

Mon-21-002

Hydrographic characteristics of the Shatsk Lakes according to the EU Water Framework Directive

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SUMMARY

Shatsk lakes are located in the north-west of Ukraine in the interfluvium of the Western Bug and Pripjat in the wetlands of the Upper Pripjat lowland. There are 28 lakes in the group. The borders of Poland and Belarus are nearby. The aim of the work was the typification of Shatsk lakes in accordance with the requirements of the Water Framework Directive of the European Union (EU WFD), taking into account the area of the water table, the height of the catchment area, the average depth and distribution of geological rocks. The results showed that very small in area (66%) and shallow in depth (87%) lakes prevail here. Although there are two large lakes in area and medium in depth (Svityaz and Pulemetske).



Introduction

Shatsk lakes, which are located in the interfluvium of the Western Bug and Pripjat, are of karst origin and are a unique natural complex of Volyn Polesie in Ukraine (Fig. 1). For the first time, detailed hydrographic survey of Shatsk Lakes was carried out by Polish scientists S. Lencewicz and E. Rühle in the 1930s, when this territory belonged to Poland.

In the 1970s, the study of Shatsk Lakes was associated with drainage reclamation in this region. In 1975, scientists of the Taras Shevchenko Kiev State University for the first time carried out complex and hydrochemical studies of various types of water bodies in the Shatsk region: lakes - Svityaz and others; drainage channels of the Kopaevskaya drainage system; underground aquifers of the Quaternary and Cretaceous horizons (Peleshenko et al., 1975). During these years, a scientists from the Institute of Hydrobiology of the Academy of Sciences of the Ukrainian SSR began to engage in research on the Shatsk Lakes. In 1983, the Shatsk National Natural Park was created, and comprehensive monitoring and research of lakes began. Scientists from the Lesya Ukrainka Volyn National University began to study the lakes (Ilyin, 2008; Fesyuk et al., 2020).



Figure 1 Map of the Shatsk Lakes (Volyn region, Ukraine); source: own elaboration.

The ecosystems of the Shatsk Lakes are among the best preserved among the plain landscapes of Eastern Europe. Due to the absence of large industrial facilities in the region, good water quality is maintained in large lakes. Therefore, this area has significant recreational potential, primarily due to the presence of water bodies.

Methods of research

For the study, materials from the Shatsk National Natural Park were used, the results of our own long-term expeditionary research on the Shatsk Lakes. The typification of Shatsk lakes was carried out in accordance with the requirements of the Water Framework Directive of the European Union (Directive 2000) according to the methodology for determining the bodies of surface and groundwater adapted in



XV International Scientific Conference "Monitoring of Geological Processes and Ecological Condition of the Environment"

17–19 November 2021, Kyiv, Ukraine

Ukraine (Methodology, 2019). The following parameters of the lakes were investigated: the area of the water surface, the average depth, the location by the height of the area, the type of geological rocks occurring in the area.

Results

Shatsk lakes are located in the interfluvium of the Western Bug and Pripjat in the wetlands of the Upper Pripjat lowland. Among the bedrocks, chalk and marl of the Upper Cretaceous age prevail, which leads to the intensive development of karst. This is also facilitated by atmospheric precipitation and groundwater, which circulate through cracks and form numerous ascending springs in the lakes. The Shatsk Lakes District includes 28 lakes with a total area of about 61.31 km² and a volume of water mass of 312.8 million m³. The Shatsk National Natural Park includes 23 lakes. The area of the lakes ranges from 0.01 km² to 26.21 km².

The largest and deepest are lakes Svityaz (maximum depth 58.4 m) and Pulemetske (19.2 m). With some exceptions, other lakes are shallow, with a flat bottom and depths not exceeding 7 m. The deepest lakes Svityaz, Pulemetske, PISOCHNE have narrow depressions in the basins (the depths - 20-50 m). The bottom of the lakes is sandy, and in deep places - muddy. The shores are mostly low, swampy, overgrown with vegetation. The average long-term amount of precipitation at the Svityaz meteorological station is 590 mm, with an amplitude of fluctuations ranging from 338 mm (1961) to 854 mm (1974). In Lake Svityaz, the water level for 2018-2019 decreased by 35 cm. In 2018, the amount of precipitation at the Svityaz meteorological station was 586 mm, and in 2019 - 505 mm.

The typification of the Shatsk lakes by the area in accordance with the requirements of the European Union Water Framework Directive (EU WFD) (Directive 2000) showed that there are 2 large lakes (Svityaz and Pulemetske), 6 - medium, 5 - small, 15 - very small. That is, very small amounts to 53% (Table 1). At the same time, in the basin of the Western Bug on the territory of Ukraine, lakes are very small, accounting for 71% (Khilchevskiy et al., 2019, 2021).

Table 1 Typology of Shatsk lakes by area in accordance with the requirements of the Water Framework Directive of the European Union

Lake type	Area, km ²	Number of lakes	Share of total, %
Big	10-100	2	7
The average	1.0-10	6	22
Small	0.5-1,0	5	18
Very small	< 0.5	15	53
Total		28	100

Large lakes: Svityaz, Pulemetske. *The average area of the lake:* Luky, Lucymer, Ostrivianske, PISOCHNE, Peremut, Krymne. *Small lakes:* Chorne Velyke, Somynets, Chorne Male, Karasynets, Ozertse. *The lakes are very small:* Velyke Pishchanske, Moshne, Prybych, Dovhe, Klymivske, Krugle, Lynovets, Gerasymove, Rytets, Zvedynka, Navrattia, Oleshno, Plotychchia, Piavochne, Male Pishchanske.

Table 2 Typology of Shatsk lakes by average depth in accordance with the requirements of the Water Framework Directive of the European Union

Lake type	Average depth, m	Number of lakes	Share of total, %
Deep	> 15	0	0
Average depth	3-15	4	14
Shallow in depth	< 3	24	86
Total		28	100



According to the EU WFD, in the Shatsk group, only two types of lakes are distinguished by depth: medium depth (3-15 m) - 14% of lakes; shallow (<3 m) - 86% of lakes (Table 2).

There are 4 lakes of medium depth: Svityaz, Pulemetske, PISOCHNE, Lutsymer. All the other 24 lakes of the Shatsk group are shallow.

The complete typification of Shatsk lakes according to hydrographic characteristics (water surface area, catchment height, average depth, distribution of geological rocks) made it possible to distinguish 5 types of lakes (Khilchevskiy et al., 2020):

- 1) large lakes in area on lowlands of average depth in silicate rocks (total 2 - Svityaz, Pulemetske);
- 2) medium-sized lakes by area in lowlands of medium depth in silicate rocks (only 2 - Lucymer, PISOCHNE);
- 3) medium-sized lakes in terms of area in the lowlands, shallow in depth on silicate rocks (4 in total - Luky, Ostrivianske, Peremut, Krymne);
- 4) small lakes in area in the lowlands, shallow in depth on silicate rocks (only 5 - Chorne Velyke, Somynets, Chorne Male, Karasynets, Ozertse);
- 5) very small lakes in terms of area in the lowlands, shallow in depth on organic rocks (15 in total - Velyke Pishchanske, Male Pishchanske, Moshne, Prybych, Dovge, Klymivske, Krugle, Lynovets, Gerasymove, Rytets, Zvedynka, Navrattia, Oleshne, Plotychchia, Piyavochne).

In addition to the well-known large and medium-sized lakes (Table 3), which most of all attract recreants, there are very small dystrophic water bodies with an area of 0.01-0.18 km² (15 lakes). Over the past 80 years, their parameters have decreased by 2 times (shallowing, overgrowth).

The lakes are at the stage of extinction, which requires the use of technical means to restore and maintain their stability (Fig. 2). The share of such lakes is 50% (for example, Piyavochne, Ozertse, Navrattya, Krugle, Dolge, Gerasymove, Klymivske, Male Pishchanske, etc.). They have already lost their natural state and recreational and tourist importance.

Table 3 Morphometric characteristics of large, medium and small lakes of the Shatsk group

Lake	Area, km ²	Volume, thousand m ³	Length, km	Width, km	Depth		Sapropel deposits, m
					average, m	maximum, m	
Svityaz	26.21	19070.0	7.81	3.36	6.9	58.4	2.5
Pulemetske	15.52	6363.2	6.06	2.56	4.1	19.2	2.3
Luky	6.42	4105.0	5.15	1.25	0.6	3.5	4.2
Lucymer	4.43	1949.2	3.10	1.43	3.4	11.0	4.2
Ostrivianske	2.11	4853.0	2.42	0.87	1.6	3.8	4.3
PISOCHNE	1.86	1283.4	1.85	1.00	4.0	16.2	3.1
Peremut	1.47	323.4	1.89	0.78	1.4	6.7	3.0
Krymne	1.41	408.9	2.15	0.65	2.9	5.5	3.0
Chorne Velyke	0.84	169.7	1.36	0.62	1.8	4.8	3.1
Velyke Pishchanske	0.54	884.0	1.31	0.41	1.1	3.0	3.9

In addition, due to drainage reclamation in the region, against the background of which there is a partial shallowing of lakes and, accordingly, an improvement in the growth conditions for hygrophyte and hydrophyte plants, the process of accumulation of bottom sediments is intensified. So, in lakes Krugle, Ostrivianske, Gerasymove, Zvedynka, Karasynets, Lynovets and others, the thickness of bottom sediments reaches more than 5.0 m, and the water layer is only 1.0-2.0 m (Ilyin, Pasichnyk, 2019).





Lake Piyavochne



Lake Navrattia

Figure 2 Dystrophic lakes of Shatsk Lakeland (2020); source: Shatsk National Natural Park.

Conclusions

1) The performed typification of Shatsk lakes by the area according to the requirements of the EU WFD showed that there are 2 large lakes (Svityaz and Pulemetske), 6 - medium, 5 - small, 15 - very small (only 28 lakes). That is, very small lakes make up 66%. 2) According to the average depth in Shatsk Lakes, there are only two types of lakes: average depth (3-15 m) - 13%; shallow (<3 m) - 87% of lakes. 3) Taking into account the area, the height of the catchment, the average depth, the distribution of geological rocks, there are 5 types of lakes.

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