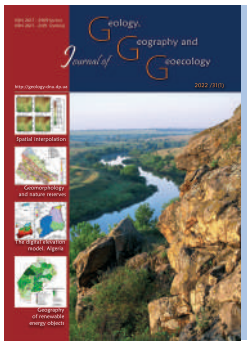

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Environmental assessment of the quality of surface waters in the upper reaches of the Pripyat basin in Ukraine using different methods

Valentyn K. Khilchevskyi[1], Iryna M. Netrobchuk[2], Natalya P. Sherstyuk [3], Myroslava R. Zabokrytska[2]

[1]*Taras Shevchenko National University of Kyiv, Kyiv, Ukraine,* hilchevskiy@ukr.net
[2]*Lesya Ukrainka Volyn National University, Lutsk, Ukraine,* iryna-nim@ukr.ne; mirazabor@ukr.net
[3]*Oles Honchar National University of Dnipro, Dnipro, Ukraine,* sherstuknp@gmail.com

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Abstract. The aim of the study is to assess the quality of river waters in the upper reaches of the Pripyat River in Ukraine using two methods of environmental assessment of surface water quality in the relevant categories and to identify the effectiveness of these methods. The main factors influencing the water quality of the upper reaches of the Pripyat River in the Volyn region in the absence of large industrial and municipal enterprises in the basin are: the location of quite large rural settlements on the river bank, many of which do not have centralized drainage; the impact of the water of the Turiya River, which is polluted by domestic wastewater in Kovel; development of farms during unsatisfactory condition of the reclamation network; increase of anthropogenic pressure due to construction and plowing of the river. In order to perform ecological assessment of river water quality in the upper reaches of the Pripyat River, the Methodology of Ecological Assessment of Surface Water Quality by Relevant Categories approved in 1998 in Ukraine (Methodology-1998) and the modernized version of this methodology developed in 2012 were used by Ukrainian Research Institute of Environmental Problems (methodology-2012). The second method contains improved evaluation method of water quality according to the criteria of salt composition of water, taking into account the hydrochemical zoning of Ukraine. Analysis of the results obtained by two methods showed that the average annual salt composition (I_1) quality of river waters of the upper Pripyat mainly corresponded to the 1st, 4th categories of I, III classes ("excellent", "satisfactory" by condition, and "very clean", "slightly contaminated" by the degree of contamination). According to troph-saprobiological (I_2) indicators – the 4th category of class III water quality ("satisfactory" by condition and "slightly polluted" by the degree of pollution). According to the indicators of specific substances of toxic water (I_3) – the 3rd, 5th category II, III classes of water quality ("good", "mediocre" by condition and "fairly clean", "moderately polluted" by the degree of contamination). According to the average annual values of integrated ecological indices (I_E), obtained by two methods, the water quality of the upper Pripyat was characterized by the 3rd, 4th categories of II, III classes ("good", "satisfactory" in condition and "sufficient", and "clean", "slightly contaminated" by the degree of contamination). The results of the assessment of the surface water quality of the upper reaches of the Pripyat River by two methods showed that the requirements of the method-2012 are higher to the salt composition of water than in the method-1998. According to this method, water quality was characterized by a worse class (III) compared to the method of 1998, according to which the quality of river waters in the upper reaches of the Pripyat corresponded to class I. Thus, the method-2012 sets stricter requirements for environmental assessment of river water quality, which can make it a more effective mechanism in the field of water protection.

Keywords: river headwaters, water quality, ecological assessment, methodology, index, Pripyat, Volyn region, Ukraine.

Екологічна оцінка якості поверхневих вод верхів'я басейну Прип'яті в Україні за різними методиками

В.К. Хільчевський[1], І.М. Нетробчук[2], Н.П. Шерстюк[3], М.Р. Забокрицька[2]

[1]*Київський національний університет імені Тараса Шевченка,* hilchevskiy@ukr.net
[2]*Східноєвропейський національний університет імені Лесі Українки, Луцьк, Україна, iryna-nim@ukr.ne;* mirazabor@ukr.net
[3]*Дніпровський національний університет імені Олеся Гончара, Дніпро, Україна,* sherstuknp@gmail.com

Анотація. Метою дослідження є оцінка якості річкових вод верхів'я р. Прип'ять в Україні за двома методиками екологічної оцінки якості поверхневих вод за відповідними категоріями та виявлення ефективності цих методик. Головними чинниками, що впливають на якість води верхів'я р. Прип'ять у межах Волинської області в умовах відсутності в басейні великих промислових та комунальних підприємств є: розташування на березі річки досить великих сільських населених пунктів, значна частина з яких не має централізованого водовідведення; вплив води р. Турія, що забруднюється господарсько-побутовими стічними водами м. Ковель; розвиток фермерських господарств в умовах незадовільного стану меліоративної мережі; збільшення антропогенного навантаження через забудову та розорювання заплави річки. Для виконання екологічної оцінки якості річкових вод верхів'я

Прип'яті використані офіційно затверджена в 1998 р. в Україні «Методика екологічної оцінки якості поверхневих вод за відповідними категоріями» (методика-1998) та модернізований варіант цієї методики, розроблений в 2012 р. в Українському науково-дослідному інституті екологічних проблем (методика-2012). У другій методиці вдосконалено блок оцінки якості вод за критеріями сольового складу води з урахуванням гідрохімічного районування території України. Аналіз отриманих результатів за двома методиками засвідчив, що за середньорічними показниками сольового складу (I_1) якість річкових вод верхів'я Прип'яті в основному відповідала 1-й, 4-й категоріям I, III класів («відмінні», «задовільні» за станом та «дуже чисті», «слабко забруднені» за ступенем забрудненості). За трофо-сапробіологічними (I_2) показниками – 4-й категорії III класу якості вод («задовільні» за станом та «слабко забруднені» за ступенем забрудненості). За показниками специфічних речовин води токсичної дії (I_3) – 3-й, 5-й категорії II, III класів якості води («добрі», «посередні» за станом та «досить чисті», «помірно забруднені» за ступенем забрудненості). За середньорічними значеннями інтегральних екологічних індексів (I_E), що отримані за двома методиками, якість води верхів'я Прип'яті характеризувалася 3-ю, 4-ю категоріями II, III класів («добрі», «задовільні» за станом та «досить чисті», «слабко забруднені» за ступенем забрудненості). Результати виконаної оцінки якості поверхневих вод верхів'я р. Прип'ять за двома методиками, показали, що вимоги методики-2012 є більш високими до показників сольового складу води, ніж у методиці-1998. За цією методикою якість води характеризувалася гіршим класом (III) порівняно з методикою-1998, за якою якість річкових вод верхів'я Прип'яті відповідала I класу. Таким чином, в методику-2012 закладено більш жорсткі вимоги при проведенні екологічної оцінки якості річкових вод, що може зробити її більш дієвим механізмом в галузі охорони вод.

Ключові слова: верхів'я річки, якість води, екологічна оцінка, методика, індекс, Прип'ять, Волинська область, Україна.

Introduction

The part of the main European watershed, which separates the surface runoff between the Baltic and Black Seas is located in the west of the Volyn region. The Buh River, which flows into the Vistula Basin and the Baltic Sea (Khilchevskyi, Zabokrytska**,** etc., 2018; Khilchevskyi**,** Grebin**,** etc., Zabokrytska**,** 2019), runs on the western heights of this watershed. The Pripyat River, the largest right tributary of the Dnipro (Black Sea basin), originates from the eastern routes of the main European watershed. The source of the Pripyat is near the village Budnyky of Kovel district. The river flows within the Kovel and Kamin-Kashyrski districts of Volyn region and Varash district of Rivne region. The names of districts are indicated in accordance with the reform of administrative-territorial districts in Ukraine in 2020 (Resolution of the Verkhovna Rada of Ukraine, 2020). Near Senchytsi village, Varash district, Rivne region, Pripyat crosses the state border with the Republic of Belarus, where it flows through the Polissya lowland in a valley of the Pinsk marshes. In the lower reaches (last 50 km) the Pripyat River flows into the Kyiv region (Ukraine) and near the city of Chornobyl flows into the Kyiv Dnipro Reservoir. The total length of the river is 775 km (254 km in Ukraine), the area of the basin is 114.3 thousand km^2 (68.37 thousand km^2 in Ukraine). According to the hydrographic zoning of the territory of Ukraine in 2016, the Pripyat River stands out as a separate sub-basin in the Dnipro basin (Khilchevskyi, Grebin, Sherstyuk, 2019).

A natural feature of the Pripyat sub-basin is that its upper reaches are located in the Volyn region of Ukraine. The formation of the chemical composition of river water begins here, the main features of which are preserved throughout the length of the river. The upper reaches of the Pripyat River in the Volyn region (72 km) have been transformed into the main canal of the Upper Pripyat drainage system (Kharakterystyka baseinu r. Prypiat, 2021) which is one of the largest canal in Europe. The Upper Pripyat hydroelectricity production plant is located in Volyn region. It provides water supply to the Beloozersk water system, which maintains the water level in the navigable Dnipro-Buh canal in the territory of Belarus.

The state of the headwaters is important for the entire river basin, as it has formed one of the largest natural wetlands in the Polissya region, characterized by high levels of biodiversity and is extremely valuable under the Ramsar Convention on Wetlands. In this regard, in 2007 the Pripyat-Stokhid National Nature Park was established in this territory, as well as in other protected areas of both local and national importance.

The main water and environmental problems of the Pripyat sub-basin are identified in the river basin management plan: pollution of water bodies with organic matter, nutrients, hydromorphological changes. The last ones are related to drainage reclamation in the 20th century, which led to the diversion of riverbeds, regulation of runoff (ponds, reservoirs), as well as flood protection (Holovni vodno-ekolohichni problemy, 2021).

Contamination of river water with organic matter and nutrients largely takes places due to point sources, among which the dominant role is played by domestic wastewater. In addition, in recent years there has been an active diversion of river banks and floodplains for country construction, gardening and horticulture on poor soils with the use of mineral fertilizers and pesticides. All this contributes to the growth of pollutants in the river and changes in the riverbed (Netrobchuk, Olasiuk, 2020).

Therefore, it is important to assess the quality of surface waters to determine their ecological status, as well as suitability for using it for various purposes. In addition, such an assessment is the basis for the determining of the anthropogenic load on the river basin, making appropriate management decisions in the field of use, protection and reproduction of water resources. It is also relevant for the preservation of unique wetlands of Volyn Polissya.

The state of problem's study

The Pripyat Basin attracts the attention of many researchers of both surface waters (Babych et al., 2002; Convention, 2013; Upravlenie, 2012) and groundwater (Brachet, Valensuela, 2012; Davybida, Tymkiv, 2020). Regional studies of the hydrochemical regime and surface water quality of the Pripyat basin in the context of the entire territory of Ukraine are presented in the works (Khilchevskyi, Peleshenko, 1987; Khilchevskyi et al., 2018; Khilchevskyi, Osadchyi et al., 2019; Khilchevskyi, Sherstyuk et al., 2020). The analysis of scientific publications also shows that the quality of river waters is determined not only by the content of chemicals, but also by the hydrological regime, which is determined primarily by climatic conditions. In particular, the studies (Daus, 2019; Vasylenko, 2010) revealed the impact of land drains amount on water quality and changes in the characteristics of spring floods of rivers on the right bank of the Pripyat. In addition, the scientific works (Morozova, 2011; Osadchyi, 2012), which revealed the peculiarities of the formation of the hydrochemical regime of the Pripyat River in summer and autumn and the chemical composition of water in water bodies of the National Nature Park Pripyat-Stokhid are noteworthy. The impact of the chemical composition of precipitation on water bodies of Ukraine, as well as long-term fluctuations in the chemical composition of surface waters and the relationship with climate change are analyzed in the works (Khilchevskyi, Kurylo et al., 2019; 2020).

A retrospective analysis of the dynamics of changes and assessment of the quality of surface waters of the upper reaches of the Pripyat and its right-bank tributaries within Western Polissya was performed in publications (Hopchak, 2017; Netrobchuk, 2007; 2014). Also, considerable attention is paid to the issues of assessing the state of surface waters of the Volyn region by the level of anthropogenic pressure, which are presented in studies (Netrobchuk, 2018 a; 2018 b; Yatsyk et al., 2019). Resources and quality of surface waters of Ukraine in the conditions of anthropogenic load and climate change are considered in the publication (Osadchyi, 2017).

A study of the possibilities of comprehensive assessment of water quality by different methods and identification of shortcomings of existing methods, including water pollution index, complex water pollution index, generalized environmental index was performed in the work (Urasov et al., 2007).

The analyzed works on the Pripyat basin used a methodology for assessing surface water quality by relevant categories, developed and approved by the Ministry of Ecology of Ukraine in 1998 (Metodyka, 1998). At the same time, in 2012 the specialists of the Ukrainian Research Institute of Environmental Problems developed and proposed a more innovative method for assessing water quality by relevant categories, taking into account the requirements of the EU Water Framework Directive 2000/60 / EC (Metodyka, 2012). Therefore, there is a need to conduct a study to assess the quality of surface waters of the upper Pripyat using this method.

The Purpose of the Study is to assess the quality of surface waters of the Pripyat River in Ukraine using two methods of environmental assessment of surface water quality in the respective categories (Metodyka, 1998) and (Metodyka, 2012), and to evaluate the effectiveness of these methods.

Materials and methods of research

The following sources of information were used to determine the ecological assessment of surface water quality in the upper reaches of the Pripyat River: the database of the State Agency of Water Resources of Ukraine "Chysta voda" (2013–2019) and ecological passports of Volyn and Rivne regions for 2013–2019 (Ecological passport of Volyn region, 2019; Ecological passport of Rivne region, 2019).

Assessment of river water quality was carried out by (Metodyka, 1998) and (Metodyka, 2012), which for ease of use in the text will be referred to as the method-1998 and method-2012. The 2012 methodology improved the unit for assessing water quality according to the criteria of water salt composition, taking into account the hydrochemical zoning of the territory of Ukraine.

The criterion basis for environmental assessment of water quality in the relevant categories of both methods is a system of classifications based on three blocks of indicators: salt composition of water; troph-saprobiological (ecological and sanitary) indicators of water; specific substances of toxic action water.

The block of indicators of salt composition of water (I_1) includes indicators: mineralization, chlorides, sulfates. Troph-saprobiological block includes: suspended solids, nitrogen, phosphorus, dissolved oxygen, biochemical oxygen demand (BOD_5). As there are no data on the presence and concentration of specific radiation substances in the surface waters of the Pripyat upstream, the assessment was performed only for specific substances of toxic water: iron (total), copper, manganese.

In general, the ecological assessment of water quality by both methods is: first, to determine the block indices of water quality for each of the three blocks – salt composition (I_1) of water, troph-saprobiological (I_2) indicators; specific substances of toxic water (I_3); secondly, in the implementation of the joint environmental assessment of water quality using the integrated environmental index (I_E) – is calculated as

the average of the sum of I_1, I_2, I_3; thirdly, these indices determine the affiliation of waters to a certain class and category of water quality using environmental classifications.

Mathematical, comparative-descriptive, cartographic methods using the computer program MapInfo Professional 8.0 were used for the research.

Main material presentation

The area of the upper basin of the Pripyat River is 3/4 of the area of the Volyn region. Pripyat has a well-developed hydrographic network. Most tributaries are fully or partially canalized as a result of drainage reclamation. The main tributaries of the upper reaches of the Pripyat in the Volyn region are the rivers Vyzhivka, Turiya, Tsyr, Stokhid, Styr (Kharakterystyka baseinu r. Prypiat, 2021). Characteristics of natural conditions in the upper reaches of the Pripyat River are covered in the works (Netrobchuk, Olasiuk, 2020; Zubkovych, Martyniuk, 2020).

Monitoring points. To study the quality of river waters in the upper reaches of the Pripyat, 6 points with available hydrochemical information were selected (Table 1).

Table 1. Monitoring points in the upper reaches of the Pripyat in the territory of Ukraine, according to which the ecological assessment of river water quality was performed according to (Metodyka, 1998) and (Metodyka, 2012)

River	Point	Where it flows	Region
Pripyat	Ratne	Dnipro	Volyn
Pripyat	Lyubyaz	Dnipro	Volyn
Pripyat	Senchytsi	Dnipro	Rivne
Vyzhivka	Yakushiv	Pripyat	Volyn
Turiya	Kovel	Pripyat	Volyn
Stokhid	Lyubeshiv	Pripyat	Volyn

Three major points were selected on the Pripyat River: Pripyat River – Ratne township; Pripyat – Lyubyaz village; Pripyat – Senchytsi village (Rivne region, border with Belarus). The 3 points were also selected on its tributaries: Vyzhivka River (right tributary of the Pripyat River) – Yakushiv village; Turiya River (right tributary of the Pripyat River) – Turiya town, Kovel; Stokhid River (right tributary of the Pripyat River) – Stokhid town, Lyubeshiv. Five points represent the state of river waters in the Volyn region. One point in the territory of Rivne region (Senchytsi village) is involved as the closed one.

Ecological assessment of water quality of the upper reaches of the Pripyat River in the relevant categories was performed in accordance with the average annual values of block indices according to the data of 2013–2019. The results of calculations are presented in the Fig. 1 and in the Table 2.

Assessment of water quality by block indices. It should be noted that according to the method of 2012 in the component structure of the water salt composition of water (I_1) hydrochemical regions were identified. Therefore, according to the zoning map of the territory of Ukraine for water mineralization (Metodyka, 2012), the upper reaches of the Pripyat River belong to the hydrochemical region – Southern and Eastern Polissya. Thus, the average long-term values of water mineralization for the upper reaches of the Pripyat River were 275 mg/l, which corresponds to the 2nd category of class II water quality ("very good" in condition, "clean" in terms of pollution). According to the chloride content, the water of the upper Pripyat River belongs to the hydrochemical region of Polissya and Zakarpattia. The average annual concentration of chloride ions in the waters of the upper Pripyat River was 34 mg/l and belonged to category 6 of class IV water quality ("bad" in condition, "dirty" in the degree of contamination).

Spatially, the waters of the Pripyat river are more mineralized in the eastern part of the basin, in particular in the observation point of Lyubyaz village with a long-term average of 269 mg/l and the highest rate (321 mg/l) in 2017. Among the tributaries, the highest rates of water mineralization of 275 and 341 mg/l, respectively, were recorded in the basins of the rivers Vyzhivka and Turiya. In addition, in terms of time, the highest water salinity of 427 mg/l was recorded in 2019 in the basin of the Turiya River, which is due to the relatively low rainfall during that year (Khilchevskyi, Kurylo et al., 2020).

The worst values of chloride ions 24 and 20 mg/l (2017) and 18.1 and 19.1 mg/l (2019) at an average long-term value of 17 mg/l, respectively, were recorded in the waters of the basin of the river Turiya river basin waters and Lyubyaz village. According to the information provided in the environmental passports of the Volyn region (Ecological passport of Volyn region, 2019) within which the basin chlorine is treated only those wastewater discharged into the river Turiya near Kovel. Thus, the increased content of chloride ions in the river Pripyat near Lyubyaz village can be explained by the impact of chlorine-contaminated waters of the Turiya River (Netrobchuk, 2018).

In the space-time aspect, the average annual concentration of sulfate ions ranged from 56 mg/l (2018) at the observation point of Ratne (central part of the basin) to 55 mg/l (2017) – Lyubyaz village at perennial averages of 43 and 42 mg/l, respectively. The worst value of 68 mg/l in 2016 was recorded in the water of the Stokhid river basin (eastern part of the basin). This shows that the worst (maximum) values of sulfate ions, in general, are inherent in those areas that are located near large settlements: Ratne, where wastewater (including that without treatment) is discharged into surface water bodies; village Lyubeshiv, where wastewa-

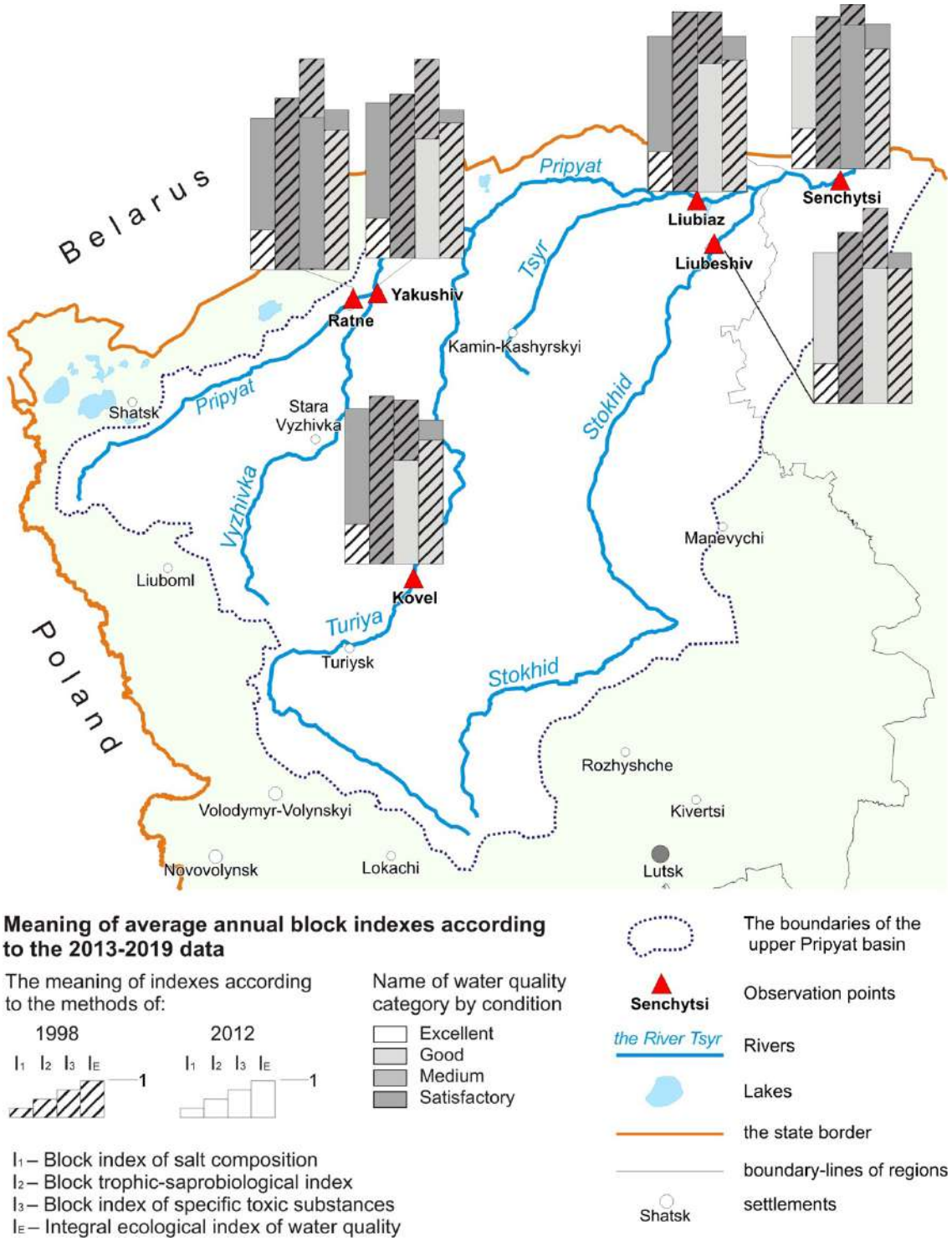

Fig. 1. Map of ecological assessment of surface water quality of the upper reaches of the Pripyat River (2013–2019) in the Volyn region (Ukraine) by (Metodyka, 1998) and (Metodyka, 2012).

ter enters the filtration fields, which are located near the river Stokhid.

The Fig. 2 shows that the average values of I_1 according to the methodology of 2012 varied from 3.5 (2014) to 4.1 (2017) and characterized river waters of the 3rd category of class II water quality ("good" in condition, "fairly clean" by the degree of pollution) and the 4th category of the III class of water quality ("satisfactory" in condition, "slightly polluted" by the degree of pollution). In 2018–2019, the value of I_1 decreased to 3.8, which corresponded to the 4th category of class III water quality "satisfactory", "slightly polluted" water with a tendency to "good", "fairly clean". Thus, there was a tendency to improve the salinity of water.

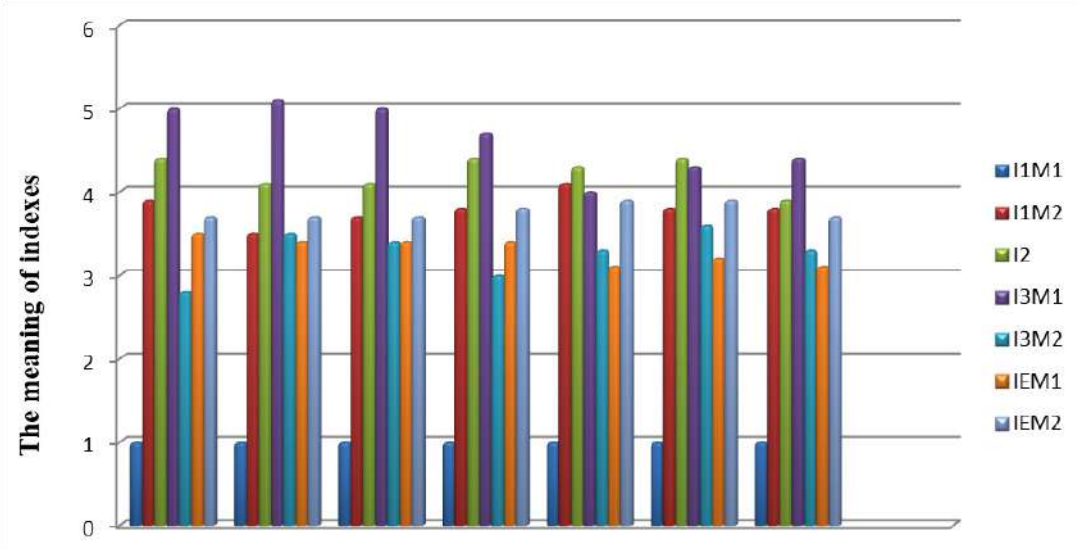

Fig. 2. Temporal dynamics of changes in water quality of the upper reaches of the Pripyat River (Volyn region, Ukraine) according to the average annual values of block (I_1, I_2, I_3) and ecological (I_E) indices according to the data of 2013–2019 M_1 – values of indices for methodology-1998; M_2- the value of indices according to the methodology of 2012.

Thus, using two methods (method-1998 and method-2012), the calculations of the average values of the indices of the block of salt water composition indicators (I_1) lived 1 and 3.8 (Table 2, Fig. 1) and characterized the surface waters of the upper Pripyat River of the 1st category of the I class of water quality ("excellent" in condition, "very clean" in degree of morbidity) and 4th category of the III class of water quality (satisfactory in condition, "weak disease" in degree of disease).

Table 2. Ecological assessment of water quality in the upper reaches of the Pripyat River (2013–2019) in Volyn region (Ukraine) according to the average values of block (I_1, I_2, 1_3) and integrated (I_E) ecological indices according to Methodology, 1998) and (Methodology, 2012)

Block and integrated ecological indices	Classes and categories of water quality according to ecological classification				Classes and categories of water quality according to ecological classification			
	Value of indices	category / class	Water quality by its nature state	Water quality by degree of its purity	Value of indices	category / class	Water quality by its nature state	Water quality by degree of its purity
Point	**Pripyat River – Ratne**				**Pripyat River – Lyubyaz**			
I_1	1.0*	1/I	excellent	very clean	1.0	1/I	excellent	very clean
	3.8**	4/III	satisfactory	slightly contaminated	3.9	4/III	satisfactory	slightly contaminated
I_2	4.3	4/III	satisfactory	slightly contaminated	4.5	4/III	satisfactory	slightly contaminated
I_3	5.3*	5/III	moderate	moderately contaminated	4.5	4/III	satisfactory	slightly contaminated
	3.8**	4/III	satisfactory	slightly contaminated	3.2	3/II	good	quite clean
I_E	3.5*	3/II	good	quite clean	3.3	3/II	good	quite clean
	4.0**	4/III	satisfactory	slightly contaminated	3.9	4/III	satisfactory	slightly contaminated
I_1	**Pripyat River – Senchytsi**				**Vyzhivka River – Yakushiv**			
	1.0*	1/I	excellent	very clean	1.0	1/I	excellent	very clean
	3.3**	3/II	good	quite clean	3.9	4/III	satisfactory	slightly contaminated

Block and integrated ecological indices	Classes and categories of water quality according to ecological classification				Classes and categories of water quality according to ecological classification			
	Value of indices	category / class	Water quality by its nature state	Water quality by degree of its purity	Value of indices	category / class	Water quality by its nature state	Water quality by degree of its purity
I_2	3.8	4/III	satisfactory	slightly contaminated	4.1	4/III	satisfactory	slightly contaminated
I_3	4.1*	4/III	satisfactory	slightly contaminated	5.0	5/III	moderate	moderately contaminated
	3.6**				3.0	3/II	good	quite clean
I_E	3.0*	3/II	good	quite clean	3.4	3/II	good	quite clean
	3.6**	4/III	satisfactory	slightly contaminated	3.7	4/III	satisfactory	slightly contaminated
Turiya River – Kovel					**Stokhid River – Lyubeshiv**			
I_1	1.0*	1/I	excellent	very clean	1.0	1/I	excellent	very clean
	3.9**	4/III	satisfactory	slightly contaminated	3.8	4/III	satisfactory	slightly contaminated
I_2	4.2	4/III	satisfactory	slightly contaminated	4.3	4/III	satisfactory	slightly contaminated
I_3	4.1*	4 /III	satisfactory	slightly contaminated	4.9	5/III	moderate	moderately contaminated
	2.6**	3/II	good	quite clean	3.4	3/II	good	quite clean
I_E	3.1*	3/II	good	quite clean	3.4	3/II	good	quite clean
	3.6**	4 /III	satisfactory	slightly contaminated	3.8	4/III	satisfactory	slightly contaminated

Note: * – assessment of water quality according to the method-1998; ** – assessment of water quality according to the method-2012.

The values of water quality measures by troph-saprobiological indicators in both methods do not differ. The average long-term value of the block index I_2 in all observation points in the upper reaches of the Pripyat was 4.2, which is the basis for classifying its waters as Category 4 water quality class III ("satisfactory" in condition, "slightly polluted" in degree) pollution). The Fig. 1 and the Table 2 show that in the spatial aspect the lowest indicator I_2 (3.8) was recorded at the observation point Senchytsi village. This corresponded to 4 (3) subcategories of class III water quality ("satisfactory", "slightly polluted" with a tendency to "good", "fairly clean"). However, the worst value of I_2 (4.5) was observed in the area with kindness – 4 (5) subcategories of water quality class III ("satisfactory", "slightly polluted" waters with a tendency to approach "mediocre", "moderately polluted"). Thus, the eastern part of the Pripyat River basin is more polluted than other parts of the river.

The average annual value of I_2 on the tributaries of the upper reaches of the Pripyat River ranged from 4.1 at the observation point at Yakushiv village (Vyzhivka river basin) to 4.3 at the observation post of Lyubeshiv village (Stokhid river basin). This corresponded to the 4th category of class III water quality ("satisfactory" in condition, "slightly polluted" in the degree of pollution). Fig. 2 shows that the average annual values of I_2 ranged from 4.4 in 2013; 2016 and 2018 to 4.1 in 2014–2015. I_2 was 3.9 in 2019, which showed a tendency to improve water quality.

Another indicator: iron (for northern Polissya, except for the rivers Goryn, Styr and Sluch) is included in the block index in the content of specific substances of toxic action water (I_3) of the methkd-2012. At the same time, the values of iron content were grouped into a larger gradation, which reduces the category of water quality. Regarding the values of other indicators in this block, everything remained unchanged. Thus, according to the zoning map of the territory of Ukraine in terms of iron content in the water, the upper reaches of the Pripyat River belong to the 2_{nd} hydrochemical region: northern Polissya (Metodyka, 2012).

Thus, the average annual concentration of iron in the waters of the upper reaches of the Pripyat River was 0.82 mg/l, which is four times higher than the MPC. Maximal values of total iron 1.19; 1.04; 2.44 mg/l recorded in the water near the villages of Ratne, Lyubeshiv and Senchytsi village on the border with Belarus. Such a high content of iron in the river waters of the upper Pripyat is due primarily to the influx of a chemical element from the floodplain swamps.

The average copper concentration was 0.01 mg/l. The maximal values were observed mostly in the eastern part of the basin, in particular near the village Lyubyaz (0.01 mg/l), Lyubeshiv village, Senchytsi village (0.01 mg/l). The average value of manganese concentration

was 0.13 mg/l. The maximal value of 0.54 mg/l was recorded at the border with Belarus.

The Figure 1 shows that in the spatial dynamics of the average values of the block of indicators of specific substances of toxic water (I_3), the values ranged from 4.1 near the Senchytsi village, Kovel to 5.0 (Yakushiv village) and 5.3 (Ratne village) for observation points on the Pripyat River according to the method-1998 with an average long-term value of 4.6. This gave grounds to classify river waters as the 4th and 5th categories of water quality class III ("satisfactory" and "mediocre" in condition and "slightly polluted" and "moderately polluted" in terms of pollution). The average values (I_3) determined by the method-2012 for many years ranged from 3.0 (Yakushiv) to 3.8 (Ratne) at an average value of 3.3 and characterized waters 3 and 4 category II and III classes of water quality "good" and "satisfactory" in condition and "fairly clean" and "slightly contaminated" in the degree of contamination). The Table 2 shows that the best (smallest) values of I_3 (2.6) were recorded in the area of Kovel, which is the basis for classifying the waters of the Turiya River to the 3rd category of class II water quality "good" in condition and "Quite clean" in the degree of contamination).

In the temporal aspect, the deterioration of water quality in the block of specific substances of toxic water at the observation points on the Pripyat River was observed in 2013–2016, and the improvements were recordered in river water quality since 2017–2019 (Fig. 2).

As it can be seen from the calculations based on the criteria for the content of specific substances of toxic water, according to the 1998 methodology, the river waters of the upper Pripyat are characterized by higher (worse) water quality categories compared to the modernized 2012 methodology.

Assessment of water quality according to the integrated ecological index. Thus, the average value of the integrated ecological index of water quality (I_E) for 2013–2019 for all observation points in the upper reaches of the Pripyat, respectively, according to two methods, was 3.3 and 3.8. This gave grounds to assign waters to the 3rd, 4th categories of II, III classes of water quality ("good", "satisfactory" in condition and "fairly clean", "slightly polluted" in the degree of pollution).

The Fig. 1, Table 2 shows that in the spatial aspect the highest average values of the integrated ecological index (I_E) on the Pripyat River and its tributaries (3.4; 3.5) and (3.8; 3.9), according to both methods, were recorded in observation points in Yakushiv village, Ratne township, Ratne township Lyubeshiv township, Lyubyaz village. This gave grounds to classify waters as categories 3 and 4 of water quality classes II and III ("good", "satisfactory" in condition, "fairly clean", "slightly polluted" in terms of pollution). The lowest average values of the integrated ecological index (I_E) according to both methods (3.0; 3.6) were recorded at the observation point Senchytsi village and 3.1; 3.6 – in the Kovel city. This corresponded to the 3rd, 4th categories of II, III classes of water quality ("good", "satisfactory" in condition, "quite clean", "slightly polluted" in the degree of pollution).

As shown in the Fig. 2 shows, the values of integrated environmental indices (I_E) on average values at observation points on the Pripyat River ranged from 3.1 (2017; 2019) to 3.5 (2013) according to the methodology of 1998 and from 3.7 (2013–2015; 2019) to 3.9 (2017; 2018) – according to the methodology of 2012. This corresponded to the 3rd, 4th categories of II, III classes of water quality ("good", "satisfactory" in condition, "quite clean", "slightly polluted" in the degree of pollution).

Thus, the water quality of the upper Pripyat in all observation points according to the 1998 methodology was characterized by stability during 2013–2016, i.e. corresponded to 3 (4) subcategories of "good", "fairly clean" water with a tendency to approach" satisfactory, "slightly polluted"). Starting from 2017–2019, there was a tendency to improve water quality to the 3rd category of water quality class II ("good" in condition and "fairly clean" in terms of pollution).

According to the 2012 methodology, the average values of integrated ecological indices (IE) also showed stability, i.e. water corresponded to the 4th category of water quality class III ("satisfactory" in condition and "slightly polluted" in terms of pollution) throughout the studied period.

The main factors influencing the water quality of the upper reaches of the Pripyat River in the absence of large industrial and municipal enterprises in the basin are: the location of large enough rural settlements on the river bank, many of which do not have centralized drainage; the impact of the water of the Turiya River, which is polluted by domestic wastewater; development of farms in unsatisfactory condition of the reclamation network; increasing anthropogenic load due to construction and plowing of the river floodplain (Netrobchuk, Olasiuk, 2020).

Conclusions

The study showed that the average annual salt composition (I_1), obtained by two methods, the water quality of the upper Pripyat, mainly corresponded to the 1st, 4th categories of I, III classes of water quality "excellent", "satisfactory" in condition and "very clean", "slightly contaminated" in the degree of contamination). According to troph-saprobiological (I_2) indicators, the water quality of the upper Pripyat corresponded to the 4th category of the III class of water quality ("satisfactory" in condition and "slightly polluted" in the degree of pollution). According to the indicators of specific substances of toxic water (I_3) the water quality of the

upper Pripyat corresponded to the 3rd, 5th categories of II, III classes of water quality "good", "mediocre" and "fairly clean", "Moderately polluted" by the degree of contamination).

According to the average annual values of integrated ecological indices (I_E), obtained by two methods, the water quality of the upper Pripyat was characterized by 3rd, 4th categories of II, III classes of water quality "good", "satisfactory" in condition and "fairly clean", "slightly contaminated" by the degree of contamination).

Thus, the results of the environmental assessment of water quality in the upper reaches of the Pripyat River by two methods, showed that the water salt composition is lower than it is required (Metodyka, 2012). According to this method, water quality was characterized by a worse class (III) compared to (Metodyka, 1998), according to which water quality corresponded to class I. Thus, (Metodyka, 2012) set stricter requirements for environmental assessment of river water quality, which can make it a more effective mechanism in the field of water protection.

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