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Hydrographic characteristic of ponds distribution in Ukraine – Basin and regional features

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Abstract

The purpose of the research is to establish the total number of ponds in Ukraine and to analyse the territorial distribution in the administrative areas, as well as in the river basin districts, as the main hydrographic units of water management. Cadastral data of the State Agency of Water Resources of Ukraine regional offices as of 2019 was used in the research (as to Crimea, Donetsk and Luhansk regions we applied the data as of 2014). According the researches there are 50,793 ponds in Ukraine with a total water table area of 2,92899 ha and the volume of 3,969.4 mln m^3 of water in 2019. The quantitative distribution of ponds across Ukraine is unequal. Most of them are concentrated in the central part of the country (10.5% of the total number of ponds in the country are in Vinnytsia region). Least of them are in Luhansk region (0.7%). Almost half of the ponds are located in the Dnieper River Basin (48.5%). The lowest quantity of ponds is in the Black Sea Basin (1.2%). The regulation of river basins districts (the rivers of the Sea of Azov, Crimea and Black Sea Basins) reaches 0.71–0.77. As of 2019, 28% of the ponds are rented out. In order to identify the real status of the ponds (both quantitative and qualitative), their recreational role, the environmental impact and the regulation of the hydrographic network in Ukraine, it is necessary to increase the attention to ponds monitoring.

Key words: *pond, river basin district, river regulation, Ukraine*

INTRODUCTION

For centuries people have built dams on small rivers and brooks to create the ponds, which accumulated water for household needs and in order to provide water for water mills and etc. Today, ponds are used for various purposes – for irrigation, fishing, recreation purposes, for fire protection and etc. The main functional purpose of the ponds is the impact on the environment, as well as the microclimate of the surrounding area. In addition to the main functional purpose, ponds contribute to the reduction of maximum water discharges of rivers and temporary streams. The research has found that globally on the planet ponds cover a larger total area than lakes [DOWNING *et al.* 2006]. The European Pond Conservation Network (EPCN) was registered in Geneva to promote conservation and biodiversity of ponds in the changing European landscape in 2009 [CEREGHINO *et al.* 2014].

Analysis of the publications on the study of ponds in Ukraine as water bodies shows that more attention was paid to the hydrochemistry and hydrobiology of the ponds. This situation can be explained by the applied tasks to have a reliable information of ponds water quality for fishing. An important generalizing work was the monograph by KONENKO [1971], which reflects the general patterns of water chemical composition of Ukrainian ponds.

The interest in the quality of ponds water is also evident in present time in Ukraine, Poland, Belarus and Russia. The main impetus for such research is local fisheries [BONISŁAWSKA *et al.* 2013; YEVTUSHENKO, KHYZHNIAK 2012]. In addition, the researchers have interest in water quality and the ecological status of ponds because of their

high recreational potential [AFANASIEVA *et al.* 2010; PRAJS *et al*. 2010; ZHEZHERIA *et al.* 2015]. The generalized ponds zoning has been implemented on the territory of Belarus [KIRVEL 2005]. The functional-genetic classification of ponds by its purpose, method of construction, geomorphology, power sources and hydrological regime has been developed for the Central Black Earth region of Russia [MISHON 2003]. In the work by KHILCHEVSKYI [2017] an attempt was made to relate the hydrochemical classification of ponds in Ukraine with the functional-genetic classification. The average mineralization of water in ponds is growing from the northwest to the southeast: from 100 mg·dm^{-3} in the mixed forest zone to 600–1200 mg·dm^{-3} in the forest-steppe zone and 2000–5000 mg·dm^{-3} in the steppe zone.

Thus, ponds are a characteristic element of the agrarian landscape in Ukraine, and they are also found in urban park zones (there are 28 378 villages and 1 344 cities in the country in total) [Derzhstat Ukainy 2018]. That is why, in our research we try to answer the questions, which are important for water management – what is the total number of ponds in Ukraine and how are they distributed?

The purpose of the research is to establish the total number of ponds in Ukraine and to analyse the territorial patterns of their distribution in the administrative areas, as well as in the river basin districts, as the main hydrographic units of water management.

MATERIALS AND METHODS

The research used primary information about the ponds of the State Agency of Water Resources of Ukraine (Ukr. Derzhavne ahentstvo vodnykh resursiv Ukrainy) regional offices as of 01.01.2014 and 01.01.2019. The main characteristics that were statistically processed are the following: the number of ponds; the area of the water table; volume of water; ownership – ownership of territorial communities, rental by organizations. The materials were summarized according to the following principles: 1) by administrative areas – Crimea (data as of 01.01.2014) and 24 regions (in some areas of Donetsk and Luhansk regions as of 01.01.2014); 2) by nine river basin districts, which were highlighted during hydrographic zoning of the territory of Ukraine in 2016.

The distribution of ponds by river basin districts. In 2016, hydrographic zoning of the territory of Ukraine was performed in accordance with the requirements of the EU Water Framework Directive [Directive 2000/60/EC; KHILCHEVSKYI *et al.* 2019; Vodnyi kodeks 1995]. It is determined that the main hydrographic unit for integrated water management is the river basin districts (Fig. 1).

There are nine river basin districts (RBDs) established in Ukraine: Dnieper RBD – 1; Dniester RBD – 2; Danube RBD – 3; Southern Bug RBD – 4; Don RBD – 5; Vistula RBD – 6; RBD of the Crimea – 7; RBD of the Black Sea – 8; RBD of the Sea of Azov – 9.

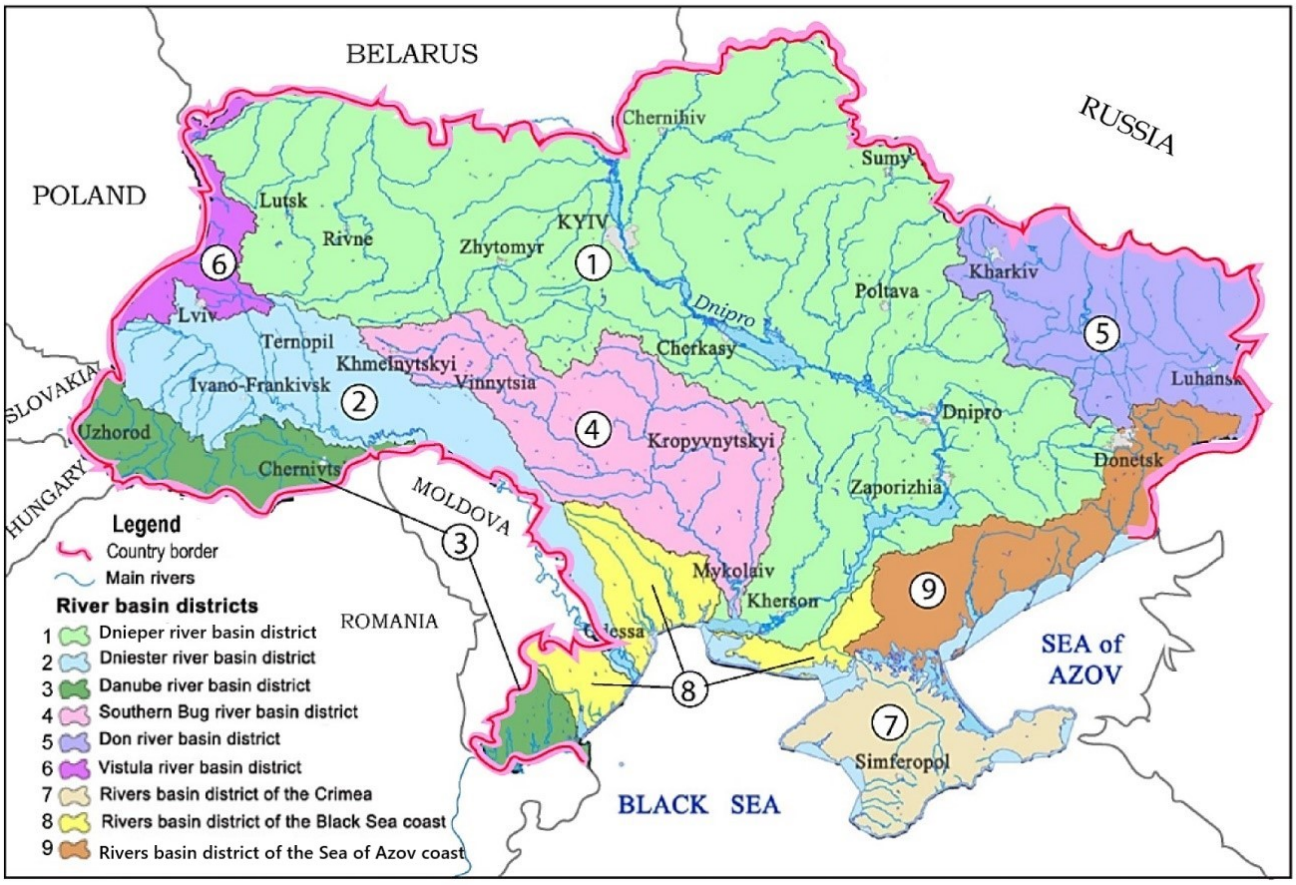

Fig. 1. Map of hydrographic zoning of the territory of Ukraine; source: MENR [2018]

RESULTS AND DISCUSSION

In Ukraine, a pond is an artificially created reservoir with a capacity not exceeding 1.0 mln m^3 [Vodnyi kodeks 1995]. Therefore, ponds are local importance water bodies (surface water that are located and used within the same area and are not considered national importance water bodies). Such low status of ponds, as water bodies, has led to the fact that their monitoring in Ukraine was not properly maintained. Until recently, the total number of ponds in the country was only 28.8 thous. [PALAMARCHUK, ZAKORCHEVNA 2006]. However, investigations (2014) in Ukraine showed that the number is 72% higher, – 49 444 ponds with a total water table area of 289 109 ha and a volume of 3 984.5 mln m^3 of water [HREBIN *et al.* 2014].

So, such a "hydrographic discovery" forced these investigations to be repeated in 2019 to verify the results. Unfortunately, the database doesn't contain information on annexed Crimea as well as in the temporarily occupied territories of Donetsk and Luhansk regions.

According to 2019 researches, there are 50 793 ponds in Ukraine with a total water table area of 292 899 ha and a volume of 3 969.4 mln m^3 of water (Tab. 1). As can be seen from the data of 2019 are slightly higher than in 2014, but quite close (the difference is 0.4–2.7%).

The distribution of ponds by administrative areas. The quantitative distribution of ponds across Ukraine is unequal (Tab. 2). They are located mostly on the territories of administrative regions of central and western Ukraine (forest-steppe zone): Vinnytsia – 10.5% of the total number of ponds in the country (5 341 ponds), Dnipropetrovsk – 6.5% (3 292 ponds), Kyiv – 6.3% (3 215 ponds) and Lviv – 6.3% (3 192 ponds) regions.

The least number of ponds of the total amount in the country is within Luhansk – 0.7% (362 ponds), Transcarpathian region has 1.3% (645 ponds), Ternopil region has 1.7% (886 ponds) and Odessa region has 2.0% (992 ponds).

According to the total surface area of the ponds, the leading positions in Ukraine are Vinnytsia – 8.3% (24 366 ha), Khmelnytskyi region – 7.4% (21 743 ha) and Poltava region – 6.8% (20 025 ha). The smallest is the total area of ponds in the Transcarpathian region – 0.5% (1 672 ha), Luhansk – 1.0% (2 832 ha) and Chernivtsi – 1.3% (3 945 ha).

In terms of the total volume of ponds, Ukraine's leading positions are occupied by Poltava region – 7.0% (279 mln m^3), Dnipropetrovsk region – 6.9% (274.8 mln m^3)

Table 1. The number of ponds in Ukraine and their parameters according to 2014 and 2019 researches

Year	Number	Area (ha)	Volume (mln m^3)
2014	49 444	289 109	3 969.4
2019	50 793	292 899	3 984.5
The absolute difference	1 349	3 790	15.1
Difference (%)	2.7	2.3	0.4

Source: own study.

Table 2. Availability of ponds within the administrative areas in the territory of Ukraine, 01.01.2019

Administrative area	Region area (km^2)	Number of ponds and their parameters			Rental ponds	
		number	area (ha)	volume (mln m^3)	% of total number	area (ha)
Autonomous Republic of Crimea[1)]	26 200	1 898	12 480	205.7	22	4 790
Vinnytsia	26 513	5 341	24 366	248.0	10	4 640
Volyn	20 144	1 119	5 342	57.8	50	3 128
Dnipropetrovsk	31 914	3 292	18 812	274.8	25	7 661
Donetsk[1)]	26 517	2 146	12 100	258.1	22	3 520
Zhytomyr	29 832	1 943	13 281	177.0	25	5 193
Transcarpathian	12 777	645	1 672	22.6	100	1 672
Zaporizhia	27 180	1 192	8 840	148.1	19	2 250
Ivano-Frankivsk	13 900	1 364	5 100	44.7	40	2 107
Kyiv	28 131	3 215	17 181	247.1	19	9 330
Kirovograd	24 588	2 788	17 317	246.5	40	8 646
Luhan[1)]	26 684	362	2 832	76.7	11	280
Lviv	21 833	3 192	9 440	105.1	17	1 990
Mykolaiv	24 598	1 172	9 259	99.7	32	4 065
Odessa	33 310	992	12 118	198,0	11	2 106
Poltava	28 748	2 691	20 025	279.0	27	3 971
Rivne	20 047	1 688	8 549	93.9	55	4 876
Sumy	23 834	2 192	11 389	125.3	24	4 615
Ternopil	13 823	886	5 629	58.8	41	2 921
Kharkiv	31 415	2 539	12 384	221.6	23	3 715
Kherson	28 461	1 154	12 317	152.4	2	1 324
Khmelnytskyi	20 645	2 917	21 743	200.9	44	9 325
Cherkasy	20 900	2 950	17 160	234	54	11 522
Chernivtsi	8 097	1 109	3 945	39.5	48	2 059
Chernihiv	31 865	1 807	8 960	147.4	7	939
Kyiv (city)	839	103	322	9.7	0	0
Sevastopol (city)[1)]	864	96	336	12.0	0	0
All over Ukraine	603 628	50 793	292 899	3 984.5	28	106 645

[1)] Data on the 01.01.2014.
Source: own study.

and Donetsk region – 6.5% (258.1 mln m^3). Vinnytsia region is only in the fourth place by this indicator – 6.2% (248 mln m^3). The lowest total value of the total volume of ponds is Transcarpathian region – 0.6% (22.6 mln m^3, Chernivtsi region – 1.0% (39.5 mln m^3) and Ivano-Frankivsk region – 1.1% (44.7 mln m^3).

Almost all rivers of Ukraine belong to the Black and the Sea of Azov Basins. But the Vistula RBD belongs to the Baltic Sea Basin and occupies only 2.5% of the territory of the country [KHILCHEVSKIY *et al.* 2019].

Almost half of the ponds of the total number in the country are concentrated in the Dnieper River Basin – 48.5% (24 634) – Table 3. The part of the Southern Bug River Basin has 19.6% (9 954 ponds), the Dniester River Basin has 11.6% (5 899 ponds). The least number of ponds is in the Black Sea Basin – 1.2% (656 ponds), in the Sea of Azov Basin there are 2.8% (1 417 ponds) and in the Vistula River basin there are 2.9% (1 459 ponds).

As to the total area of the ponds in Ukraine, the ratio between the river basin districts varies.

The part of the Dnieper Basin District is growing and is more than half of the total ponds area in the country – 53% (156 227 ha), the second position is the Southern Bug River Basin District – 19.3% (56 400 ha), and the Dniester River Basin takes the third place – 8.4% (24 622 ha). The smallest is the total area of ponds in the district of the Vistula River Basin – 1.5% (4 453 ha), in the Black Sea Basin – 1.9% (5 545 ha) and in the Sea of Azov RBD – 2.9% (8 378 ha).

Half of the total volume of ponds in Ukraine is in the Dnieper River Basin – 50.0% (1 998.2 mln m^3). The portion of the Southern Bug River Basin District is 17.3% (691.2 mln m^3). The districts of the Don and Dniester Basins have almost the same ponds volume – 7.8% (312.4 mln m^3) and 7.3% (290.7 mln m^3) respectively. The lowest total volume of ponds is in the district of the Vistula River Basin, it is 1.3% (49.9 mln m^3), in the Danube River Basin with 2.8% (110.1 mln m^3) and in the Black Sea Basin with 2.9% (115.2 mln m^3).

River flow regulation coefficient by artificial water bodies – *k*:

$$k = W_1 : W_2 \quad (1)$$

Where: W_1 = artificial water bodies volume (mln m^3), W_2 = river flow volume (mln m^3).

Regulation coefficient (*k*) for certain districts of Ukraine's river basins reaches: RBD of the Sea of Azov – 0.71; rivers of Crimea – 0.76; RBD of the Black Sea – 0.77. And on a large number of small rivers in the river basin districts of the Black Sea, the Sea of Azov, the Don, the lower part of the river basin districts of the Dnieper and the Southern Bug, the regulation coefficient reaches 1.0 [HREBIN *et al.* 2014].

Ponds are an integral part of the water fund of Ukraine. All water (water bodies) in the territory of Ukraine constitute the state water fund. However, individuals and legal entities may rent some water bodies. Thus, reservoirs (other than complex reservoirs), ponds, lakes and closed natural reservoirs may be provided for fishery, cultural, health, medical, recreational, sporting and tourism purposes and conducting research activities [Vodnyi kodeks 1995]. The process of renting in Ukraine began in 1999.

As of 01.01.2019, out of 50 793 ponds in Ukraine, 72% were owned by territorial communities, 28% were leased (Tab. 2, 3). In 2014, this proportion was slightly different: 64% and 36% [HREBIN *et al.* 2014].

As to the regions of Ukraine, the highest rents are in the Transcarpathian region – 100%. In the Rivne region 55% of ponds are rented, in Cherkasy region 54% are rented, in Volyn region 50% are rented. The lowest number of rented ponds is in Kherson region (2%), Chernihiv region – (7%), Odessa region – (11%) and Vinnytsia region – (10%).

Among the river basin districts, the highest number of rental ponds are in the Danube Basin – 68% and the Southern Bug River Basin – 34%. The lowest is in the regions of the Sea of Azov Basin (9%) and the Black Sea Basin (11%) respectively.

Morphometric characteristics of ponds. According to the classification of ponds by area proposed by MISHON [2003], the majority of ponds in Ukraine of to their area are very small (up to 2 ha) and small (from 2 to 10 ha). In some regions of the country their total number is from 75.1 to 92.6% of the total number of ponds. The number of middle ponds (with the area of 10–25 ha) varies from 6.2 to 16.2% in different regions. Large (over 25 to 50 ha) and very large (over 50 ha) ponds account for between 1.7 and 8.4% of the total area of ponds – Figure 2.

Table 3. Availability of ponds within river basin districts in Ukraine, 01.01.2019

River basin district (RBD)	Area RBD (km^2)	Number of ponds and their parameters			Rental ponds	
		number	area (ha)	volume (mln m^3)	% of total number	area (ha)
Dnieper RBD	296 315	24 634	15 6227	1 998.2	26	56 391.0
Dniester RBD	53 961	5 899	24 622	290.7	24	7 379.6
Danube RBD	30 625	1 965	10 071	110.1	68	5 263.8
Southern Bug RBD	63 700	9 954	55 811	691.2	34	24 629.0
Don RBD	55 273	2 815	14 976	312.4	25	4 364.0
Vistula RBD	12 892	1 459	4 453	49.9	25	1 443.5
RBD of the Crimea	27 218	1 994	12 816	217.7	21	4 790.0
RBD of the Black Sea coast	27 179	656	5 545	115.2	11	1 081.0
RBD of the Sea of Azov coast	36 866	1 417	8 378	199.1	9	1 303.0
All over Ukraine	604 742	50 793	292 899	3 984.5	28	106 645.0

Note: 604 742 km^2 = total area of nine river basin district (including coastal waters); 603 628 km^2 = the territory of Ukraine.
Source: own study.

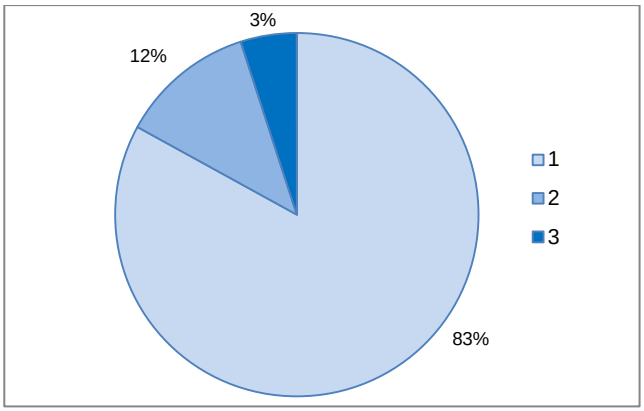

Fig. 2. Ponds in Ukraine by area: very small and small (1), middle (2), large and very large (3); source: own study

By the volume of accumulated water, the majority of ponds in Ukraine belong to very small (up to 10 thous. m^3) and small (from 10 to 50 thous. m^3). The total number of these two categories ranges from 41.9–56.1% in the southern regions to 53.1–73.2% in the northern ones. The number of middle ponds volume (from 50 to 200 thous. m^3) is from 19.1 to 39.2% in some regions. From 7.3–11.6% in the northern regions to 12.2–20.2% in the southern regions, with the total number of large ponds (the volume from 200 to 500 thous. m^3) and very large (from 500 thous. m^3 to 1.0 mln m^3).

General ponds status. According to the investigations of the State Agency of Water Resources of Ukraine, a significant part of the country's ponds are in poor technical condition. They were built mainly in 1960–1980 by simplified project documentation. They have earth dams with loose slopes and many of them are blurred. The hydraulic structures, as a rule, do not meet modern requirements.

The mudding of ponds is 10–25%, and in the southern steppe regions it reaches 50–60%. They were overgrown with aquatic vegetation, which led to a decrease in the volume and area of the water table. Most of small as to their area and shallow ponds lost their economic importance and turned into artificial evaporators, which waste water. This situation impedes the regulation and management of small river runoff and affects their hydrochemical regime [KHIL'CHEVSKII *et al.* 1994].

The water losses from additional evaporation from the surface of reservoirs and ponds are quite significant, especially in the area of insufficient humidity where they can reach 20–40% of the runoff volume of the rivers on which they are built in a very low water year. Given their poor technical condition as a result of prolonged exploitation, the question arises about the elimination of some of these reservoirs and their conversion to floodplain hayfields.

In 2013, the Ministry of Ecology and Natural Resources of Ukraine (Ukr. Ministerstvo ekolohii ta pryrodnykh resursiv Ukrainy) approved the “Procedure for developing a water body passport”. This passport provides for the establishment of morphometric, hydrochemical and technical parameters of the water body, hydrological characteristics of the river, where the reservoir is located. It also regulates ponds operational activities to ensure the working reliability of the hydraulic structures.

CONCLUSIONS

1. Ponds are very important artificial water bodies in Ukraine, as evidenced by their total number (50 793). The vast majority of ponds (75.1–92.6% – by area; 41.9–73.2% – by volume) belongs to the categories of “small” and “very small”.

2. The distribution of ponds throughout the country is associated with physico-geographical conditions, as well as the economic activity of the region at the time of the creation of water bodies. The highest indicators of the ponds number and volumes (6.2–7.0%) are in the administrative regions located within the forest-steppe zone (Poltava, Dnipropetrovsk, Donetsk, Vinnytsia), and the lowest are in Transcarpathia (0.2%).

3. The distribution of ponds and their volumes correlates with the size of river basin areas. The highest indicators of the volume of ponds are observed for the Dnieper River Basin region (50.0%), the lowest – for the Vistula River Basin region (1.9%).

4. Since 1999, ponds rental has been permitted in Ukraine. In 2019, 28% of ponds were leased. In regions, this indicator varies from 2 to 100% of rental ponds.

5. Moreover, in order to identify the real status of the ponds (both quantitative and qualitative), their economic and recreational role, the environmental impact and the regulation of the hydrographic network in Ukraine, it is necessary to increase the attention to comprehensive monitoring of the ponds.

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