

MORPHOMETRIC AND PERFORMANCE CHANGES IN CATCHMENT  
OF MESOTROPHIC LAKE PIASECZNO IN 1839-1977  
ON THE BASIS OF HISTORICAL AND CURRENT  
TOPOGRAPHIC CARTOGRAPHIC MATERIALS

*Artur Serafin*

Department of General Ecology, Agricultural University, ul. Akademicka 13, 20-950 Lublin  
email: artur.serafin@ar.lublin.pl

**Abstract.** Changes of morphometric traits in lake Piaseczno are a resultant of climatic conditions, including atmospheric precipitations, as well as activities influencing the water balance within that region. Northern part of the lake, with a slight inclination of the lake bed, is the most vulnerable to transformations, because it is strongly susceptible to fluctuations of atmospheric supply and tensions of irrigation meliorations. Dynamic changes of Piaseczno shore line have an effect on all the morphometric elements, causing serious oscillation in their values. Changes in the catchment performance are mainly associated with practical management of its natural resources. The result is reducing the woodland and peat-bog along with increase of agrocenoses and recreational areas. Despite the extensive character of those transformations due to useless agricultural and permeable soils, agriculture and then recreation are considered as the general factors affecting the lymnological status of lake Piaseczno.

**Key words:** lake, morphometry, catchment management, cartographic materials

#### INTRODUCTION

Mesotrophic lake Piaseczno is a natural and landscape gem of the Łęczyńsko-Włodawskie Lake District and thus it has been used for many years for recreational purposes. Historical, social, and economic transformations within lake Piaseczno region caused changes in management and topography of its catchment, sometimes affecting (along with climatic factors) the change of morphometric parameters of the lake, which additionally determined its water trophy.

## MATERIAL AND METHODS

Cartographic analyses were made on the basis of comparison of topographic maps from different dates (1839-1977) achieved from the Institute of Geography, UMCS, Lublin:

1. „*Topographic Map of the Kingdom of Poland*” from 1839 being a result of topographic measurements made by Russian Corps of Military Topographers in 1828-1831 (1:126 000);
2. „*Military-Topographic Picture of Western Russia*” from 1887–1890 in German magnification to 1:25 000 on the basis of so-called „wiorstówka” (1:42 000), sheet No XXVI-13-F;
3. „*Karte Des Westlichen Russlands*” from 1915, sheet Łęczna, M-36; original (1:100 000);
4. „*Topographic Map of W. I.G.*” from 1937, sheet Łęczna, 43-36 (1:100 00);
5. „*Topographic Map of Poland*” from 1977, 136.21 Piaseczno, original (1:25 000) made by photogrammetric method on the basis of picture taken in 1976 – so-called “modern map”.

Due to the fact that topographic measurements were made in different ways – field and aerial – as well as at different map scales thus with different level of details, the cartographic analysis of lake Piaseczno requires some kind of scientific expertise. Therefore, the above maps were compared on the basis of readable traits of lake Piaseczno morphometry: shape, shore line development, lake surface area as well as range of general catchment elements (woodlands, wet areas, agrocenoses) and length of roads. Calculations served for preparation of schematic comparative maps (about 1:25 000) made using planimetric methods and millimetre tracing paper; results for subsequent cartographic measurements are presented in Tables 1 and 2.

## RESULTS

Analysis of the cartographic materials revealed that both the shore line that determines the shape of the lake and areas of studied topographic elements within its catchment have considerably changed. The most apparent differences occurred when comparing the oldest map (1839) to other ones, among which the differences were no so obvious (Tab. 1, 2).

For the map prepared in 1839, the diversity of lake Piaseczno shore line with elevated ratio of its development (1.32) determined its more complex shape. Low shape coefficient (0.31) with mean width of 467 m and maximum length of 1466 m indicated significant elongation of the lake (Tab. 1). Analysis of its topographic traits also confirmed that fact. Narrowing in longitudinal direction and widening

in central and northern part is apparent. Moreover, characteristic indentation of shore line of about 200 m deep directing to south-east was present, but it was not marked on subsequent maps. Complications of lake Piaseczno shape in that period and considerable elongation resulted in its lowest surface area among all analysed maps (68.8 ha).

**Table 1.** Morphometric traits of Lake Piaseczno on the basis of topographic maps from 1839-1977

Piaseczno Years	Area (ha)	Length (m)		Width (m)	Shape factor	Shore line	
		max.	max.	mean		Length (m)	Develop. (k)
1839	68.8	1466	740	467	0.31	3880	1.32
1887-1890	82.4	1525	750	589	0.38	3850	1.19
1915	88.7	1466	820	566	0.38	3866	1.16
1937	88.5	1466	820	569	0.39	3858	1.16
1977	84.7	1464	819	579	0.40	3788	1.16

**Table 2.** Area of particular elements of Lake Piaseczno catchment on the basis of topographic maps from 1839-1977

Piaseczno Years	Catchment elements (ha)			
	Forests, woodlands	Swamps, peat-bogs	Agrocenoses	Roads (m)
1839	151.87	58.37	37.18	6200
1887-1890	99.15	22.65	49.60	6175
1915	103.37	54.50	79.22	6200
1937	109.37	42.50	38.68	5825
1977	87.31	21.81	103.15	6525

Widening of the lake range in the northern and south-eastern direction can be seen in subsequent materials. It influenced increase of the lake surface area, higher values of shape coefficient indicating significantly lower lake elongation, as well as lower value of shore line development factor, which proves that it became more uniform.

The largest surface area was recorded on the map from 1915 (88.7 ha). In the 20<sup>th</sup> century, these values were moderately high, exceeding 84 ha. Maximum length was from 1464 m (contemporary) to 1525 m (1887-1890); at maximum width from 740 m (19<sup>th</sup> century) to 820 m (1915, 1937). Mean widths of the lake,

necessary to calculate the shape coefficient, were quite uniform (with the exception of 1839), and at the current value of 579 m (1977) they made the oscillations slight: from 566 m (1915) to 589 m (1887-1890). The above morphometric traits made the shape coefficient more uniform, from 0.38 (turn of the 19<sup>th</sup> century) to 0.40 (1977).

Length of the shore line associated with the complexity of the lake shape at the end of 19<sup>th</sup> and in 20<sup>th</sup> century was similar: 3788-3866 m, which, at appropriate ratio to the circle circumference of the same area as the lake, determined uniform values of the shore line development coefficient (1.16 in 19<sup>th</sup> century and 1.19 at the end of 19<sup>th</sup> century) – Table 1.

In 1839-1977, for readable topographic traits associated with the catchment management manners, apparent differences that may result from not uniform minuteness of compared maps and interpretational differences can be seen (Tab. 2). Estimated differences were related to all analysed topographic elements of the catchment and they were more obvious particularly for its natural components. Woodland, peat-bog, and swamp areas in the catchment of lake Piaseczno were the largest for the earliest period (1839). In 1887-1890, natural areas within the catchment decreased to 90.15 ha for forests and to 22.65 ha for wetland area, which determined general trends for further changes.

At the beginning of the 20<sup>th</sup> century, the area of above topographic elements in the catchment of lake Piaseczno was comparable to or lower than in the first half of 19<sup>th</sup> century: 103.37-109.37 ha for woodlands and 4.5-54.5 ha for swamps and peat-bogs. Nowadays (1997), the area of wetlands decreased to 21.8 ha, and the area of forests stopped at the level of 87.3 ha.

Small water reservoirs in the north-western part of the catchment, situated directly at lake Piaseczno shore line, are topographic elements marked on the contemporary topographic map. Field observations revealed that they are peat-bog holes incidentally filled with water of periodical character and making no permanent catchment element. A similar remark refers to melioration ditches marked in northern and southern parts in direct neighbourhood of the lake, that for many years have been grown with meadow and peat-bog plants, thus they do not function.

An increase of agrocenoses area occurred along with the decrease of the area of natural environment components, which is the consequence of economic and social activities associated with rural development. The largest agrocenoses area in lake Piaseczno catchment has been recorded lately (103.15 ha), while the smallest (37.18 ha) in the first half of 19<sup>th</sup> century. For other materials, calculated agrocenoses areas varied showing considerable progress at the turn of 19<sup>th</sup> century: from 49.6 ha at the end of 19<sup>th</sup> century to 79.2 ha in 1915. In 1937, the area of agrocenoses was lower (38.68 ha), which may be associated with low minuteness of analysed map.

The lowest road length within lake Piaseczno catchment (5825 m) was calculated for the material from 1937, whereas the highest (6525 m) for the current map. For other analysed maps, length of roads was comparable, ranging from 6175 m to 6200 m (Tab. 2).

#### DISCUSSION

Water relations associated with the atmospheric supply and human activity have had an influence on morphometric traits and management manner within lake Piaseczno catchment since 19<sup>th</sup> century.

Among anthropogenic factors, irrigation of the catchment area associated with digging the melioration ditches, and later the functioning of the Wieprz-Krzna Canal along with Lublin Coalmine Basin activities, which affected water relations within the entire Łęczyńsko-Włodawskie Lake District, were crucial (Serafin 2004). General changes referred to the northern part of shore line that, due to the significant shallowness of the lake bed, became very vulnerable to transformations and determined the fluctuations of other morphometric parameters values of lake Piaseczno.

Analysis of available source materials reveals that at the beginning of 20<sup>th</sup> century, lake Piaseczno was extremely clear and transparent, with oligotrophic features, and completely surrounded by forests (Lityński 1919). Although – on the basis of natural observations and physical parameters of lake water – the trophy status of lake Piaseczno was confirmed in subsequent years (Wilgat 1954, Fijałkowski 1959), analysis of topographic maps (both from the end of 19<sup>th</sup> and the beginning of 20<sup>th</sup> century) along with publications available later (Fijałkowski 1959) indicates considerable percentage of afforested wet areas adjacent to north-western shore and agrocenoses developing at the eastern shore of the lake. Therefore, it is contrary to earlier opinions on full forestation of lake Piaseczno shores. Current observations of the lake could also lead to biased conclusions that, although in reality 50% of the shore length is forested (Wilgat 1954), it is completely surrounded by woodlands. This results from the presence of tree and birch bands that do not meet the features of forest ecosystems, and in many cases they interfere with recreational investments or agrocenoses.

Analysis of maps prepared at the turn of 19<sup>th</sup> century reveals that the catchment of lake Piaseczno was characterized by significant percentage of its natural components, with a low share of agrocenoses at extensive agriculture associated with low-quality soils, could not considerably affect the change of the lake trophy character. In 19<sup>th</sup> and at the beginning of 20<sup>th</sup> century, anthropopression towards lake Piaseczno water was slight due to extensive agriculture (soil type), which is confirmed by analysis of the map prepared in that period, when the surplus of natural catchment

elements (forests, woods, and wet areas) over the agrocenoses was significant and apparent (Tab. 2).

The decrease of afforested areas took place in 20's and 30's of the 20<sup>th</sup> century in lake Piaseczno catchment as a result of colonization and agricultural management as well as wasteful exploitation of forests, and due to World War II (Chmielewski 2001), which is confirmed by comparison of analysed map from the first half of 19<sup>th</sup> century with later cartographic materials (Tab. 2). The decrease of wet areas resulted from the attempts of their agricultural utilization and was associated mainly with irrigation meliorations, which in 1915-1952 referred north-western and southern parts, and in 1952-1987 – northern part, leading to the reduction of the lake surface area along with wet areas within the catchment by about 10%.

Such transformations made the agrocenoses area increase from 37.17 ha in 19<sup>th</sup> century to 103.15 ha at present. Agrocenoses, due to low quality of permeable podzolic soils originated in the Pleistocene, despite not favouring the agricultural press intensification, played an enormous role in enriching the ground waters in biogenic elements (Misztal, Smal 1995). The soil performance status within the catchment, along with the attractiveness of Piaseczno surroundings, generates changes of catchment management into recreational and tourist. In 1976-92, area for recreation increased three-fold: from 4.3% to 13.3% of total catchment area at the cost of arable lands, and post-bog reservoirs and wet areas in northern part of the catchment got smaller as a result of low water levels (Furtak, Turczyński 1998). Part of these wet areas was irrigated by digging the ditch towards the lake passing along the eastern shore of peat-bog, and then covering the peat surface with several-tens-centimetre thick layer of coal loams from Coalmine "Bogdanka".

Afforestation of about 100 ha of post-agricultural land, namely in the north-eastern part of lake Piaseczno catchment in 1952-1992, was one of the positive changes in its performance management (Chmielewski *et al.* 1995).

## CONCLUSIONS

1. Changes in morphometry of lake Piaseczno are a resultant of atmospheric and anthropogenic factors influence, mainly associated with the agriculture and recreation.

2. Changes in performance management within lake Piaseczno catchment affecting its topography character are associated with the practical possibilities to exploit natural resources, which has an effect on increasing the agrocenoses area and, at present, lands for recreation.

## REFERENCES

- Chmielewski T.J., 2001. System of spatial planning harmonizing the nature and economy (in Polish). T. 1. Wyd. Politechnika Lubelska, Lublin.
- Chmielewski T. J., Sielewicz B., Butrym I., 1995. Structural and functional changes of lake ecosystems on the background of ecological structure changes within Poleski National Park region during past 40 years. (in:) Protection of aqueous ecosystems in Poleski National Park and surroundings (in Polish). Red. Radwan S. Wyd. TWWP, Lublin.
- Fijałkowski D., 1959. Plants of lakes in Łęczynsko-Włodawskie Lake District and adjacent peat-bogs (in Polish). Annales UMCS, sec.B, vol.XIV, 3, 131-207.
- Furtak T., Turczyński M., 1998. Changes in management of lake catchment on the example of lake Piaseczno. (in:) Łęczyńsko-Włodawskie lakes (in Polish). Natural monograph. Ed.: Harasimiuk M., Michalczyk Z., Turczyński M. Wyd. UMCS, PIOŚ, Bibl. Monit. Środ., Lublin.
- Lityński A., 1919. Preliminary report on investigations in the Łęczna-Włodawa Lakeland in July and August 1919 (in Polish). Przegl. Ryb., 1, 173-181.
- Misztal M, Smal H., 1995. Soils in Poleski National Park and surroundings (in Polish). (in:) Protection of aqueous ecosystems in Poleski National Park and surroundings. Red. Radwan S. Wyd. TWWP, AR, Lublin, 70-78.
- Serafin A., 2004. Impact of long-term changes in natural environment of catchment area on limnological status of Lake Piaseczno (in Polish). Ph.D. Dissertation. Typescript.
- Wilgat T., 1954. Łęczyńsko-Włodawskie lakes (in Polish). Annales UMCS, sec.B, 8.

ZMIANY W MORFOMETRII I W UŻYTKOWANIU ZLEWNI  
MEZOTROFICZNEGO JEZIORA PIASECZNO W LATACH 1839-1977  
NA PODSTAWIE HISTORYCZNYCH I WSPÓŁCZESNYCH  
TOPOGRAFICZNYCH MATERIAŁÓW KARTOGRAFICZNYCH

*Artur Serafin*

Katedra Ekologii Ogólnej, Akademia Rolnicza, ul. Akademicka 13, 20-950 Lublin  
email: artur.serafin@ar.lublin.pl

**Streszczenie.** Zmiany cech morfometrycznych jeziora Piaseczno są wypadkową warunków klimatycznych, w tym głównie opadów atmosferycznych oraz zabiegów wpływających na stosunki wodne tego rejonu. Najbardziej podatną na przeobrażenia jest północna część linii brzegowej o niewielkim nachyleniu masy jeziornej silnie reagująca na fluktuacje zasilania atmosferycznego i presję melioracji odwadniających. Dynamiczne zmiany przebiegu linii brzegowej Piaseczna wpływają na wszystkie pozostałe elementy morfometryczne jeziora decydując o niekiedy znacznych wahaniach ich wartości. Zmiany w sposobie użytkowania zlewni wiążą się głównie z praktycznym zagospodarowaniem jej zasobów naturalnych. Efektem tego jest zmniejszenie powierzchni leśnych i torfowisk, oraz zwiększenie arealu agrocenoz i terenów rekreacyjnych. Mimo ekstensywnego charakteru tych przemian zdeterminowanych mało przydatnymi rolniczo przepuszczalnymi glebami, właśnie rolnictwo, a w późniejszym okresie rekreację, traktuje się jako zasadnicze czynniki wpływające na status limnologiczny jeziora Piaseczno.

**Słowa kluczowe:** jezioro, morfometria, użytkowanie zlewni, materiały kartograficzne