

Typology of rivers and lakes within the Ukrainian part of the Vistula basin (Bug and San) and its compatibility with investigations in Poland

Typologia rzek i jezior ukraińskiej części dorzecza Wisły z zastosowaniem doświadczenia Polski

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Abstract: This article describes an investigation of the hydrographical network in the Ukrainian part of the transboundary basins of the Bug and San rivers entering the Vistula basin, carried out by the authors using the typology of rivers and lakes in line with the European Union Water Framework Directive (WFD) 2000/60/EC requirements. The typology of the rivers is based on the typology system adopted in Poland. There are 5 abiotic types in the Bug river basin specified within the Ukraine. The small and medium upland rivers on carbonate or loess rocks dominate. Among the large rivers are the Poltva, Rata, Luga and Ryta. Four abiotic types of rivers are distinguished in the Ukrainian part of the San basin. The most numerous group consists of the small upland rivers on flysch rocks of the Carpathians. The analysis of the structure of the river basin networks showed that the small rivers form 98,5% of the total number (3115 rivers) in the Vistula basin within the Ukraine. Only 1,25% of the basin's rivers form medium rivers. The percentages of large and very large rivers in the total basin streams are, respectively, 0,2 and 0,05%. There are 68 lakes within the Ukrainian part of the Bug basin, the majority of them (48 lakes, or nearly 71%) are in the category of very small lakes. As for the categories of medium and small lakes, each of them has 9 lakes (13%). There are only two large lakes, the Switiaz and Pulemetske (3%).

Streszczenie: W niniejszym artykule na podstawie badań hydrograficznych dokonano typologii rzek i jezior ukraińskiej części zlewni transgranicznych rzek Bug i San dorzecza Wisły zgodnie z wymaganiami WFD 2000/60/WE. Przeprowadzona typologia rzek opiera się na przyjętym w Polsce systemie typologii. W dorzeczu Bugu na Ukrainie zidentyfikowano 5 abiotycznych typów rzek. Dominują małe i średnie rzeki górskie na podłożu węglanowym lub lessowym, wśród dużych rzek – rzeki Poltwa, Rata, Ługa i Ryta. W ukraińskiej części zlewni Sana wyróżnia się 4 abiotyczne typy rzek. Najliczniejsza grupa składa się z małych rzek górskich na skałach fliszowych Karpat. Analiza struktury sieci hydrograficznej wykazała, że małe rzeki w dorzeczu Wisły na Ukrainie stanowią 98,5% (3115 rzek). Tylko 1,25% rzek dorzecza Wisły tworzą rzeki średnie. Udział dużych i bardzo dużych rzek w dorzeczu Wisły wynosi odpowiednio 0,2 i 0,05%. W ukraińskiej części zlewni Bugu znajduje się 68 jezior, z czego większość (48 jezior lub prawie 71%) dotyczy jezior bardzo małych. Jeśli chodzi o kategorie małych i średnich jezior, każda z nich obejmuje 9 jezior (13%). W zlewni Bugu są tylko dwa duże jeziora – Switiaz i Pulemetske (3%).

Key words: abiotic typology, Bug, San, WFD 2000/60/EC.

Słowa kluczowe: typologia abiotyczna, Bug, San, WFD 2000/60/EC.

INTRODUCTION

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The agreement of the Association between the European Union and Ukraine, signed in 2014, stipulates the employment of the European norms and standards, especially in the field of water use and protection. Water relations in the European Union are governed by a number of water-protection directives, of which the basic document is the Water Framework Directive (WFD 2000/60/EC). According to the modern hydrographic zoning of Ukraine, the river basin area (River Basin District) is taken as the main hydrographic unit. In the ruling adopted by the Verkhovna Rada of Ukraine of 04.10.2016 the Law "On applying the corrections for certain legislative acts of Ukraine regarding



Fig. 1. The Bug and the San rivers in the Vistula basin
Rys. 1. Rzeki Bug i San na tle dorzecza Wisły

implementation of integrated approaches to water resources management on the basin principle", 9 districts of river basins are set: the Dnieper, the Dniester, the Danube, the Southern Bug, the Don, the Vistula and rivers of the Crimea, the Black Sea rivers and the rivers of Azov.

About 98% of river runoff is directed from Ukraine to the Black and Azov Seas. Runoff from the area of the Vistula river basin (the Bug and the San), which covers the territory of three countries – Ukraine, Poland and Belarus – is directed to the Baltic Sea.

International interest in the Ukrainian part of the Vistula basin motivates the necessity of following the compatibility (conformity) principle of surface water body typology studied in different countries, but within the limits of the same river basin, which is the Vistula. This problem is urgent, hence the involvement of

scientists of the Taras Shevchenko Kyiv National University, the Lesia Ukrainka Eastern European National University (Lutsk city) and the Polish Geological Institute (Polish Geological Institute-National Research Institute) in Warsaw city.

Analysis of problems under investigations. Although the area of the Vistula basin (Fig. 1), the surface waters from which are directed to the Baltic Sea, forms only about 2% of the Ukrainian territory, the interest in the basin water body studies, particularly in water quality in the last decades, is very significant. It should be noted that the fundamental work is "Hydrochemistry of Ukraine» (Horiev et al. 1995), which deals with the natural conditions of the chemical composition of surface waters, specifically of the Bug basin. In other works attention was paid to hydroecological problems within the Ukrainian part of the river basin (Kowalczyk, Chil-

czewski 2002; Zabokrytska et al. 2005; Zabokrytska 2006) and Belarusian part of the river basin (Tokarchuk, Tokarchuk 2010). The estimation of hydrographic network of the Vistula river basin district (the Bug and the San) is carried out in Ukraine as prescribed by the WFD 2000/60/EC requirements (Khilchevskiy et al. 2016). The questions of basin system implementation for the Bug water resources management are considered (Zabokrytska, Bondaruk 2007; Mushka 2013). An integrated characterization of lakes of the Shatsky National Park in the Bug basin is presented (Khomik 2013). The onset of hydro-chemical research of Shatsky lakes is characterized and the information is obtained on water quality (Khilchevskiy 2015).

As of now, the published works are not available, wherein the complex compatible hydrographical study over the Ukrainian and Polish parts of the Vistula basin would be carried out.

The purpose of this study is the implementation of abiotic typology of rivers and lakes of the Ukrainian part of the Vistula basin by catchment area and water surface area, as prescribed by the WFD 2000/60/EC requirements, as well as coordination of the results with those ones obtained in Poland.

The authors have some experience of such investigations on the Bug river basin, (Khilchevskiy et al. 2016), on the Ros river basin (tributary of the Dnipro) (Hrebin et al. 2015) and other methodological materials (Hrebin et al. 2013; 2016).

DATA AND METHODS

Typology of rivers by the EU WFD 2000/60/EC. Methodological approaches for performing typology of the surface water bodies are listed in Annex II of the WFD. There are two proposed typological systems: System A is based on the division of Europe into eco-regions and compulsory listing of qualification parameters (Illies 1978); System B foresees the use of parameters, except of obligatory ones, the series of additional features that are peculiar to natural conditions of concrete country.

Following the principle of compatibility, when typology of rivers is performed within the one river basin district for the Ukrainian part of the Bug basin, the classification adopted in Poland should be applied. The

typology of the surface water bodies of the Vistula basin is made on the basis of the above mentioned.

Typology of rivers in Poland has been developed at the Institute of Meteorology and Water Management in 2004 and is based on A WFD 2000/60 / EC with some added parameters of B system (Błachuta et al. 2010). Abiotic typology of rivers is made on the basis of three parameters: belonging to eco-region; relative height and geological conditions of drainage system; the catchment area.

The territory in Poland is assigned to four European eco-regions, modified on the basis of physical and geographic zoning (Kondracki 2001), of which the Vistula basin is assigned to three eco-regions: the Central Uplands, the Eastern and Central Plains.

The rivers in Poland are distributed according to relative height of drainage system into:

- mountain rivers – more than 800 m a.s.l. (above sea-level),
- upland rivers – 200-800 m a.s.l.,
- lowland rivers – less than 200 m a.s.l.

Geological drainage system type is classified on the basis of the 3 main types of rocks: siliceous (such as granite, gneiss, feldspar, etc.); carbonate; and organic. On the coast of the Baltic Sea, additional units are introduced – the coastal saline river waters and delta streams of the Zhulav Vistula.

The rivers of Poland are divided by catchment areas into:

- very large rivers – catchment areas over 10 000 km²;
- large rivers – 1 000-10 000 km²;
- medium rivers – 100-1000 km²;
- small rivers – 10-100 km².

Physical and geographical diversity of river drainage systems in combination with their catchment areas allow 26 abiotic river types to be distinguished in Poland.

Hydrography of the Bug and San rivers within the Ukraine. The Bug is a tributary of the second order of the Vistula river (a left tributary of the Narev river). The area of the Bug basin is 39 420 km², of which there are 11 205 000 km² in Ukraine (28,3% of the total area), representing 1,86% of the whole area of Ukraine. The total length of the Bug river is 772 km, of which 404 km are in Ukraine. Its basin extends from the southeast to the

ARTYKUL PROBLEMOWY

northwest over the territory of three countries: Ukraine, Poland and Belarus (Table 1). In Ukraine and Belarus the Bug river is known as the Western Bug.

The source of the Bug is in Ukraine, within the northern edge of the Volyn-Podolsk Upland (Holohory-Kremenetskaya ridge, Lviv plateau), near the Verkhobuzh village of Zolochiv district, Lviv region. From the source to Ustilug city of Volyn region the Bug has an upland nature, when flowing through the hilly, very rough terrain. Downstream from the Ustilug city the Bug River flows through a wide valley and has a typical flat nature.

The Ukrainian part of the Bug basin is situated within the two regions of Ukraine – Volyn and Lviv (Table 2), and is bordered in the south-west by the San river basin, in the south by the Dniester river basin and in the east by the Prypiat river basin. It is bordered in the north by Belarus, and on the west by Poland.

The San river is the right tributary of the Vistula river. It flows both in Ukraine and in Poland. The total length is 458 km, of which 56 km is within the area of Ukraine. Total area of the San river basin is equal to 16 861 km², of which 2 471 km² is within the Ukraine (Table 3).

RESULTS

Typology of the Bug river basin rivers. The Bug river basin is mainly located within the Eastern Baltic-Belarusian and Central-Polish Lowlands on morainic old glacial deposits. Only the upper part of the basin is occupied by chalky deposits in the Volyn-Podolsk Upland areas, as well as a small area of Lublin-Lviv Upland with eolian soils.

In the Polish part of the Bug basin one can distinguish 7 abiotic types of rivers (Soszka et al. 2007):

- 1) small upland rivers on carbonate rocks of the Central Uplands and Plains;
- 2) small lowland rivers on eolian soils of the Central and Eastern Plains;
- 3) small lowland rivers of juvenile- and old glacial landscapes of the Central and Eastern Plains;
- 4) medium and large lowland rivers of old glacial landscapes, as well as on the eolian soils of the Central and Eastern Plains;
- 5) very large lowland rivers of juvenile- and old glacial landscapes, also on eolian soils of the Central and Eastern Plains;

Table 1. Morphometric characteristics of the Bug river basin within the Ukraine, Poland and Belarus

Tabela 1. Charakterystyka morfometryczna zlewni rzek Bug i San dorzecza Wisły w obrębie Ukrainy, Polski i Białorusi

| Country / Total | Length of the river within country / total, km | Specific part of country in a total length of river, % | Basin area within the country/ total, km ² | Specific part of the country in a total basin area, % |
|------------------------|--|--|---|---|
| Ukraine | 404 (220*) | 52 (28*) | 11205 | 28 |
| Poland | 214 | 28 | 17815 | 46 |
| Belarus | 154** | 20** | 10400 | 26 |
| Bug across 3 countries | 772 | 100 | 39420 | 100 |

Note: * - frontier section of the river between Ukraine and Poland;
** frontier section of the river between Belarus and Poland.

Table 2. Morphometric characteristics of the Bug river basin within Ukraine

Tabela 2. Charakterystyka morfometryczna zlewni rzeki Bug w obrębie Ukrainy

| Region / total | Length of the river within the region/ total, km | Specific part of region in a length of Ukrainian part of river, % | Basin area within the region/ total, km ² | Specific part of region in area of Ukrainian part of basin, % |
|---|--|---|--|---|
| Lviv | 184* | 45 | 6586 | 59 |
| Volyn | 220** | 55 | 4619 | 41 |
| The Bug river in the territory of Ukraine | 404 | 100 | 11205 | 100 |
| The Bug river basin in the territory of Ukraine, Poland and Belarus | 772 | - | 39420 | - |

Note: * - 154 km – over the Lviv region area and 30 km along the administrative border of Lviv and Volyn regions ** - boundary between Ukraine and Poland.

Table 3. Morphometric characteristics of the San river basin within Ukraine and Poland
Tabela 3. Charakterystyka morfometryczna zlewni rzeki San w obrębie Ukrainy i Polski

| Country /total | Length of the river within country / total, km | Specific part of country in a total length of river, % | Basin area within the country/ total, km ² | Specific part of country in a total basin area, % |
|----------------|--|--|---|---|
| Ukraine | 56 (55*) | 12 | 2471 | 15 |
| Poland | 402 | 88 | 14390 | 85 |
| Всього | 458 | 100 | 16861 | 100 |

Note: * - frontier section of the river between Ukraine and Poland.

6) small rivers in valleys of large lowland rivers with active peat formation process;

7) medium and large rivers in valleys of large lowland rivers with active peat formation process.

The Bug river within Poland belongs to the category of very large lower-course rivers with a meandering river bed, with a flat, spreading and often swamped floodplain. Swamping is common also for 40% of the Bug tributaries – small and medium-sized lowland rivers. The small lowland rivers on sandy substrata are dominant within the juvenile-glacial landscapes in the near-river bed part of the Western Bug river basin. Small and medium upland rivers on carbonate or loess rocks make up only 12% of the Bug tributaries and are concentrated in Volyn-Podolsk Upland.

With the Polish experience of abiotic typology of rivers, the five types of abiotic rivers in the Bug basin within the Ukraine are identified:

- small upland rivers on carbonate rocks of the Central Uplands and Eastern Plains;
- small lowland rivers on eolian soils of the Eastern Plains;
- small lowland rivers of old glacial landscapes of the Eastern Plains;
- medium and large lowland rivers of old glacial landscapes, as well as on eolian soils of the Eastern Plains;
- very large lowland rivers of old glacial landscapes, also on eolian soils of the Eastern Plains.

In accordance with typology carried out in accordance with the EU WFD, there is a very large river in the Bug basin within the Ukraine – the Bug itself, (its length within the Ukraine is equal to 404 km, catchment area – 11 205 km²) and the following major rivers: Poltva – 60 km, 1 440 km²; Rata – 76 km, 1 820 km²; Luga – 89,1 km, 1 351,4 km². The Poltva and the Luga basins are completely located within the Ukraine, but the source of

the Rata River is on the Poland Sub-Carpathian Voivodstvo a few kilometers from the Ukrainian-Polish frontier; correspondingly, the upper part of the river basin area, being equal to about 50 km², is spaced within the neighbouring country. It should be noted that within the Volyn region Shatsk district another large river (according to the typology complying with the WFD), the Rita river, which is the left tributary of the Mukhavets River, rises from the Krymne Lake. The Mukhavets, in its turn, is the right tributary of the Bug River within Belarus. The total length of the Rita river is 76 km (of which only 1 km is within the Ukraine), and its catchment area is 1 730 km² (271 km² is within the Ukraine). Resulting from the drainage land reclamation, the river bed was converted into a stream channel, excluding 3,5 km of the near-river bed area. Thus, four rivers in the Bug basin within the Ukraine can be attributed to the category of the large rivers.

Within the limits of the Ukrainian part of the Bug basin, there are also 30 medium rivers (catchment area from 100 to 1 000 km²) and 44 small rivers (up to 100 km²) with a length of 10 km and more. Eight small rivers do not have their own names. Besides, the Bug basin includes 1 960 small rivers with a length of less than 10 km (Palamarchuk, Zakorchevna 2006).

In total, there are 2 045 rivers in the Ukrainian part of the Bug river basin, of which 2 010 are small rivers (98,3%). The length of the overwhelming majority of them (1 966 small rivers) does not exceed 10 km. Only 1,45% fall in the category of medium rivers. The share of large and very large rivers of the total river quantity falls, respectively, 0,2 and 0,05% (Table 4).

Typology of the San basin rivers. The San is the largest Carpathian tributary of the Vistula river. The greater part (85%) of the San basin is situated in Poland. The source of the San river is in the Western Beskids within the Ukraine.

ARTYKUL PROBLEMOWY

There are 10 abiotic river types distinguished in the Polish part of the San River basin:

- i. small upland rivers on eolian soils of the Central Uplands and Plains;
- ii. small upland rivers on carbonate rocks of the Central Uplands and Plains;
- iii. medium upland rivers on eolian and/or carbonate rocks of the Central Uplands and Plains;
- iv. small upland rivers on flysch rocks of the Carpathians;
- v. medium upland rivers on flysch rocks of the Carpathians;
- vi. large upland rivers of the Carpathians and Eastern Plains;
- vii. small lowland rivers on eolian soils of the Central Uplands and Eastern Plains;
- viii. small lowland rivers of juvenile and old glacial landscapes of the Central and Eastern Plains;
- ix. medium and large lowland rivers of old glacial landscapes, as well as on eolian soils of the Central and Eastern Plains;
- x. very large lowland rivers of juvenile and old glacial landscapes, also on eolian soils of the Central and Eastern Plains;

The largest group within the Polish part of the San basin contains the small upland rivers on flysch rocks of the Carpathians and the small lowland rivers of juvenile- and old-aged glacial landscapes of the Central and Eastern Plains.

By applying the Polish experience in abiotic typology for rivers in the San basin within the Ukraine there were 4 abiotic types of rivers identified:

- small upland rivers on flysch rocks of the Carpathians;
- medium upland rivers on flysch rocks of Carpathians;
- large upland rivers of Carpathian and Eastern

Plains;

- very large lowland rivers of juvenile- and old-aged glacial landscapes, also on eolian soils of the Central and Eastern Plains.

Within the limits of the Ukrainian part of the San basin there are 33 rivers with length above 10 km, plus 1 033 shorter stream-lets.

By the WFD typology, there is a very large river in the San river basin within the Ukraine – the San itself (its length within the Ukraine is 56 km, and catchment area: 2 471 km²) and two large rivers: the Vyshnia – 79 km long, 1 220 km² catchment area, and the Zavadiivka (Lubachivka) – 88,2 km, 1 129 km². Both of these are right bank tributaries of the San river, rising in Ukraine and emptying into the main river within Poland.

Within the Ukrainian part of the San river there are 9 medium rivers (catchment areas from 100 to 1 000 km²) and 25 small rivers (catchment areas up to 100 km²), with lengths within the Ukraine of 10 km and more. There are 4 unnamed channels among the small rivers. An additional 1 033 small rivers the Ukrainian part of the basin have a length less than 10 km.

Altogether, within the Ukrainian part of the San basin 1 070 rivers can be counted, of which 1 058 (98,9 %) are small rivers. The length of most of them (1 033 small rivers) is under 10 km. Just 0,8 % of all rivers of the basin form medium rivers. The percentages of large and very large rivers in the overall quantity of rivers in the basin are, respectively, 0,2 and 0,1 % (Table 5).

Typology of lakes attributed to the Bug and San basins. Typology of lakes in Poland was developed in 2004 at the Institute of Environmental Protection PAS, and like the other EU countries deals only with the larger lakes which occupy areas of 0.5 km² and above (Kolada et al. 2005).

The abiotic division of lakes in Poland is based on four parameters:

Table 4. Quantity of rivers to fit the categories (by WFD) within the Ukrainian part of the Bug river basin
Tabela 4. Ilość rzek w podziale na kategorie (zgodnie z WFD) w obrębie ukraińskiej części zlewni Bugu

| River category | Catchment area, km ² | Number of rivers of given category | % in a total number of rivers |
|----------------|---------------------------------|------------------------------------|-------------------------------|
| Very large | above 10 000 | 1 | 0,05 |
| Large | 1000 – 10 000 | 4 | 0,2 |
| Medium | 100 – 1000 | 30 | 1,45 |
| Small | Less than 100 | 2010 | 98,3 |
| Total | | 2045 | 100,0 |

Table 5. Quantity of rivers by certain categories within the Ukrainian part of the Bug river basin
Tabela 5. Ilość rzek w podziale na kategorie (zgodnie z WFD) w obrębie ukraińskiej części zlewni Sanu

| River category | Catchment area, km ² | Number of rivers of given category | % in a total number of rivers |
|----------------|---------------------------------|------------------------------------|-------------------------------|
| Very large | above 10 000 | 1 | 0,1 |
| Large | 1000 – 10 000 | 4 | 0,2 |
| Medium | 100 – 1000 | 30 | 0,8 |
| Small | less 100 | 2010 | 98,9 |
| Total | | 1070 | 100,0 |

- belonging to eco-region;
- geological conditions of drainage system;
- the relationship between catchment area and lake volume (Schnidler's coefficient);
- vertical stratification of water.

A number of WFD mandatory parameters, including water surface area, depth and relative altitude of lake catchment area, are not applied in the Polish typology. The feature of Polish lakes is their shallow depth (to 15 m), and the WFD classifies them into one category – shallow lake. All the Polish lakes, which occupy areas above 0,5 km², also belong to the same category according to elevation of the catchment area – low-lying lake, with a catchment elevation less than 200 m above level. 97% of the lakes are small and medium, with areas of less than 5 km².

The universally adopted approach, according to WFD EU, concerning territorial distribution into four eco-regions was found to be inappropriate for the conditions of Polish lakes, since all the lakes under study are concentrated only in the northern part of Poland. That is why the physical-geographical zonation is applied according to Kondracki (2001) and two lake regions are distinguished: the Central-Polish and Eastern-Baltic-Belarusian Lowlands. There are two sub-regions within the Eastern-Baltic-Belarusian lowlands: juvenile- glacial Lowlands and Polissya Plains.

The vast majority of lakes in Poland are located on glacial deposits. Due to uniformity of deposits, the geological parameter is replaced by a hydrochemical one – calcium content in water, either low (up to 25 mg/dm³) or high (over 25 mg/dm³).

According to Schnidler's coefficient the lakes of Poland can be classified into two categories – with strong and weak effect of drainage system. Threshold value is Schnidler's coefficient, which is equal to 2. The lakes at

the lowest level in the hierarchy can be distinguished in accordance with water exchange conditions into: stratificated and unstratificated.

Physical-geographical diversity of drainage system in combination with hydro-chemical features and conditions of water exchange allows for distinguishing 13 types of abiotic lakes in Poland.

In the Polish part of the Bug basin only the Vlodawskie White Bug Lake has an area of more than 0,5 km². It is attributed to Polissya Plain sub-region and falls into the category of high calcium content with clear vertical stratification of waters.

On evidence derived from the Water Resources Administration of Western-Bug River Basin located in Lutsk city (Zakhidno-Buzke 2016) there are 68 lakes in the Ukrainian part of the Bug basin, most of which (48 or about 71%) are classified to the category of very small, with areas less than 0,5 km² (Table 6). Each of the other two categories - medium and small lakes - has nine lakes (13% of the total number).

Within the Ukrainian part of the Bug basin there are only two large lakes, the water surface area of which lies in the range 10 to 100 km². This is the Switiaz lake (area of water surface equals to 26,2 km²) and the Pulemetske lake (15,7 km²). Both of them are attributed to the Shatsk group, which includes roughly 30 lakes located in Shatsk district in the northwest of Volyn region.

Unlike the Bug basin, no natural basin with an area of over 0,5 km² is identified within the Ukrainian part of the San basin. On evidence derived from the Lviv Regional Water Resources Administration, within the limits of Ukrainian part of the San basin the existing 32 lakes of total area of 0.26 km², all belong to the category of very small lakes and are not subject to typology (Lvivske oblasne 2016).

ARTYKUŁ PROBLEMOWY

Table 6. Quantity of lakes by categories (according to WFD EC) within the Ukrainian part of the Bug river
Tabela 6. Ilość jezior w podziale na kategorie (zgodnie z WFD) w obrębie ukraińskiej części zlewni Bugu

| River category | Water surface area, km ² | Number of lakes of given category | % of total number of lakes |
|----------------|-------------------------------------|-----------------------------------|----------------------------|
| Very large | above 100 | - | 0,0 |
| Large | 10 – 100 | 2 | 3,0 |
| Medium | 1,0 -10 | 9 | 13,2 |
| Small | 0,5 -1,0 | 9 | 13,2 |
| Very small | less 0,5 | 48 | 70,6 |
| Total | | 68 | 100,0 |

Because of the impossibility at this stage of using all necessary set of parameters (as to drainage system geology, the relationship between catchment area and volume of the lake, the vertical stratification of lake water), the closer typology of lakes within the Ukrainian part of the Bug and San basin cannot be completed.

SUMMARY

The typology of rivers, which has been made in line with European Union WFD and the typological system adopted in Poland, allows identification of: for the Bug Basin – five abiotic types of rivers within the Ukraine and seven abiotic types within Poland; for the San Basin – four abiotic types of rivers within the Ukraine and ten abiotic types within Poland.

By WFD EU the prevailing majority of small and medium upland rivers are on carbonate rocks or eolian soils. The Bug River itself is categorised as a very large river.

The largest group in the basin of the San consists of small and medium upland rivers on flysch rocks of the Carpathians. The San River belongs to very large rivers – Cherry and Zavadvivka (Lubachivka).

Overall within the Ukrainian part of the Bug basin there are 2 045 rivers, of which 2 010 (98,3%) are small rivers. The length of the vast majority (1966 small rivers) does not exceed 10 km. Only 1,45% of all basin rivers are medium ones. The percentages of large and very large rivers in the total number of rivers are, respectively, 0,2 and 0,05%.

Overall within the Ukrainian part of the San basin there are 1 070 rivers, of which 1 058 (98,9%) are small rivers. The length of the overwhelming majority, that is 1 033 small rivers, does not exceed 10 km. Only 0,8% of all basin rivers are medium ones. The percentages of

large and very large rivers in the total number of rivers are, respectively, 0,2 and 0,1%.

The comprehensive study of lakes in the Bug and San basins is at a slightly less comprehensive level in Ukraine, as compared to Poland. Available information relating to the lakes in the river basins under investigation is concerned with the water surface area.

There are 68 lakes within the Ukrainian part of the Bug basin, the majority of them (48 lakes or nearly 71%), when classified using the WFD, are related to the category of very small lakes. As for the categories of medium and small lakes, each of them has nine lakes (13%). There are only two large lakes, the water surface area of which equal from 10 to 100 km². These are the Switiaz and the Pulemetske Lake (13%).

Within the Ukrainian part of the San basin, no natural origin lake with an area of over 0.5 km² was identified. The existing 32 lakes with 0,26 km² of their total area are attributed to the category of very small lakes and are not subject to typology.

The prospects for future investigations: for the purpose of lake typology in the Bug basin within the Ukrainian territory, as prescribed by the WFD And classification system adopted in Poland, there is need for research on a set of parameters: e.g. geology of drainage system, relationship between catchment area and volume of lake, and the vertical stratification of lake water.

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