# WATER QUALITY OF SMALL RIVERS IN THE PRIPYAT BASIN: ENVIRONMENTAL AND FISHERY ASSESSMENT

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DOI: https://10.20535/2218-930022022263183

*The study of anthropogenic causes of the deterioration of the state of small rivers is the first step towards their conservation and restoration, improving the human environment as a whole. The aim of the study is the fishery and environmental assessment of water quality of small rivers in the Pripyat River basin (the area of right-bank tributaries in the middle part of the river) within the Rivne region in the northern-west region of Ukraine. The initial data for the assessment have been the results of monitoring (27 physical and chemical indicators) during 2010–2018.*

*The assessment by the integral ecological index ($I_e$) has shown that the rivers belonged to the II quality class in terms of average values and were characterized as "clean" and "clean enough". According to the worst values, the rivers belonged to the II-III quality classes and were characterized as "fairly clean" – "slightly polluted" – "moderately polluted". The best water quality by the $I_e$ index was established for the Zhabichi River within the urban-type settlement of Demydivka. Water quality of the Ustia River below the runoff of the cities of Rivne and Zdolbuniv has corresponded to IV-V classes i.e. was "dirty" and "very dirty" (high content of phosphates, nitrogen compounds, copper, manganese, and zinc). In terms of trophic state, the water of the rivers is mesotrophic (according to average values) and eutrophic (according to the worst values), except for the part of the Ustia River below the runoff of the city of Rivne, where the water is polytrophic.*

*The rivers have failed to meet water quality standards for fishery water use by COD, $BOD_5$, and heavy metals content (Cu, Mn, Fe, Zn).*

***Keywords:*** *monitoring, Pripyat, small rivers, surface water quality, trophic state*

Received: 18 August 2022 Revised: 5 November 2022 Accepted: 9 December 2022

## 1. Introduction

The state of small rivers, as the most vulnerable part of the river system, fully reflects all the environmental problems of Ukraine and the state of their solution, or rather, the absence of such.

The deterioration of surface water quality due to pollution is one of the manifestations of the global water crisis, and water blindness in general (Clarke, 1991). Reservoirs and watercourses, including small rivers, are subject to intense pollution by wastewater from enterprises, dumping of household waste, silted up as a result of plowing the floodplain and slopes of the river valley, deforestation, drainage of some wetlands and parts of them, or entire wetland complexes for agricultural needs in Europe and certain regions. All these factors lead to biodiversity decrease, a reduction in the self-purification ability of rivers, and a loss of water quality (Smith, 2003; Water and agriculture, 2020; UN, 2022).

Ukrainian scientists have been studying the water quality and ecological condition of the Pripyat tributaries for years (Romanenko et al, 2004, Hopchak, 2018; Tolochyk,

Volodymyrets, 2018, Khilchevskyi et al., 2021, Fedoniuk et al, 2021).

The aim of the study was the fishery and environmental assessment of the water quality of small rivers of the Pripyat River basin within the Rivne region of Ukraine.

The establishment for the reasons of surface water quality deterioration is the first stage on the way to recovery and to the improvement of the human environment as a whole. Finding out the anthropogenic causes of negative changes in water quality and their elimination (Trach et al, 2021), in addition to the actual water protection value, will ensure the preservation of vulnerable aquatic organisms (Moshynskyi, Solodka, 2018, Klymenko et al, 2018, Fedonyuk et al, 2020, Grokhovska, Konontsev, 2020).

## 2. Materials and Methods

The objects of the study were small rivers in the Pripyat River basin in the north-western part of Ukraine (within the area of right-bank tributaries in the middle part of the river) within the 16th European ecoregion by the Water Framework Directive (2000). The rivers belong to the group of lowland rivers. Hydrochemical studies were carried out at 33 control sites located in the Rivne Oblast (region) (*Fig. 1*).

*Water quality analysis and assessment.* The initial data for the assessment were the results of monitoring (27 physical and chemical indicators) provided by the analytical control department of the State Department for Environmental Protection in Rivne Oblast. Monitoring data for 2010–2018 were analyzed. Surface water quality indicators (mineralization, pH, the content of chlorides, sulfates, ammonium nitrogen, nitrate and nitrite nitrogen, phosphorus phosphates, dissolved oxygen, chemical oxygen demand (COD), biochemical oxygen demand ($BOD_5$), Fe, Cu, Zn, Mg, Mn, Ca, Ni, total chromium, phenols, petroleum products, etc) were determined in accordance with the current governing normative documents.

Water quality and the aquatic environment state were evaluated according to the environmental assessment of surface water quality by the relevant categories (Romanenko et al, 1998) (the aggregation of indicators into indices), the quantitative generalization of which is the integral ecological index ($I_e$), which was set by three blocks indices according to formula (1):

$$I_e = \frac{I_1 + I_2 + I_3}{3}, \quad (1)$$

where $I_1$ – index of indicators of salt composition; $I_2$ – index of trophic and saprobic indicators (ecological and sanitary); $I_3$ – index of indicators of specific toxic substances.

The water quality indices were determined by average and the worst values.

Compliance with water quality standards for fishery water use was established by the formula (2):

$$\frac{C_1}{MPC_1} + \frac{C_2}{MPC_2} + \frac{C_3}{MPC_3} \ldots \frac{C_n}{MPC_n} < 1, \quad (2)$$

where $C_1$, $C_2$, $C_3$... $C_n$ – concentrations of selected substances (water quality parameters); $MPC_1$, $MPC_2$, $MPC_3$... $MPC_n$ – maximum permissible concentrations (water quality criteria for freshwater fish habitat).

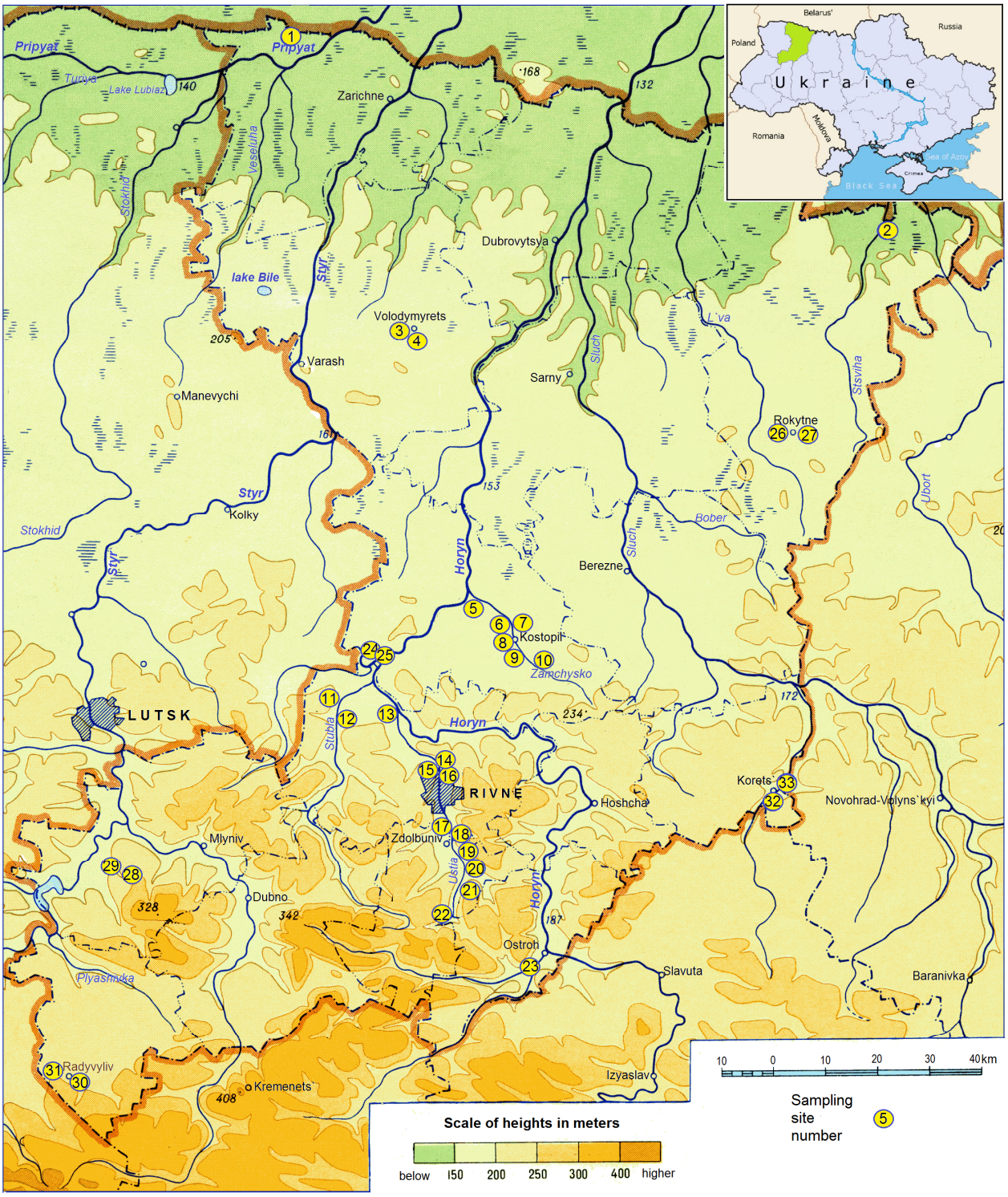


***Fig. 1.*** *The Rivne Oblast (region): sampling sites on small rivers Stohid (1), Prostyr (2), Berezhanka (3, 4), Zamchysko (5-10), Stubla/Stubelka (11,12), Ustia (13-22), Vilia (23), Putylivka (24, 25), Buniv (26, 27), Zhabichi (28, 29), Slonivka (30, 31), Korchyk (32, 33)*

## 3. Results and Discussion

The water of the Stokhid and Prostyr rivers was "clean" by average values, or "slightly polluted" by the worst (table 1), which were the content of copper and COD (5th category). The water of the Stokhid River contains a relatively low amount of dissolved oxygen and an excessive concentration of organic matter, as evidenced by the high COD and $BOD_5$ values – 1.9 and 1.3 MPC, respectively. On the Prostrir River, the maximum values were recorded also for the copper content – 11.3 MPC, followed by manganese (2.4 MPC) and iron (2.0 MPC).

***Table 1.*** *The small rivers water quality assessment by the fishery requirements (by exceeding MPC) and environmental classification (by ecological index $I_e$)*

| Rivers | $\sum_{l=1}^{n} C_l / MPC_l$ | $I_e$ | | Water quality | | | | Degree of cleanness (pollution) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | class | | category | | by class | | by category | |
| | | a. | w. | a. | w. | a. | w. | a. | w. | a. | w. |
| Stohid | 25.9 | 2.3 | 3.7 | II | III | 2 | 4 | clean | polluted | clean | slightly polluted |
| Prostyr | 24.5 | 1.9 | 3.7 | II | III | 2 | 4 | clean | polluted | clean | slightly polluted |
| Zhabichi | 25.4-30.6 | 2.3-2.4 | 3.3-4.0 | II | II-III | 2 | 3-4 | clean | clean-polluted | clean | fairly clean- slightly polluted |
| Slonivka | 27.1-160.5 | 2.2-2.8 | 4.3-5.0 | II | III | 2-3 | 4-5 | clean | polluted | clean - fairly clean | slightly polluted - moderately polluted |
| Buniv | 64.7-68.4 | 2.6 - 3.0 | 4.7 - 5.0 | II | III | 3 | 5 | clean | polluted | fairly clean | moderately polluted |
| Ustia | 24.5-63.1 | 2.2-3.1 | 4.3-4.7 | II | III | 2-3 | 4-5 | clean | polluted | clean-fairly clean | slightly polluted - moderately polluted |
| Korchyk | 51.6-53.4 | 2.7-2.8 | 4.3 | II | III | 3 | 4 | clean | polluted | fairly clean | slightly polluted |
| Stubla | 38.9-52.9 | 2.3-2.4 | 3.7-4.0 | II | III | 2 | 4 | clean | polluted | clean | slightly polluted |
| Vilia | 49.4 | 2.4 | 4.3 | II | III | 2 | 4 | clean | polluted | clean | slightly polluted |
| Putylivka | 33.7-35.1 | 2.4 | 4.0 | II | III | 2 | 4 | clean | polluted | clean | slightly polluted |
| Berezhanka | 35.5-63.5 | 2.8-3.0 | 4.7 | II | III | 3 | 5 | clean | polluted | fairly clean | moderately polluted |
| Zamchisko | 54.0 - 164.9 | 2.6 - 3.2 | 4.3 - 5.0 | II | III | 3 | 4-5 | clean | polluted | fairly clean | slightly polluted - moderately polluted |

*Note: a. – assessment by average values; w. – assessment by the worst values.*

The water of the *Zhabichi* River within the urban-type settlement of Demydivka above the discharge from the treatment facilities of the Communal Services Department has had the best quality by the Ie index (by the worst values) among the studied

watercourses of the Pripyat River basin. The maximum excess of water quality standards for fish was recorded in terms of the heavy metals content – copper (up to 14.5 MPC), manganese (up to 3.5 MPC), and iron (up to 2.7 MPC).

The *Buniv River* water quality does not meet the fishery requirements for eight indicators near the discharge of Rokytne Glassworks. The worst indicator is copper content (20-24 MPCs).

The water of small rivers of the Horyn River basin is of different quality. It was worst in the *Ustia River*, which in terms of the trophic state is mesotrophic and eutrophic, except for the part below the city of Rivne, where the water is polytrophic. This is the worst trophic state characteristic in the study region – the 5th-7th categories were established by nitrogen compounds, phosphates, and COD. Of the block of specific criteria for toxic effects, the worst indicators were the content of copper (4th-6th categories in all sites), fluorides (5th category in two sites), and zinc (5th category in one).

Downstream of the cities of Zdolbuniv (industrial center, population over 24,000) and Rivne (the administrative center of Rivne Oblast, population over 243,000), where under-treated wastewater enters the Ustia river, the excess of the quality criteria for freshwater fish habitat for 8-10 indicators was recorded. There were high concentrations of nitrites, copper, manganese, and zinc; all these toxic substances are able to bioaccumulate, which creates significant threats to the existence of ichthyofauna and leads to a non-compliance of fish products with sanitary and hygienic standards (fig.2).

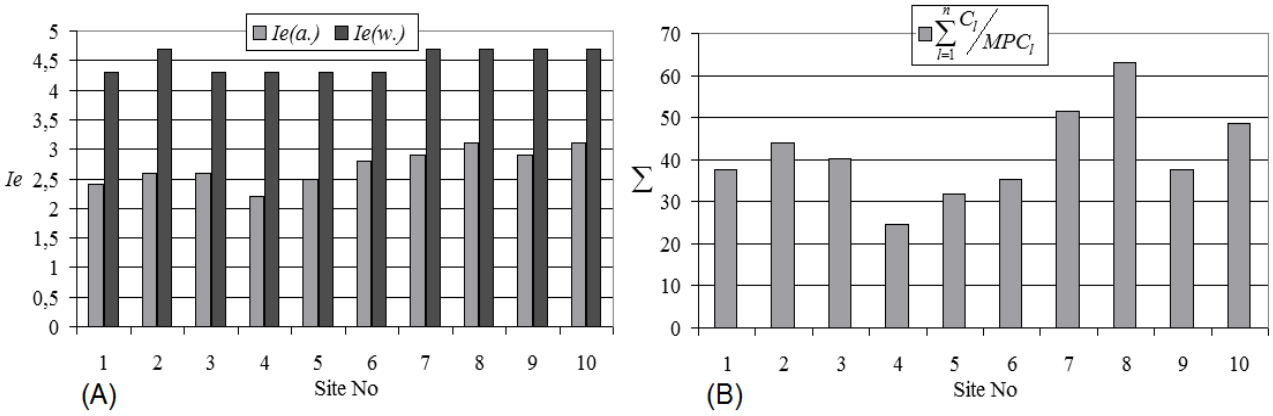


***Fig. 2.*** *Assessment of surface water quality of the Ustia River: (A) – by the integral ecological index (Ie); (B) – by the water quality criteria for freshwater fish habitat (MPCs exceeding)*

In terms of the trophic state, the *Zamchisko River* is mesotrophic (according to average values) and eutrophic (according to the worst values). At all sites, there is an excess of water quality standards for fish by COD, $BOD_5$, copper, iron, zinc, and manganese. The maximum excess in terms of COD and $BOD_5$ was recorded within the city of Kostopil below the discharge from the sewage treatment plants of the communal services - 2.2 and 3.7 MPC units, respectively.

The worst water quality category of the *Viliya River* was established by the copper content (6th category), nitrates, and COD (5th

category). An excess of MPC was observed for six indicators (iron, manganese, copper, zinc, COD, and $BOD_5$); the worst result – was copper content (34 MPC).

The worst water quality category of the *Berezhanka River* according to tropho-saprobiological indicators was established by the content of nitrogen nitrate and nitrite ($7^{th}$ category), between toxic indicators – copper and iron ($6^{th}$ category). There are significant exceedances of fishery requirements – for six to eight indicators, the highest of which were copper (6-27 MPC) and iron (10-15 MPC).

The worst water quality category of the *Putylivka River* was established by the nitrate and nitrite content, COD ($6^{th}$ category). The maximum exceedances of the water quality indicators for fish of the river were recorded in terms of copper content – 19 MPC.

The worst water quality indicators of the *Korchyk River* were copper ($6^{th}$ category), nitrites, and COD ($5^{th}$ category). An excess of the MPC was established for the following indicators: COD, $BOD_5$, and the content of copper, manganese, zinc, ammonium, and nitrites. As in all water bodies of the region, the greatest excess was recorded for the concentration of copper – 28 and 32 MPC. The high content of copper in the surface waters of the region is due to natural factors - deposits are located in Volyn and Rivne Oblast copper ores (Rudenko et al, 2017).

The main source of pollution of small rivers in the region is wastewaters of big cities and settlements (Rivne, Zdolbuniv, Kostopil, etc) which cause an increase in mineralization, concentration of macro- and microelements, and organic substances. In addition, there are a large number of diffuse sources of pollution: runoffs from urbanized areas, agricultural lands, farms, livestock complexes, summer cattle camps, etc. Anthropogenic eutrophication causes the annual summer "blooming" of the water of the Ustia River and the Basivkut reservoir in the city of Rivne.

The concentration of heavy metals in the water can be higher in the river section above the place of discharge from the treatment facilities in comparison with the section below, for example, for the Zhabichi river by 1.3–2.0 times. This can be explained by the formation of complex compounds with organic substances contained in municipal wastewater. It is known that heavy metals are capable of forming sufficiently strong compounds with low mobility with organic substances. In particular, the adsorption capacities of sediments for heavy metals, and toxic elements are arranged in the sequence: Zn < Pb < Cu < Cr (Lin, Chen, 1998).

## 4. Conclusions

The assessment of surface water quality of the small rivers in the Pripyat River basin in the Rivne region of Ukraine according to the $I_e$ index has shown that the rivers belong to the II quality class in terms of average values and are characterized as “clean” and “clean enough”. According to the worst values, the rivers belong to the II-III quality classes and are characterized as “fairly clean” – “slightly polluted” – “moderately polluted”. The best water quality by the $I_e$ index has been established for the Zhabichi River. In terms of trophic, the water of the rivers is mesotrophic (according to average values) and eutrophic (according to the worst values), except for the part of the Ustia River below the city of Rivne, where the water is polytrophic. Most often, the $7^{th}$ category of water quality (very dirty) was set by the content of phosphates, less often – nitrogen compounds. The worst criterion among the

block of specific toxic substances ($7^{th}$ category) has been the high concentration of copper.

All the rivers have failed to meet the water quality criteria for freshwater fish habitat by indicators of chemical oxygen demand (COD), biochemical oxygen demand $BOD_5$, and the heavy metals content (Cu, Mn, Fe, Zn).

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# ЯКІСТЬ ВОДИ МАЛИХ РІЧОК БАСЕЙНУ ПРИП'ЯТІ: ЕКОЛОГІЧНА ТА РИБОГОСПОДАРСЬКА ОЦІНКА

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*Дослідження антропогенних причин погіршення стану малих річок є першим етапом на шляху їх збереження та відновлення, покращення середовища існування людини в цілому. Метою дослідження є рибогосподарська та екологічна оцінка якості води малих річок басейну р. Прип'ять (ділянка правобережних приток у середній частині річки) у межах Рівненської області у північно-західному регіоні України. Вихідними даними для оцінки стали результати моніторингу (27 фізико-хімічних показників) впродовж 2010–2018 років.*

*Оцінка за інтегральним екологічним індексом ($I_e$) показала, що річки за середніми значеннями відносяться до II класу якості та характеризуються як «чисті» та «достатньо чисті». За найгіршими значеннями річки належали до II-III класів якості та характеризувалися як «достатньо чисті» – «слабко забруднені» – «помірно забруднені». Найкраща якість води за індексом $I_e$ встановлена для річки Жабичі в межах селища міського типу Демидівка. Якість води річки Устя нижче стоку міст Рівне та Здолбунів відповідала IV-V класам, тобто була «брудною» та «дуже брудною» (підвищений вміст фосфатів, сполук азоту, міді, марганцю та цинку). За трофністю вода річок є мезотрофною (за середніми значеннями) та евтрофною (за найгіршими значеннями), за винятком частини р. Устя нижче стоків м. Рівне, де води річки політрофні.*

*Річки не відповідають нормам якості води для рибогосподарського водокористування ($ГДК_{риб}$) за ХПК, $БПК_5$ та вмістом важких металів (Cu, Mn, Fe, Zn).*

***Ключові слова**: малі річки, моніторинг, Прип'ять, трофічний стан, якість поверхневих вод*