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Influence of Landscape Organization on Surface-water Quality Forming on an Example of Ustya River Basin (Ukraine)

Tetiana P. Fedoniuk[1], Anastasiia A. Zymaroieva[2], Viktor M. Pazych[1], Anatoliy A. Petruk[3]*

1 - Polissia National University, Educational and scientific center of ecology and environmental protection, Staryi Blvd, 7, Zhytomyr, Zhytomyrs'ka oblast, 10008 UKRAINE
2 - Polissia National University, Faculty of Forestry and Ecology, Staryi Blvd, 7, Zhytomyr, Zhytomyrs'ka oblast, 10008 UKRAINE
3 - State Ecological Inspection in Rivne Region, Rivne, UKRAINE
[*]Corresponding author: tanyavasiluk2015@gmail.com

Abstract. River ecosystems of Polissya are in a state of deep degradation. Agricultural lands, close to watercourses, are localized on the terraces of river valleys, in some places - floodplain. Such placement of lands in case of improper operation poses an ecological threat not only to the Ustya River, but also to the entire river system of the Goryn River, a tributary of which it is. With this in mind, the aim of our research was to assess the current hydrological, hydrochemical and hydrobiological condition of water bodies in the Ustya River basin, to identify the causes of possible deterioration and to justify measures to improve them. The ecological condition of the aquatic ecosystems of the Ustya River, in particular their soil cover, the granulometric composition of the basin and its contribution to the pollution of surface waters of the territory are determined in article. The ecological condition of the Ustya River basin is assessed and the main factors of anthropogenic changes of aquatic ecosystems within the Ustya River basin are determined, as well as the scale and consequences of their impact on water quality. The analysis of the processes of water quality formation within the water bodies of the Ustya River basin is carried out, the main directions of dynamics on three blocks of indicators are estimated and the integrated ecological indices of water quality in the observation points are determined. Solving the set tasks allowed us to comprehensively assess the ecological situation of landscapes in the Ustya River basin.

Key words: aquatic ecosystems, floodplain soil, water quality, sustainability of landscapes.

Introduction

The formation and sustainable development of the ecosystem is based on the ecological conditions of the respective landscapes, on the basis of which their individual morphological features are formed (Fedonyuk et al., 2019). One of the priority areas of sustainable ecosystems and solving environmental problems that are formed at the local, regional and global levels is the optimal organization and land use of state territory on the land, which gives the greatest effect of environmental measures (Jungwirth et al., 2002). This approach is important for the use of river ecosystems, which are characterized by complex terrain and intense erosion processes.

River ecosystems of Polissya are in a state of deep degradation, which consists of siltation, lowering of water levels and total pollution (Berge et al., 2010). The degradation of Polissyan small rivers has been intensive during the last 60-70 years, which is due to the significant plowing of landscapes up to the water's edge. As a result of such management, the streams that replenish the rivers began to disappear. This, in turn, has led to siltation of the river, overgrowing it with wetland vegetation, waterlogging, reducing runoff and deteriorating water quality (Gupalo et al., 2020).

Agricultural lands close to streams are located on the terraces of river valleys, in some places - floodplain, especially in the delta arm (lower) part. A significant part of them is covered by drainage and irrigation melioration systems, from which water is discharged into watercourses, streams, etc. Such placement of lands in case of improper exploitation and lack of constant ecological monitoring poses an ecological threat not only for the Ustya River, but also to the entire river system of the Goryn River, a tributary of which it is.

According to various sources of information, today in Ukraine the natural landscapes of rivers are almost destroyed, or are at different stages of degradation. And water protection zones, if any, are reduced to small coastal plantations that do not properly perform the function of sewage filtration (Hryb & Voytyshyna, 2009; Vystavna et al., 2018; Reva et al., 2014).

The main hydro-chemical parameters of the Ustya River tributaries have been at a consistently low level for the last five years. Some of the tributaries are contaminated with organic matter (1.1–1.7 MPC) and total iron (1–2.8 MPC) (Shelyuk & Shcherbak, 2018).

In the Pripyat basin, where the Goryn River and its tributaries belong, the ecological condition of small rivers has deteriorated in recent years due to the inefficient operation of existing treatment facilities of both large enterprises and production departments of housing and communal services. The level of mineral nitrogen, which reaches 1.4 mg / l (1 - 7 MPC for various water bodies of the basin), has increased especially (Fedoniuk et al., 2019).

Proof of the unfavorable state of the hydro-ecological network of Ukraine is a comprehensive assessment of the ecological condition of small river basins located in different natural areas, conducted by the Ukrainian Research Institute of Water Management and Environmental Problems under the guidance of Professor AV Jacyk (Jacyk et al., 2007). Of the 62 pools studied, only one is characterized as "minor changes". The ecological condition of the six-river basins (10%) was assessed as satisfactory, 25 (40%) as bad, 19 (31%) as very bad and 11 (18% of all studied basins) as catastrophic.

The Ustya River basin with all its constituent components - riverbed, floodplain, terrace, slopes is a sufficiently self-regulating system that is able to function independently of the influence of external factors (Romanchuk et al., 2017; Klymenko et al., 2018; 2019; Fedoniuk et al., 2019). The geosystem of the basin is quite complex both in terms of the number of factors that affect its functioning and the peculiarities of interaction between them. Given the basin approach provided by the EU Water Framework Directive, economic entities, influencing certain natural components, make their adjustments to the entire ecological state of the studied hydro system (Fedoniuk et al., 2019b). In this way, the river becomes an integral indicator of environmental quality, where the indicators of landscape structure, surface water quality and diversity of living organisms are closely interrelated. Many authors note the impact of water quality and landscape structure on biodiversity over the living conditions of organisms (Mollov et al., 2009; Yancheva et al., 2015; Fedoniuk et al., 2020). As a result, there is a need to outline a system of indicators and tools for accurate forecasting of possible changes in the qualitative and quantitative state of individual components of landscapes and their possible impact on surface water quality. It should become a tool to optimize river basin management, formation, use and protection of the landscape.

The aim of this study was to assess the current hydrological, hydro-chemical and hydro-biological status of water bodies in the Ustya River basin, to identify the causes of possible deterioration and to find relationships between deterioration factors and water quality indicators.

Material and Methods

To analyze the ecological situation in the basin of the Ustya River, water, coastal soil and bottom sediments were taken. Sampling of soil, bottom sediments and water was carried out at points confined to large settlements and places of increased anthropogenic pressure from the source to the mouth of the Ustya River. A total of 10 permanent observation points were laid, as well as soil samples at a distance of 5-50 m from the water's edge. The observation points assessed the relief, the rate of land transformation, soil and vegetation, fauna, sources and volumes of anthropogenic pressure and the main causes of landscape degradation (Table 1).

The research scheme was divided into three main blocks:

1. Description of the river basin: hydrographic and water management zoning, climate, relief, geology, hydrogeology, soils, vegetation, hydrological regime, features of the river basin.

2. Identification and classification of water bodies (WM), as well as analysis of their initial state - the territory of the basin was characterized by indicators: ecoregion; category of surface waters; typology; geographical and hydromorphological differences; change of ecological condition; protected natural areas.

The study of particle size distribution was carried out on the basis of sampling from 220 points. The particle size distribution was determined in accordance with Kaczynski's classification (Kaczynski, 1953).

The ecotonization index was applied to assess the ecological stability of the landscape (Timofeeva, 2014):

$$Y = Li / S;$$

where: Y - index of species diversity;
L - the length of the ecotone, m;
S - area of the agro-landscape, ha.

Estimation of the index of species diversity: less than 5 m / ha - very weak ecotonization; 5-10 m / ha - weak ecotonization; 10-20 m / ha - average ecotonization; more than 20 m / ha - high ecotonization.

3. Analysis of the structure of the landscapes of the Ustya River basin according to the indicators of coefficient of ecological stabilization of the landscape (KESL1) and the coefficient of ecological stabilization of biotechnical elements (KESL2) and their influence on the formation of surface water quality.

To assess the ecological condition of landscapes within the location of observation points used the method of E. Klementova and V. Heinige (Klementova & Heinige, 1995), according to which we calculated the KESL1 and KESL2. The calculation of the anthropogenic transformation index was carried out according to the method of Hoffman KG (Hoffman, 1977). Estimation of the degree of anthropogenic transformation of the territory and calculation of anthropogenic transformation of the territory of the agro-landscape was carried out according to the method of Shishenko PG (Shishenko, 1999).

Water samples were taken for chemical and biological analysis, physical properties were determined in the field, other samples were preserved in accordance with the methods of sample preparation for analysis (Instructions for sampling, preparation of water and soil samples for chemical and hydro-biological analysis by hydro-meteorological stations and posts, 2016), approved by the Order of the SES of Ukraine dated January 19, 2016 № 30.

Water quality at the observation points was assessed in accordance with Romanenko & Zhukinskiy (1998), according to which all analyzes to determine water quality indicators were divided into three main blocks:

1. Block of water quality assessment according to the criteria of salt composition. This group includes indicators of water quality in terms of mineralization and electrical conductivity, sulfate and chloride content.

2. Water quality assessment unit according to chemical saprobological criteria. This group includes indicators of water quality by oxygen regime, suspended solids, transparency, pH, ammonium nitrogen content, nitrates and nitrites, phosphorus phosphates, permanganate oxidation and biochemical oxygen consumption.

3. Block of water quality assessment according to the criteria of content of specific substances of toxic and radiation action. This group includes indicators of water quality in terms of total iron, manganese, petroleum products, phenols, surfactants in water, cadmium, copper, zinc, total chromium, nickel in bottom sediments.

Each individual quality index was determined for each indicator and the average block index was calculated taking into account all these indicators. In accordance with the obtained data, the total ecological index of I_E water quality was calculated as the average value of the three block indices.

To determine the subcategories of water quality corresponding to the average values of group. In accordance with the same method, certain classes and categories were assigned according to ecological conditions: I class with one category (1) - excellent; Class II - good, with two categories: very good (2) and good (3); Class III - satisfactory, with two categories: satisfactory (4) and mediocre (5); IV class with one category (6) - bad; V class with one category (7) - very bad. We also compared the results of analyzes with SanPiN # 4630-88 Sanitary rules and standards for the protection of surface waters from pollution.

ArcGis Pro 2.5.0 software was used to map the project, and a digital terrain model was developed using the Geoprocessing: 3D Analyst toolkit. Tracing of watercourses, delineation of watercourses and their orders was carried out using the software product ArcGis Pro 2.5.0, ingesting the algorithm of hydrological modeling of the working module Spatial Analyst: Hydrology - "basin", "catchment area", "flow direction" and others hydrological parameters. The order of watercourses was determined by the Strahler method (Strahler, 1952) on the basis of a digital terrain model applying the same software product. The hydrological modeling was done on the basis of a digital elevation model.

Results and Discussion

According River passport the water body is the Ustya River, a tributary of the Goryn River, which in turn belongs to the basin of the Pripyat River. The total length of this river is 68 km. The catchment area is about 762 km^2. The Ustya River, which flows from south to north in Rivne and Zdolbuniv districts, is located in the southern part of Rivne region, or more precisely on the Volyn upland. The formation of a hill on a submerged structural basis is considered a kind of inversion of the terrain (Fig. 1). Ustya has 28 tributaries up to 10 km and three tributaries larger than 10 km: Bezodnya (length - 13 km, catchment area - 68.9 km^2) and Ustya (stream) (length - 24 km, total catchment area - 126 km^2).

All rivers of Rivne region belong to the basin of the Pripyat River, they are fed by meltwater, snow water. A smaller share of water is formed due to the inflow of groundwater and precipitation. Types of soils such as sod-podzolic

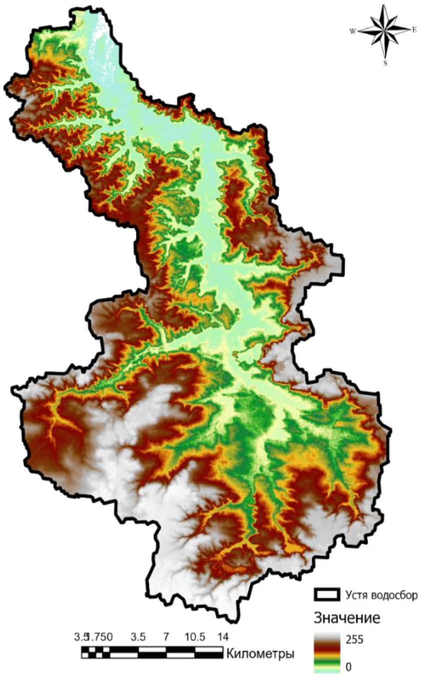


Fig. 1. Digital relief model of the Ustya River basin.

gleyed, light gray and gray podzolic, chernozems podzolic and peat soils are dominant in the catchment area of the Ustya River. Most of the soils inherent in this area are characterized by low natural fertility.

Water bodies of the study area belong to M5.1.4 - Sub-basin of the Pripyat River, water management area M5.1.4.46 - Goryn River from the border of Khmelnytsky and Rivne regions to the state border (excluding the river Sluch). A number of small rivers and streams, which are tributaries of the Ustya River, flow through the basin. Among the tributaries are the largest Kunin and Spasov.

According to agro-climatic zoning, the Ustya River basin belongs to the zone of sufficient moisture with SCC in the range from 1.3 to 1.6 with a moderately uncomfortable subzone for bioclimatic zoning. In accordance with the geobotanical zoning, the Usti basin lies entirely within the Central European Province of Deciduous Forests, South Poland-West Podolia Sub-Province of Deciduous Forests, Meadows, Meadow Steppes and Eutrophic Swamps of the Lublin-Volyn District of Hornbeam and Oak, Oak and Oak.

The surface waters of the region are defined as hydrocarbonate-calcium, with the sum of ions from 100 to 200 mg / l, and the total hardness of 1.5-2.5 mg-eq / l.

The Ustya River basin is located in the region of enhanced erosion processes, where the area of washed away soils is up to 70%. Erosion, contamination with fertilizers and pesticides and the use of heavy machinery should be singled out among the factors that determine the structural features of soils.

The soil cover of the Ustya River basin will mostly cover agricultural landscapes. Agro-landscapes occupy the largest part, but under natural landscapes such a large share remains. The analysis of particle size distribution allowed to classify soils at the level of varieties, and to assess their physical properties. In samples taken in floodplain soils in the Ustya River basin, 4 soil varieties were found: heavy loam, medium loam, light loam and light clay, with a predominance of medium and light loams 66 and 31%, respectively) (Fig. 2).

Analysis of the particle size distribution of floodplain soils in different areas of the Ustya River basin showed that the predominant soil fractions here are coarse-dusty - 43-67% and dusty - 2-30%. This fractional ratio is explained by the peculiarities of the hydrological regime, namely the position in the basin, periodic spills, depth and flow velocity. According to the results of the research, the content of physical clay (less than 0.01 mm) did not vary much depending on the zones of the basin, and for the upper, middle and lower parts of the basin ranged from 27 to 56%. At the same time, insignificant variation of the range of minimum and maximum values was noted only in the middle zone.

The soils of the Ustya River basin in different parts of the basin do not differ significantly in particle size distribution. in all zones the coarse-dusty fraction is predominant - 43-67% and dusty 12-31% (Fig. 3). However, the increased content of dusty fraction does not significantly affect the water-physical properties of the soil.

For a detailed landscape analysis, we divided the territory of the Ustya river basin into separate arrays, the precondition for the division was hydrographic features and natural and anthropogenic circumstances that have developed historically in some parts of the studied basin (Fig. 4).

Thus, separate arrays are tributaries on which settlements are located, which in one way or another make certain adjustments to the quality of water in the first sections of the river, as well as individual fragments of the river, in which changes in water composition may be influenced by certain natural or anthropogenic factors (urbanization, wastewater discharge, etc.) - see Table 2.

The study of the soil cover of the catchment area of the Ustya River showed the predominance of loamy soils. Such soils are favorable for water and physical properties, have sufficient gas exchange, loose and poorly compacted composition, have sufficient moisture permeability, but they are largely susceptible to water and wind erosion. The forest cover of the territory is extremely low. In the overall structure of the basin, it is 5.8% (Table 3).

Other important indicators that affect the quality of surface waters of the territory is the plowing degree of the territory. It was noted above that although the plowed area in the river basins of Rivne region reaches 70-80%, the Ustya river basin and its tributary plowed less - 55%, but in the basins of the tributaries Untitled (right tributaries, Kunin and Spasov) reaches 60%. Given the state of plowing of the territory, the ecological state can be defined in general as "intense", and the degree of plowing is "medium" (Table 4).

The basin of the Ustya River lies within the Ecoregion 16 Eastern Plains, the type of river is defined as UA_R_12_S_2_Si - a small river on a hill in silicate rocks (according to the Methodology for determining the arrays of surface and groundwater (paragraph 16 of section II)).

A great threat to the quality of surface waters of the region is a significant decrease in the piezometric level in the artesian horizon, which leads to the flow to it over the entire area of depression of substandard waters from adjacent waterproof strata containing high concentrations of sulfates, chlorides, sodium, fluorine, sodium, hydrogen sulfide, iron.

Table 1. Monitoring points within the Ustya River basin.

No	Research points
1	Ustya River, 0 km, place of confluence with Horyn river, below the village Orzhiv.
2	Ustya River, 5 km in relation to the confluence point in Horyn river, 3 km above the village. Orzhiv.
3	Ustya River, 20 km in relation to the Goryn River, 1 km below the city of Rivne, 4.5 km below the discharge of wastewater from the USC of the city of Rivne.
4	Ustya, Rivne, below the entrance of the reclamation canal, the area of st. Zolotiyivska.
5	Ustya, within the city of Rivne, near the pizzeria "LaRiva".
6	Ustya River, Rivne, below the storm sewer discharge in the area of Myru Avenue.
7	Ustya River, 25 km in relation to the confluence point in the Goryn River, 0.25 km below the wastewater discharge from the USC of Rivne.
8	Ustya, Rivne, near the cafe "Venice".
9	Ustya, Rivne, district street Soborna, transition to the Wild Market.
10	Exactly, lake. Hydropark, on the side of Zdolbunivska Street.
11	Ustya, Rivne, Avangard Stadium.
12	Ustya River, 30 km in relation to the confluence point in the Goryn River, 2 km above the city of Rivne, 0.2 km below the discharge of wastewater from the USC of the city of Rivne.
13	Ustya, Rivne, district street Botanical.
14	Lake Basiv Kut, within the city of Rivne, from the bridge, at the confluence with the Ustya River.
15	Ustya River, 35 km from the confluence point with the Horyn River, 1.2 km from the border of Rivne and Zdolbuniv districts and 2 km below the confluence of the tributary of the Spasiv, where the settlements of Hlynsk and Spasiv.
16	Ustya River, below Zdolbuniv, 0.5 km above the discharge from the USC of Kvasyliv village of the Rivne District Housing and Utilities Service.
17	ОСК смт. Kvasyliv of the VKH service of Rivne district, leaving the OS.
18	Ustya, Novy Dvir, street Priozernaya Dachna, from the bridge.
19	Ustya River, 38 km in relation to the confluence point in Horyn river, 20 km above Rivne, below the village of Branch-2.

20	Ustya River, 45 km in relation to the confluence point with the Goryn River, a reservoir below the village of Ivachkove, at this point a tributary is formed, without a name.
21	Ustya River, 60 km from the confluence point with the Goryn River, 1.8 km below the village of Derman-1.
22	Ustya, river source, point on the earth's surface, located above 2 km (southwest) s. Derman-1, 65 km in relation to the confluence point in the river Goryn.

Table 2. Soil cover of the Ustya River basin.

No	Soil name	Area, ha	Power of humus horizon, cm	Organic matter, %	Soil losses from water erosion from the open surface t / ha per year	Assessment of soil erosion resistance	Actual soil losses due to erosion t / ha per year	Maximum allowable erosion rate t / ha per year
1.	Gray podzolic weakly and moderately washed light loam soils on loess loam	25900	20-31	1.1-2.1	14-20	Weak	6-12	2-3
2.	Dark gray light loam on loess loams	14770	26-39	1.3-2.6	5-7	Medium good	4-6	3-4
3.	Slightly washed loamy chernozems on loess loams	11600	35-60	2.7-3.8	25-29	Average	12-15	4-5
4.	Loamy chernozems on loess loams	7900	45-85	3.5-5.0	6-9	Good	5-7	5-6
5.	Meadow-chernozem medium loamy on loam	5850	45-95	4.1-5.8	1-2	Good	1-2	5-6

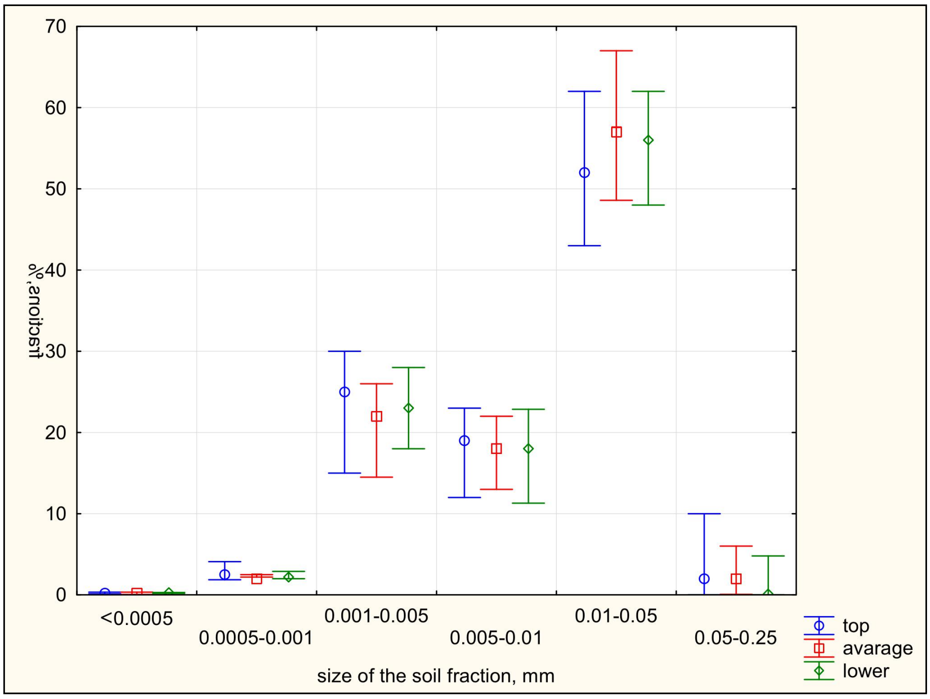


Fig. 2. Granulometric composition of floodplain soils of the Ustya River basin.

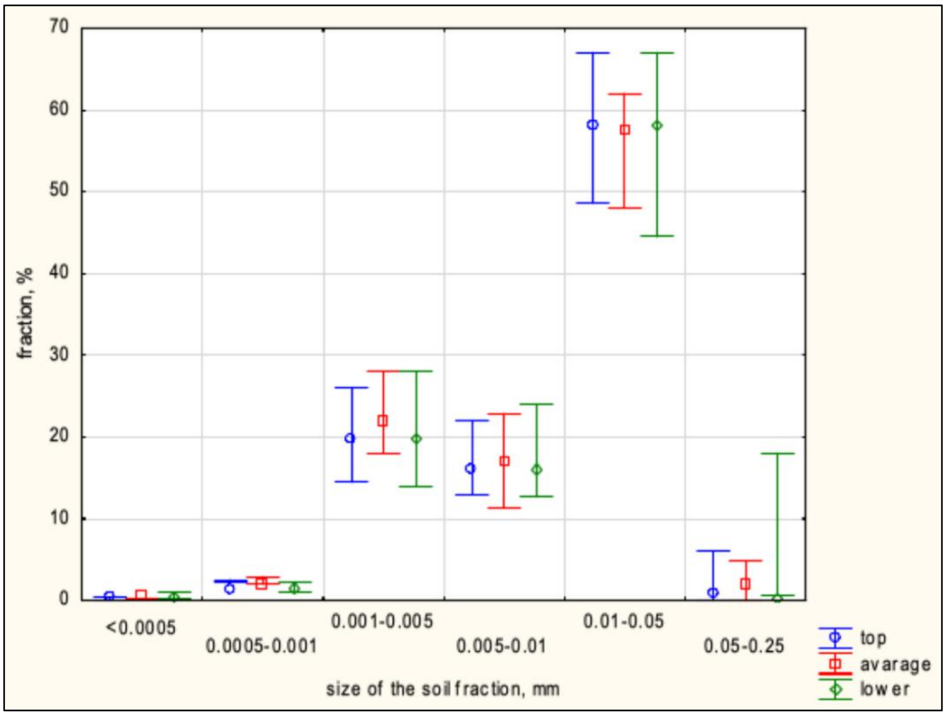


Fig. 3. Fractional composition of soils of different parts of the Ustya River basin, %.

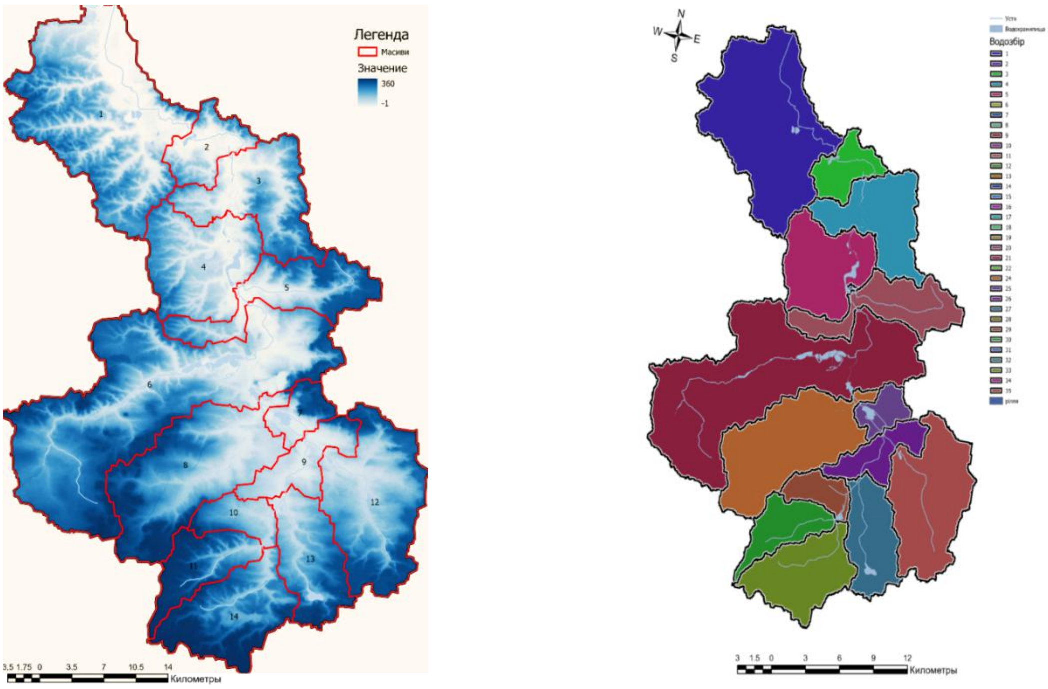


Fig. 4. Hydrographic network (left) and arrays of the Ustya river basin (right).

Table 3. Descriptions of the arrays of the Ustya River basin.

Array	Area, km^2	Description
1	120,69146	The river section from the village Orzhiv to the village Gorodok
2	21,30160	The river section from the village Zoziv to the village Velykyy Oleksin
3	49,28374	The river section from the village Maly Oleksyn to the Olimp Stadium in Rivne (section of the Ustya River below the wastewater discharge from the Rivne USC of the Rivne VKG service)
4	51,77316	Rivne (above the wastewater discharge) to the Basiv Kut reservoir
5	42,08506	village Novyi Dvir, a right-hand tributary from the village Kvasyliv
6	167,38465	Kvasylivsko-Zdolbunivska section, tributary Shvydivka
7	13,40319	village Novomilsk, pond Staromilsky
8	79,67950	A tributary of the Abyss from the village Kunin to the village Zdovbytsia
9	22,46611	village Ivachkiv, the confluence of the tributary, which originates near the village Ukrainske
10	14,97197	village Druga Gilcha, pond
11	26,13729	A tributary that originates near the village Klopit and flows near the village Druga Gilcha
12	69,31233	A tributary that originates near the village Ploske to the village Uvachkiv
13	36,51726	village Derman-1 of Zdolbuniv district
14	46,99269	Untitled tributary 2 (Verkhiv village)
Total area, km^2	762.215463	Untitled tributary 3 (Ivachkiv village)

Table 4. Ecological and landscape analysis of the Ustya River basin and its largest tributaries.

Characteristic	Ustya		Untitled (right tributary)		Kunin		Spasiv	
	km^2	%	km^2	%	km^2	%	km^2	%
Forest cover	55.7	5.8	5.7	8	9.9	13	16.1	13
Wetlands	6.3	0.7	1.8	2.5	6.08	8	1.9	1.5
Lakeiness	8.2	0.9	0.14	0.2	0.08	0.1	8.06	6.5
Protected areas	21	2.2	0.21	0.3	0.15	0.2	2.6	2.1
Plowing	529	55	43.7	61.5	45.6	60	73.2	59
Drainage	232.0	24	10.2	14.3	13.9	18.4	4.2	3.4
Urbanization	97.3	10.1	1.8	2.5	0.91	1.2	4.96	4.0
Others	32.7	3.4	6.03	8.5	36.2	0.1	14.3	11.5
Total	961.4	100	71	100	76	100	124	100

Table 5. Determining the degree of plowing of the territory.

	% of plowing	Degree of plowing	Assessment of ecological condition
1	73	strong	critical condition
2	62	strong	critical condition
3	43	average	tense state
4	33	moderate	tense state
5	50	average	tense state
6	47	average	tense state
7	66	strong	critical condition
8	70	strong	critical condition
9	72	strong	critical condition
10	55	average	tense state
11	49	average	tense state
12	53	average	tense state
13	49	average	tense state
14	66	strong	critical condition

The current hydro-chemical state of water bodies of the Ustya river basin has acquired a natural-technogenic character, and the analysis of the available hydro-chemical information allows to outline the specifics and characteristic features of the current state of river systems of Rivne region. Thus, as of 2016–2019, the water composition had a fairly high average annual level of mineralization (520–680 mg/l), and the relatively high proportion of chlorides (over 30 mg/l) in the structure of major ions indicates the intensity of the surface water pollution process. communal and livestock effluents. The nature of the annual amplitude of color of natural waters varies from the value of the quality scale "colorless" in the second half of autumn, in winter - to light gray and gray in the period of flooding and light green - in the summer period. This indicates significant volumes of terrigenous material in rivers during snow-melt and intensive development of phytoplankton (primarily green and blue-green algae) during the growing season, and thus, indirectly, the presence in the water of high concentrations of nutrients (nitrogen compounds and phosphorus). Thus, in the channel waters there was an increased content of nutrients, in particular, ammonium nitrogen (1.5-2, and sometimes more times higher than the ecological optimum), nitrites (1.5-2.5 times higher than the ecological optimum), nitrates (0.5-1.5 times higher than the ecological optimum). Unsatisfactory high values of biochemical oxygen demand (BOD_5)(2-3 times higher than the ecological optimum) indicate excessive pollution of channel waters with organic matter of autochthonous (products of extinction of aquatic organisms, especially planktonic) and allochthonous genesis (surface runoff). The presence of such specific products of technogenesis as petroleum products and heavy metals (chromium, zinc, copper, nickel) in concentrations below, at the limit and above the critical values of the MPC (maximum permissible concentrations) is noted in surface waters. The oxygen regime remains positive, which determines the predominance of oxidation processes in river waters and is an indicator of their high self-cleaning potential.

According to organoleptic parameters, surface waters have a completely satisfactory condition. The smell of water has a river character, without foreign odors of mustiness and the presence of putrefactive processes. It is characterized by a level of 2 within all investigated points.

The formation of the chemical composition of the waters in the Ustya River basin is influenced by the marl-Cretaceous deposits common here, the Upper Cretaceous and Tertiary systems, and carbonate-rich soils. This causes moderate mineralization and hydrocarbonate-calcium type of river waters (Kononenko, 1951). Water in rivers belongs to the hydrocarbonate class in the ratio of major ions, calcium group, the second type, its chemical composition is defined as $C_{Ca}II$ (Polishchuk et al., 1978).

Analysis of the dynamics of the salt composition block index of the Ustya River allows us to note that in general in 2016-2019 the water quality did not differ significantly depending on the seasons.

The natural state of the river is characterized by the values of the sum of ions, which correspond to 2 categories, for sulfates - 1, and for chlorides - 3, which is defined according to the ecological classification as "very good" and "good". At the source of the river near the Derman Village does not vary significantly during the year, so in the study period, water quality was determined within the second with the transition to the third category, ie in the range from "clean" to "fairly clean" class II quality ("good"). it can be described as "good" and "very good". Even the extreme values of the index water in this area is defined as "good". This quality condition is typical along the Kvasyliv Village.

Downstream of the Ustya River in the Kvasyliv village water quality in this unit deteriorates to the third with the transition to the second category of quality class II ("good"). Within the same category, water quality is maintained almost all year round, but in all seasons there were extremes of 3.67-4 categories, ie the transition from "good" to "satisfactory", which we associate with wastewater of Kvasyliv village, which is often insufficiently treated and contains increased concentrations of sulfates and chlorides. In addition of Kvasyliv village, such peaks of salt composition indices were observed within the Rivne city, especially in the areas below the wastewater outlet.

Analysis of the dynamics of the block index of salt composition of the Ustya River, at a distance of 35 km from the confluence point in the Goryn River, 2 km below the confluence of the Spasiv tributary, allows us to note that in general it can be described as "good". Although the chloride-sulphate composition of water causes variation of water quality within 3 subcategories of class II to 4 subcategories of class III, the mineral composition is generally favorable and is characterized by stable indicators within the entire basin of the Ustya River.

In general, the water quality in the region varies within 2-3 subcategories of class II water quality, only in the area of Kvasylivsko-Zdolbunivska area and in the area of Rivne the salt content is the highest, on the contrary, water quality was not significantly affected. This indicates the presence for the Ustya River of brines of sodium chloride composition, with a salinity of more than 250 g/dm^3, as well as the release of excessive amounts of wastewater with high content of sulfates and chlorides.

Analysis of the block of tropho-saprobological composition of surface waters of the Ustya River. According to the content of dissolved oxygen, the water of the Ustya River has an extremely wide range of variations - from 1.74 to 10.20 mgO_2 / dm^3 (from 1 to 7 categories of water quality), especially critical are the hot periods. category V class, which was visually noted in the intensification of water flowering processes and the appearance of a putrid odor.

Fluctuations in the content of suspended particles and water transparency often depend on the season: plain rivers are characterized by the maximum content of suspended solids in spring floods and minimum - in winter, mountain rivers are usually increased turbidity during rains and snowmelt in the mountains (Romanchuk et al., 2018, Fedoniuk et al., 2018). Control of these two indicators of water is very important from the toxicological point of view. Because the bulk of heavy metals and radionuclides are localized in suspended particles. Thus, according to Moore J.W. and Ramamurti S. (1987) for surface waters of moderate turbidity in suspended particles accumulate more than 90% of lead, 30–35% of arsenic and cadmium, more than 20% of mercury, etc. (Ramamurti, 1987).

Natural waters have the ability to maintain the pH during the year at about the same level, even with the receipt of alkalis or acids from external sources. Determine the ability to neutralize acids and alkalis when they enter natural waters due to dissolved carbon dioxide and bicarbonate ions (Fedoniuk et al., 2018). Most regulations set a standard for surface water in the range of 6.5 to 8.5.

In all studied periods, the transparency of water was very low, in particular it fluctuated in the range of 22… 36 cm, which corresponds to 6 categories of class IV, which indicates that certain vital processes of aquatic organisms can be suppressed. Decreased water transparency may indicate the presence of a clay fraction and a high content of iron and manganese compounds in the water.

The good transparency of water along the entire length of the river is also due to several reasons: high plowing of the coastal strip and a significant influx of humic substances due to the fragmentary cover of vegetation along the banks. Another reason is the composition of groundwater that feeds the main watercourse of the Ustya River, which is characterized, like most rivers in this region, by an increased amount of iron in almost all studied observation points. Significant areas of the river floodplain are swampy and wet, which determines the increased levels of BOD and permanganate oxidation due to the influx of hardly oxidizable humic substances, which determine a slight decrease in water transparency to 22-36 cm.

Significant variations within the basin of the Ustya River were observed for pH. In fact, this is the only indicator in this block, which sometimes recorded "excellent" water, although the worst values often reached 4 categories (slightly polluted) class III (mediocre).

Deterioration of indicators on hydrophysical and hydrochemical indicators was noted in the areas below the village. Kvasyliv, which we associate with the increased plowing of the floodplain by homesteads and more intensive agricultural production in the area.

Estimates of NDVI (normalized difference vegetation index) show that this area is devoid of vegetation and plowed most of the year, which causes constant leaching of soil fractions into the water of the Ustya River. This also explains many places with silt.

The inflow of substances from agricultural fields causes significant variations in pH towards alkalization, which can be explained by the inflow of mineral fertilizer residues into aquatic ecosystems. Thus, the range of pH variations was within 3-4 categories of II-III water quality classes (from excellent to mediocre).

Concentrations of suspended particles (turbidity) during the study period within the Basiv Kut reservoir above Rivne were relatively low, their values ranged from 16.80 to 32.93 mg / dm^3 (within 3–4 categories) (Fig. 5). The highest concentrations of suspended particles in river water were observed in summer and autumn, and the lowest - in winter.

In winter, content of suspended particles was the lowest, so, the average value for the winter was 7.5 ± 1.89 mg / dm^3 (category 3), the same values varied in the range from 6.4 mg / dm^3 (category 2) to 68.0 mg / dm^3 (6 category).

In the spring the turbidity of the water increased, the average value for the spring period was 20.47 ± 10.97 mg / dm^3 (category 4), the same values varied in the range from 12.00 mg / dm3 (category 3) to 22.4 mg / dm^3 (4 category).

In summer, the general values of the content of suspended particles increased, and in autumn reached a maximum. The average value in the summer was 25.10 ± 4.54 mg / dm^3 (category 3), the same values varied from 4.40 mg / dm^3 (category 1) to 44.00 mg / dm3 (category 5). In autumn, the average value was 24.36 ± 3.60 mg / dm^3 (category 4), the same values ranged from 4.79 mg / dm3 (category 2) to 44.0 mg / dm^3 (category 5).

Studies of water quality along the Ustya River and its tributaries over a 5-year period (2015–2019) showed that the highest turbidity was recorded within 25 km of the confluence point in the Goryn River, 0.25 km below the wastewater discharge from the USC. Rivne, VKH service, Rivne. The maximum values of average river values of 34.11 and 22.95 mg / dm^3, respectively, are recorded here, which corresponds to 4-5 categories of quality class III.

According to the analysis, the content of ammonium nitrogen reached critical divisions in all periods. The average values of ammonium nitrogen content were at the level of 1.02 mg / dm^3, which identifies this water as "bad" in both class and category. Seasonal fluctuations in ammonium ion content are usually characterized by a decrease in the spring and an increase in the summer, probably due to increased decomposition of organic matter. In the autumn-winter period, the increase in the content of ammonium ions is associated with continued decomposition of organic matter with a slight fixation of phytoplankton due to a decrease in the intensity of photosynthesis.

Extreme values of ammonium content were observed in almost all seasons. In winter, the average value was 1.39 mgN / dm^3. Although the variation of values was significant: from 0.09 to 7.60 mgN / dm^3. In the spring, the content of ammonia ions decreased slightly, which is clearly followed by a decrease in the average values (0.44 ± 0.27 mgN / dm^3), which correspond to the 4th category of class III, and the extreme values (2.70 mgN / dm^3), However, in the summer and autumn periods the content of ammonia ions increased to 0.86 and 0.93 mgN / dm^3, respectively, which generally corresponds to the 5th category of class III. The maximum values of ammonium ion content were recorded in the Ustya River, 25 km from the confluence point in the Goryn River, 0.25 km below the wastewater discharge in Rivne - 9.6 mgN / dm^3 (3.7 times higher than the MPC) on September 2, 2017, as well as in the area of treatment facilities of the Kvasyliv village – 7 mg / dm^3, (2.7 times higher than the MPC) – on February 19, 2016.

It is known that ammonium ions formed during biochemical transformations are oxidized by nitrite bacteria into nitrite ions (with subsequent formation of nitric acid). Therefore, the analysis of nitrogen metabolism was carried out comprehensively, taking into account the possible processes of transformation of forms of nitrogen content. Consequently, the content of nitrite forms of nitrogen showed a slightly worse situation in terms of water quality in the Ustya River. 7 category V class)) with average values within 0,083 mgN / dm^3 (bad, 6 category IV class), which does not exceed the established standards SanPiN # 4630-88 (3,3 mgN / dm^3), but in most cases exceeds the standards, set at (0.08 mgN / dm^3). The nitrite content in winter and spring was higher. Thus, the average values for the 4-year period reached 0.072 and 0.082, respectively, which were defined as 6 category IV class. In summer and autumn, their content decreased slightly due to faster oxidation processes in aquatic ecosystems, although the average values were defined as category 6 category IV - 0.068 mgN / dm^3. However, the maximum value was observed in autumn 2015 at the level of 3,450 mgN / dm^3 (September 2, 2015) in the area of Kvasyliv village (Rivne district). During the same period, the surface water in the area of the Rivne wastewater outlet was in the range of 1.33 mgN / dm^3. This confirms the fact that a significant contribution to the deterioration of surface water quality is made by anthropogenic activity, because in the source of water quality in terms of nitrite ions is 2-3 categories better than water quality in covered areas of wastewater outlets.

The nitrate form of nitrogen is formed in the final stages of nitrogen oxidation, and elevated concentrations of this compound indicate enhanced decomposition of organic matter under conditions of slow oxidation. At the end of the summer, an increase in the content of nitrates in the water was recorded due to the activity of phytoplankton. And even by mid-October 2019, these values did not fall. The average values of the summer period of 2019 were recorded at 2.90 mg / dm^3, which corresponds to category 7 (very dirty) V class (bad), at the same level recorded the worst values, the best indicators were recorded in winter at 0.43 mg / dm^3 (Category 3 (good) class II water quality). In winter, the situation worsened due to the slowdown of oxidation processes and the cessation of nitrogen consumption by autotrophs. Thus, in winter and spring, the content of nitrates in water averaged 0.78 and 0.83 mg/dm^3, respectively. However, even in winter, significant exceedances of the background content of nitrates were recorded - at the level of 8-9 mg / dm^3, but the extremum was still recorded in autumn (September 2, 2015) in the Kvasylivsko-Zdolbuniv section - within 12 mg / dm^3.

Deteriorated nitrogen regime is fully consistent with other data of the trophosaprobological block. This indicates an excessive anthropogenic component of the impact on water quality in the form of agricultural production in the river floodplain and the inflow of wastewater from settlements.

The term "total phosphorus" means all types of phosphates contained in water - soluble and insoluble, inorganic and organic phosphorus compounds. Significant variations were observed for this indicator in the water of the Ustya River. Thus, the average values were noted at the level of 0.396 mg/dm^3, which corresponds to 7 categories of water quality (dirty) V class (poor). Deterioration to category 6 (dirty) of the IV class (bad) was recorded at the lowest values. The ratio of N: P is not pleasant for the absence of significant "flowering" of reservoirs, as evidenced by the lack of oxygen supply to the water.

Water blooms were observed in August in all years in the central part of the river, where the floodplain is excessively plowed, which indicates a temporary imbalance of organogenic elements in the water.

In winter and spring, the average water quality index for phosphorus in the form of phosphates was 4.50-4.82, while in summer it increased to 6.59, and slightly decreased in autumn to 5.8. The maximum value of phosphorus content of phosphates was recorded on September 2, 2015 near the village of Kvasyliv, at the point of wastewater discharge - 8.3 mg / dm^3, which is 2.4 times higher than the requirements of **SanPiN** # 4630-88 Sanitary rules and standards for the protection of surface waters from pollution (3.5 mg / dm^3).

It is known that the degree of contamination of water with organic compounds is defined as the amount of oxygen required for their oxidation by microorganisms under aerobic conditions

(Maier & Gentry, 2015; Fedonyuk et al., 2020). Water oxidation is an extremely important indicator of water quality analysis, because this value characterizes the total content of organic matter and easily oxidizable inorganic impurities (hydrogen sulfide, sulfites, iron compounds II, etc.), which enter reservoirs under the condition of most natural processes, for example, with rain and melt water, due to the development of plant and animal organisms, erosion of drainage channels, wastewater discharge (Aristarkhova et al., 2021).

In addition, oxidation is an important indicator of the hygienic characteristics of water. According to its dynamics, it is possible to make decisions on the application of certain sanitary and hygienic measures. Increased oxidation in water bodies may indicate excessive discharge of wastewater or pollutants from other sources. In view of the above, this indicator can be a prerequisite for taking measures for sanitary protection of the reservoir. The determination of oxidation is based on the reaction of organic compounds with oxidants, as a result of which the amount of oxidant and its equivalent amount of oxygen spent on the oxidation of these compounds is determined.

To characterize the water in the experimental conditions, we also determined the dichromate oxidation. Because, in comparison with permanganate oxidation, it more accurately characterizes the content of organic pollutants, because potassium dichromate oxidizes about 90% of the organic substances present in the water, including difficult to oxidize.

In addition to the indicator of dichromate and permanganate oxidation, we determined the indicator that characterizes the degree of organic pollution of the reservoir - biochemical oxygen demand (BOD). This is an indicator of the amount of oxygen used to oxidize organic impurities in water, provided that it undergoes biochemical processes over a period of time (in our case, 5 days). It is known that the main oxidants of organic matter in water are bacteria, which use these compounds as a source of food and energy.

The water of the Ustya River is rather mediocre in terms of pollution by organic compounds. This is evidenced by all the studied indicators of water quality. Permanganate oxidation on average was recorded at the level of 5.48 mg O_2/dm^3, which defined it as the 5th category (moderately contaminated) of the III class. The worst values were recorded at the level of the 7th category (bad) of the V class - 15.0-15.7 mg O_2/dm^3 (February 19, 2018 and August 30, 2016). At the same time SanPiN # 4630-88 Sanitary rules and standards for the protection of surface waters from pollution requires no more than 4.51 mg O_2/dm^3, "Environmental safety standards of water bodies». " - not more than 3.0 mg O_2/dm^3.

In spring and winter, water quality in terms of biochemical oxygen consumption was between 4 and 5 categories (4.55-4.99), at the level of 4.4-5.6 mg O2 / dm^3. In summer, the quality of surface waters deteriorates to the transition to the sixth category, the average value of the summer season is 5.64, and the worst value - 6.136 (the sixth category with the transition to the seventh).

Data on dichromate oxidation confirmed the obtained data on permanganate oxidation, as the average values of this indicator characterized the water of the Ustya River as slightly polluted (category 4, class III), and the worst - bad (category 7, class V). Data on chemical oxygen demand also varied seasonally, in winter and spring the figures were slightly lower - on average at 26.8… 27.9 mg O_2/dm^3, slightly contaminated (category 4, class III), in summer and autumn deteriorated to 5 categories on average - 38.65 and 32.2 mg O_2/dm^3, respectively.

The worst value was recorded at 112 mg O_2/dm^3 on January 18, 2016. At the same time SanPiN №4630-88 requires a level of chemical oxygen demand not more than 30 mgO_2/dm^3, "Standards for environmental safety of water bodies». " - not more than 50 mgO_2/dm^3.

A separate point should be noted the concentration of iron in the water of the Ustya River, where inflated values are due to geochemical processes, as in the Ustya River basin unloaded groundwater with the highest concentration of iron ions in the Ukrainian Polissya, the content of which in the natural state reaches 8 µg / dm more (Lange, 1959). Therefore, on a general scale, the iron content in the water of the Ustya River varied within the 5th category (moderately polluted) of the third quality class (mediocre). However, according to the scale interpreted for northern Polissya, taking into account the background level of this element, the water of the Ustya River is defined as "very good" (2 category II class), with the worst values at level 3 category II class.

It should be noted the low content of heavy metals in the surface waters of the Ustya River, while the content of cadmium, zinc, chromium total, nickel water was determined at the level of category 1 quality class I or "excellent", with the worst indicators, as a rule, not recorded indicators below 3 categories of the II class ("good"). According to the content of mercury, copper and lead, the average values were fixed at the level of the 2nd category of the II class.

The manganese content was critical. It should be noted that this content is somewhat due to regional characteristics and the structure of the river basin. Its increased content is recorded almost everywhere in the water bodies of Polissya. This can be justified by leaching from forest litter, iron-manganese soil nodules, high content in peatlands. An additional imprint is caused by the high swampiness of the territory of Polissya and the proximity of the illuvial horizon of sod-podzolic soils typical for Polissya. As we suppose, extremely high concentrations of manganese at the level of category 5 of the III class of water quality were noted for the Ustya River, which cannot be explained only by its high content in the composition of humic substances, and therefore it should be considered with anthropogenic component.

The content of oil products in the water of the Ustya River was also insignificant, the average data on the content of this compound were at the level of category 1 of I class quality, slightly higher content was observed near the bridge over which the road runs. However, even at the worst values the water quality did not fall below the II class of water quality of the 2nd category (good). The presence of phenols and cyanides in the water was not noted. The presence of synthetic surfactants was recorded in small quantities, however, their content was recorded within the normative values and the worst values were identified as the 2nd category ("very good").

Similar values were confirmed by calculations of the coefficients of bottom accumulation of heavy metals and accumulation of pollutants in aquatic organisms. According to these two indicators, data were obtained, which once again confirmed the previously obtained data on the content of the main categories of heavy metals and toxins. Water is defined on average at the level of 2-3 categories of quality class II (good).

In general, the quality of water in the Ustya River is defined as favorable in terms of the content of specific substances of toxic and radiation action (Fig 5). The average values of water quality showed 2 subcategories with a transition to 1, with deterioration only in the content of total iron and manganese, which is characteristic of the geological, geomorphological and soil conditions of northern Polissya Ukraine. This causes the transition of water quality in the worst indicators to subcategory 2-3 (between the second and third).

In general, the quality of water in the Ustya River is defined as favorable in terms of the content of specific substances of toxic and radiation action. The average values of water quality showed the first with the transition to the second subcategory of water quality, with the worst indicators within 2 subcategories.

Ecological sustainability of the landscapes of the Ustya river basin. During the last decades, the landscapes of the Ustya river basin have changed significantly in the direction of increasing urban areas and areas set aside for agriculture. The creation of an integrated system of measures for the formation and maintenance of ecologically stable landscapes involves their detailed and diverse assessment.

Among the ecological problems that should be outlined in characterizing the ecological condition of the main tributaries of the Ustya basin can be distinguished as follows: for the rivers Untitled (which originates near the village of Mizotska and flows into the Ustya near the village of Zdovbytsia - Zdolbuniv) and tributaries Kunin sources of anthropogenic impact are primarily in the plowing of the territory - 43.7 and 45.6%, respectively, over-regulation of runoff, lack of coastal protection strips, etc. For the Kunin tributary there is a problem of the influence of the drainage system on the formation of runoff.

The tributary of the Spasov is generally characterized by the same problems, in particular the plowing of the territory is generally higher than the average in the basin (73.2%), runoff regulation and a significant number of ponds, the lack of coastal protection strips is complemented by the general lack of local treatment facilities .

To this end, we have used a number of coefficients that can best reflect the level of stability and anthropogenic transformation.

In order to assess the sustainability of landscapes and to prevent the fact that this area is characterized by the distribution of many Red Book species, we used to assess the indicator - the index of species diversity (ecotonization index). Which we calculated in the context of each massif, while assessing the edges of the plow, the edges of the beam and riparian strips, the edges of forests, the boundaries of plowing with other lands, boundaries and more.

In our previous work, we used this criterion to assess the stability of the landscapes of the rivers of Polissya (Romanchuk et al., 2018; Fedoniuk et al., 2018; 2019, Orlov et al., 2021) it is he who reflects the data on the ratio of areas, which are engaged in stabilizing and destabilizing components of landscapes – KESL 1, and the ratio of environmentally stable elements to the whole landscape – KESL 2.

As the landscape analysis showed, according to KESL1, the landscape has a pronounced unstable landscape.

To confirm the above data, we calculated the coefficients of ecological stability of the landscape (KESL2). In this case, the array № 14 (KESL2 - 0.51) can be considered stable, namely in the place of the tributary Untitled in the area of s. Upper, downstream the level of landscape instability increases, at the source of the Ustya River the level of instability defines the landscape as unstable (KESL2 - 0.48). A significant decrease in the level of landscape stability to "unstable" occurs in the "Kvasyliv-Zdolbuniv section" and is maintained at the same level until the village. Orzhiv, where the river Ustya flows into the river Goryn.

One of the reasons for the significant deterioration of water quality in the Ustya River basin is significant erosional dismemberment, as the river floodplain has an erosive-cumulative character. The analysis of the obtained data showed that within all arrays the average dismemberment and tense ecological condition were noted and strong dismemberment and extraordinary ecological condition were noted within the Kvasylisko-Zdolbunivska section (array 6).

Analysis of the stability and anthropogenic transformation of landscapes, we collaborated with the analysis of the quality of surface water ecotonization index (Table 5). Correlation analysis of the relationship between ecotonization indices and surface water quality indices has shown that as the integrated water quality index increases, the ecotonization index decreases. For almost all arrays with points where ecotonization indices were higher than 10, water quality was lower than 4 categories (Fig. 7A). At the same time, close correlations are observed for all water quality blocks, and especially for the blocks of salt composition and substances of toxic and radiation action.

In addition, we analyzed in detail the landscape structure of the Ustya River basin, for which we applied the criteria KESL1 and KESL2 (Fig. 7B-C). There are inverse correlations between KESL1 and KESL2 and indices of salt and trophosaprobological state, as well as integrated ecological indices of water quality, slightly weaker relationships were found with indices of toxic and radiation substances, obviously due to the fact that too high concentrations of substances in this category were not detected. This is evidenced by the fact that the presence of destabilizing components of the landscape mainly affects the flow of organic and organogenic substances to the surface waters of the territory (Table 6).

There are no significant relationships between the indices of erosional dismemberment of the terrain and indicators of water quality in certain areas.

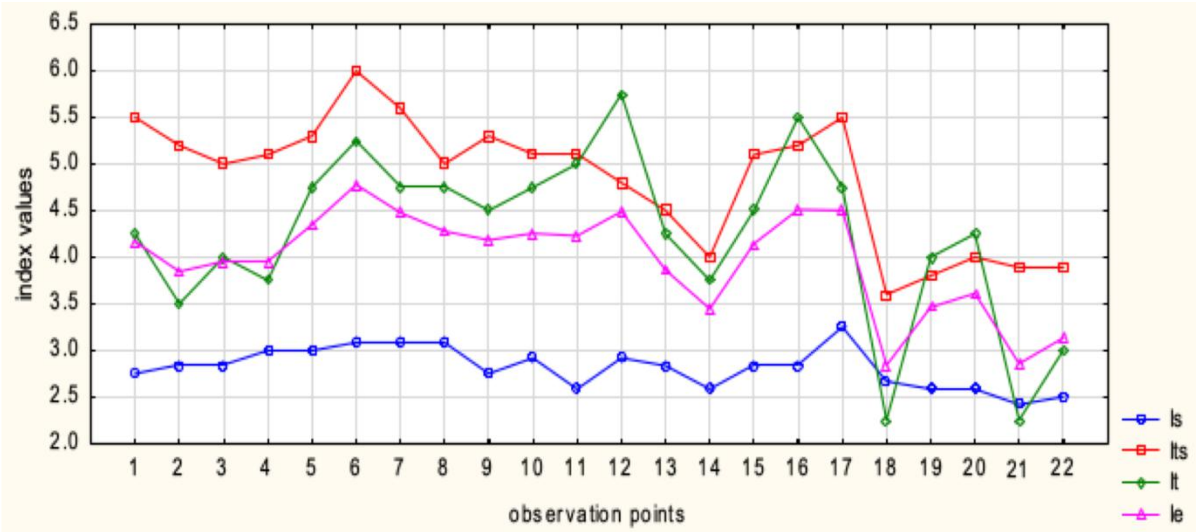
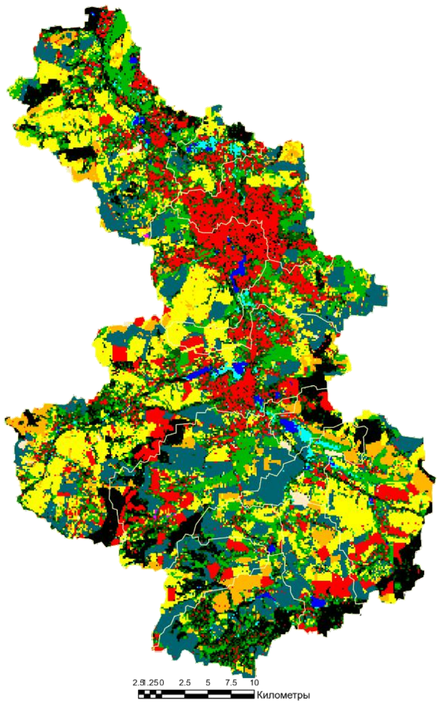


Fig. 5. Ecological classification of surface water quality of the Ustya river Obsrervation points according table 1. *Legend: Is* - salt composition index; *Its* – trofosaprobological index; *It* -toxicological composition index; *Ie* - general ecological index.

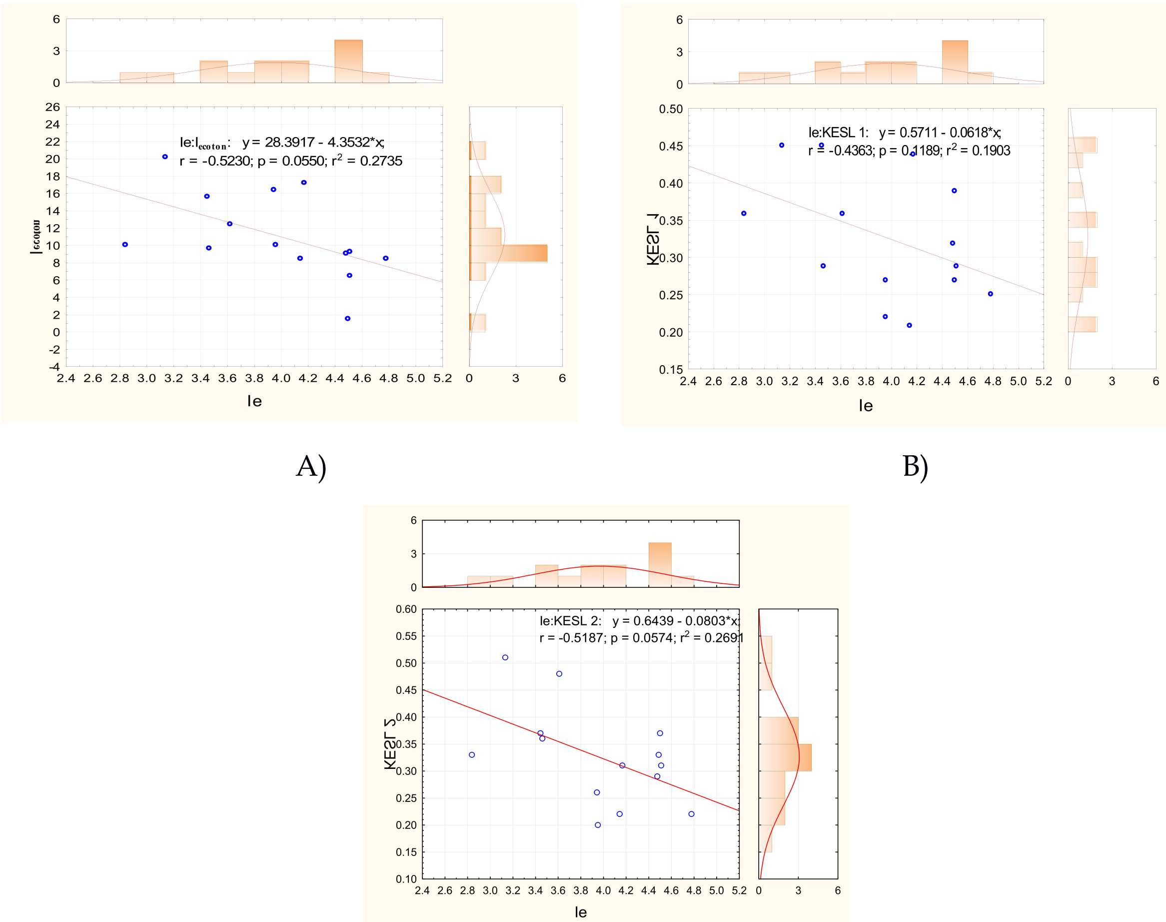


Building area and alienation for the road network
Arable land, hops
Orchards, acacias
Coniferous forests
Cities
Meadow
Pastures
Reservoirs and drains
Deciduous forests, natural spruces

Fig. 6. Types of landscape cover (landscape biotechnical elements).

Table 6. Ecological assessment of the landscapes stability of the Ustya River catchment area.

Array	I_{EKOTON}	KESL 1	K_{ER}	KESL 2	Iat	The degree of anthropogenic transformation of landscapes
1	17.3	0.44	0.41	0.31	846	Very high
2	16.5	0.27	0.59	0.26	796	Very high
3	10.2	0.22	0.47	0.20	524	Average
4	8.5	0.25	0.40	0.22	385	Moderate
5	9.2	0.32	0.53	0.29	499	Average
6	1.6	0.39	0.71	0.33	507	Average
7	15.6	0.45	0.50	0.37	576	High
8	8.6	0.21	0.38	0.22	765	Very high
9	9.4	0.29	0.43	0.31	815	Very high
10	6.5	0.27	0.36	0.37	545	High
11	10.1	0.36	0.32	0.33	465	High
12	9.7	0.29	0.46	0.36	489	High
13	12.6	0.36	0.43	0.48	502	High
14	20.3	0.45	0.46	0.51	685	Very high



A) B)

C)

Fig. 7. Relationship of ecotonization indices, KESL 1 and KESL 2 with the qualitative composition of surface waters of the Ustya river basin.

Table 7. Correlation analysis of the relationship of the main landscape criteria and water quality indices.

Correlations (stattya nova)
Marked correlations are significant at p < .05000
N=14 (Casewise deletion of missing data)

Variable	I_{ecoton}	KESL 1	K_{er}	KESL 2	% of plowed territory	The degree of anthropogenic transformation of landscapes
s	-0.60	-0.59	0.03	-0.59	-0.40	-0.20
ts	-0.29	-0.46	0.03	-0.64	-0.11	0.16
t	-0.59	-0.29	0.38	-0.30	-0.10	0.04
Ie	-0.52	-0.44	0.22	-0.52	-0.15	0.06

Conclusions

River ecosystems of Polissya are in a state of deep degradation, which consists of siltation, falling water levels and pollution. Analysis of the particle size distribution of floodplain soils in different zones of the Ustya River basin showed that the predominant soil fractions here are coarse-grained and dusty. This fractional ratio is explained by the peculiarities of the hydrological regime, namely the position in the basin, periodic spills, depth and flow velocity. In all studied periods the water transparency was very low, in particular it fluctuated in the range of 22… 36 cm, which corresponds to 6 category IV class, that is, it can be defined as poor in quality. This indicates that certain vital processes of aquatic organisms may be suppressed. Decreased water transparency may indicate the presence of a clay fraction and a high content of iron and manganese compounds in the water. Low indicators of the trophosaprobological block indicate an excessive anthropogenic component of the impact on water quality in the form of agricultural production in the river floodplain and the inflow of wastewater from settlements. The use of some indices to determine the characteristics of landscapes has shown close links with water quality indicators. For almost all massifs with points where ecotonization indices were higher than 10, water quality was lower than 4 categories, that is, it was identified as contaminated. Consequently, the peculiarities of hundreds of landscapes are decisive for the formation of water quality in the Ustya River basin.

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