groundwater was prepared (Fig.4). The map shows that in this part of the analyzed area the table of the first aquifer decreased. The greatest changes occurred within the confines of the bottom of the Narew valley, as well as — to a lesser extent — within the confines of uplands adjoining the valley. The map of differences also provided grounds for calculating water losses from the groundwater resources of the area under investigation. On the basis of calculated areas of contours of definite value of the decreased level of groundwater, as well as a percent coefficient (estimated after Mikulski, 1963) of free water content in the groundwater resources, which for the Vistula valley (the closest one to the Narew) amounts to 18.5%, the loss of groundwater resources in the part of the Narew valley bottom was estimated for the period from May 1981 to July 1988, at 3.2 mln m^3 and in the adjacent upland at 20.7 mln m^3.

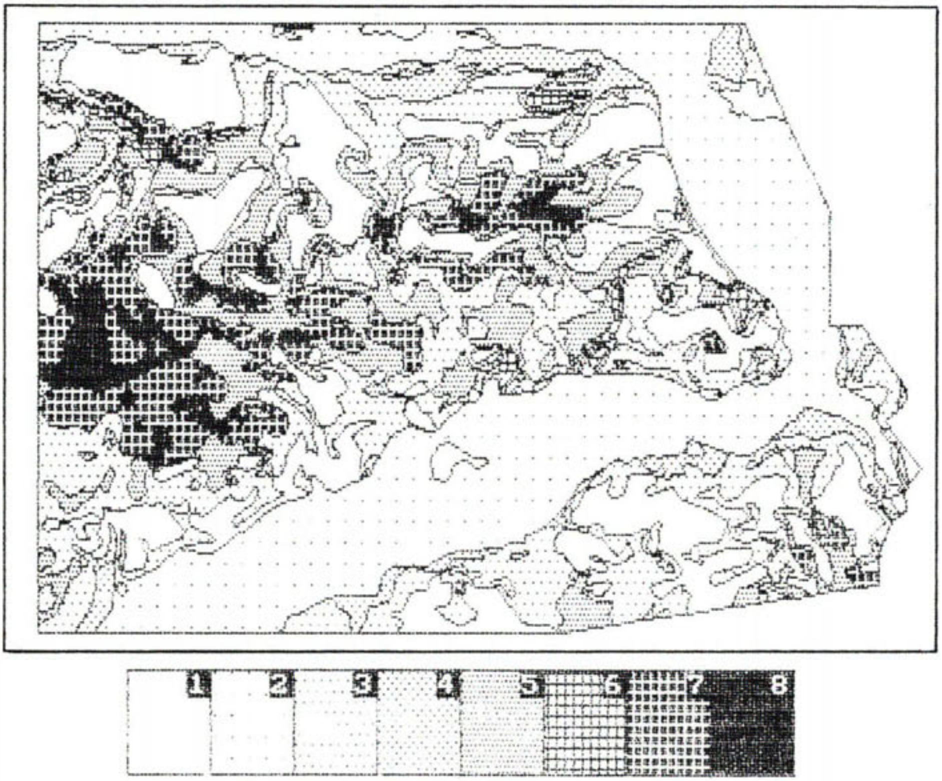

Fig.4. Potential decrease of table of the first groundwater level in years 1981-1988 on reclaimed land. 1 – 0 m; 2 – 0.5 m; 3 – 1m; 4 – 1.5 m; 5 – 2 m; 6 – 2.5 m; 7 – 3 m; 8 – 4 m. Scale 1:125 000. The SINUS geographic information system was applied for elaboration of this map

A critical assessment of the results presented may show that they have not been based on observations made in comparable periods. Thus, the mean monthly groundwater levels at Tykocin were examined in May and July in the hydrologic years 1980-1988 (Fig.5). It was noticed that the level of this water in July is usually lower than in May.

Thus, in order to compare the data from the two maps of hydroisobaths, the data obtained should be corrected by reducing them by the value of the seasonal decline of the table of these waters. In 1988 it amounted to 30 cm. Taking account of this value, the above-mentioned values of losses of groundwater resources for the bottom of the Narew valley should be estimated at 1.2 mln m^3, while for the upland area at 19.5 mln m^3. Thus, for this part of the area under investigation the loss of groundwater in the period 1981-1988 totals 16 cm per 1 m^2. The steadily declining groundwater level is also evidenced by decay of peats, as well as by more active aeolian processes on small dune hills within the confines of the Narew valley bottom.

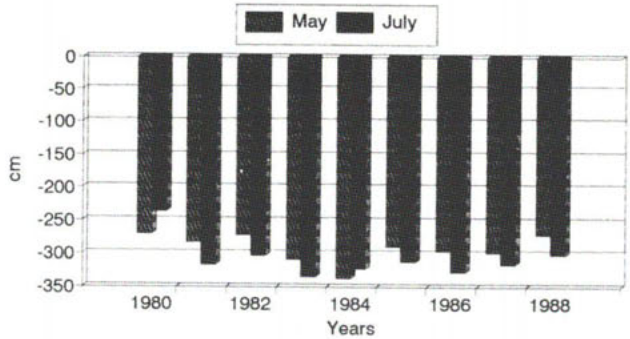

Fig.5. Depth of occurrence of table of the first groundwater level at Tykocin in May and July, in hydrological years 1980-1988 (after the IMGW data)

The third kind of data testifying to the diminishing table of the first groundwater level in this area results from the comparative analysis of hydrologic maps scaled 1:50 000 prepared in the years 1962-1968 and in the year 1987. The analysis permitted tentative conclusions on spatial tendency of changes of water relations in this area over two decades between 1968 and 1987 (Fig.6).

In this case the analysis took into account such hydrographic objects as morass areas, permanent marshes and periodic marshes.

Analysis of distribution of the above-mentioned hydrographic objects, in the areas under reclamation after 1968, situtated to the north of Warszawa-Białystok main road, showed that they occupied altogether an area of 34.5% of this part of land. In areas where land reclamation work was not conducted, they occupied 41.5% of the area.

After the soil reclamation work was completed, the proportion of morass areas in total acreage of the two areas under investigation decreased by 29.2% and 28.5% respectively. There was a considerable decrease in the area of swamps and permanent marshes (8.5% altogether in the reclaimed part). Paradoxically, the shrinkage of marshes and morass areas within the confines of the southern (unreclaimed) land was greater, amounting to 17%. Swamps and permanent marshes were replaced by periodic marshes. On the reclaimed land their total area increased by 10.7%, while on non-reclaimed land by 4%.

The quantitative analysis of changes in the area of the above-mentioned hydrographic objects indicates that a total area of morass land, which in the years 1962-1968 occupied 238.7 km^2 within the part of the Narew valley under investigation, shrank by 78.15 km^2 (32.7%) until 1987. Permanent marshes within the area of 90.7 km^2 (94.5% of their previous area) were turned into periodic marshes. Eighty-three percent of morass areas of the years 1962-1968 were turned into periodic marshes, while the remaining 17% into permanent marshes.

However, along with the above considerations doubts arise whether the

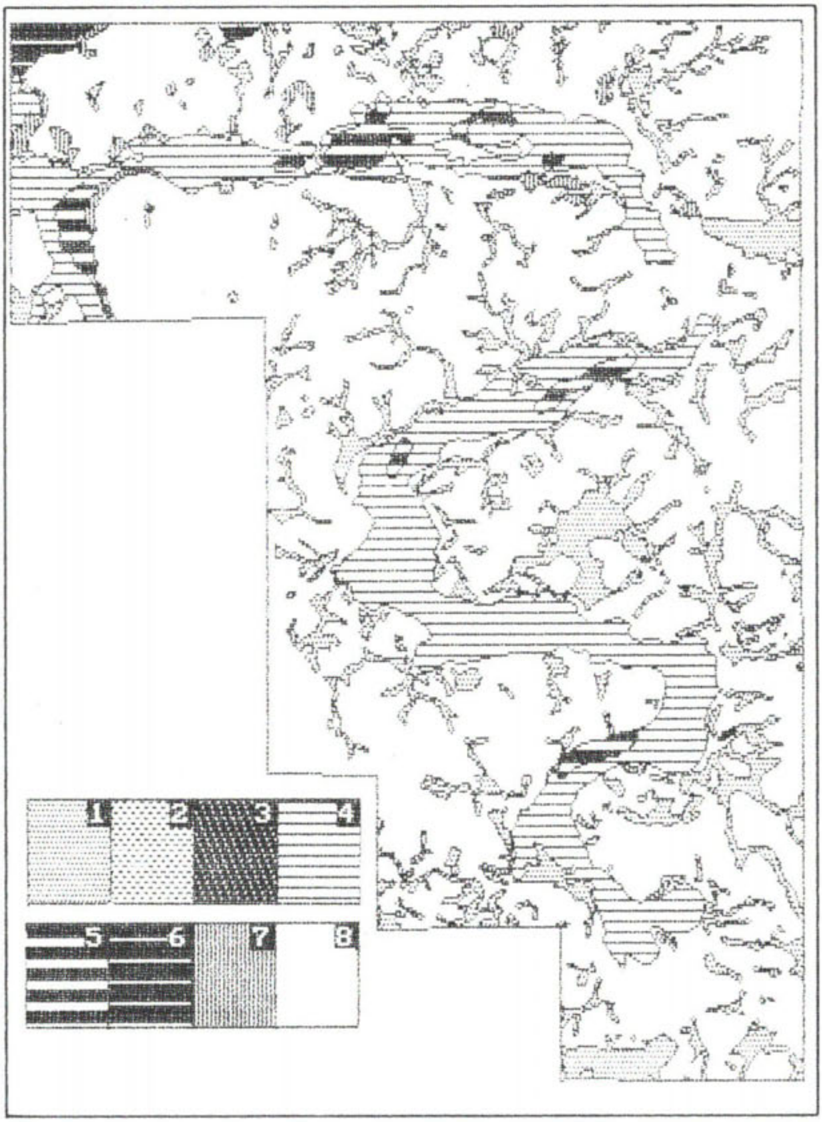

Fig.6. Changes of marsh and morass areas in period 1968-1987. 1 — Periodic marshes in 1968 — Reclaimed soil in 1987; 2 — Permanent marshes in 1968 — Reclaimed soil in 1987; 3 — Morass in 1968 — Reclaimed soil in 1987; 4 — Permanent marshes in 1968 — Periodic marshes in 1987; 5 — Morass in 1968 — Periodic marshes in 1987; 6 — Morass in 1968 — Permanent marshes in 1987; 7 — Dry ground in 1968 — Periodic marshes in 1987; 8 — other areas (after Hydrographic Map of Poland 1:50 000 (1962-1968) and Hydrographic Map 1: 50 000 (1987-1988). Scale 1:250 000. The SINUS geographic information system was applied for elaboration of this map

analyzed maps were prepared using identical criteria on the grounds of which the above-mentioned hydrographic objects were distinguished and hydroisobaths were drawn. These doubts concern only quantitative estimates of these changes, because qualitative changes and their tendencies are beyond discussion, which is confirmed by hydrologic data and satellite pictures. However, this is the issue of reliability of hydrological cartography which may not be evaluated until appropriate investigations are conducted. The analysis of historical records of the air photos might be useful in this case.

Summing up, it may be said that all the data presented in this paper show a declining groundwater table in recent years. The influence of soil reclamation in this area is significant. This effect is further strengthened by the precipitation shortage in the 1980s.

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