www.czasopisma.pan.pl PAN POLSKA AKADEMIA NAUK www.journals.pan.pl

PAN POLSKA AKADEMIA NAUK

JOURNAL OF WATER AND LAND DEVELOPMENT

e-ISSN 2083-4535

ITP-PIB

Polish Academy of Sciences (PAN) Institute of Technology and Life Sciences – National Research Institute (ITP – PIB)

JOURNAL OF WATER AND LAND DEVELOPMENT
DOI: 10.24425/jwld.2022.142310
2022, No. 55 (X–XII): 97–103

Assessment of the environmental state of surface waters of right-bank tributaries of the upper reaches of the Pripet River by macrophyte index MIR

Myroslav S. Malovanyy[1)] ✉, Maria Boiaryn[2)], Oksana Muzychenko[2)], Oksana Tsos[2)]

[1)] Lviv Polytechnic National University, Viacheslav Chornovil Institute of Sustainable Development, Department of Ecology and Sustainable Environmental Management, S. Bandera St, 12, 79013, Lviv, Ukraine

[2)] Lesya Ukrainka Volyn National University, Faculty of Chemistry, Ecology and Pharmacy, Department of Ecology and Environmental Protection, Lutsk, Ukraine

RECEIVED 21.08.2021 ACCEPTED 27.01.2022 AVAILABLE ONLINE 19.12.2022

Abstract: The results of the study of the macrophytes of the rivers Turia, Vyzhivka and Tsyr, the right-bank tributaries of the upper reaches of the Pripet River, are presented. The species composition of aquatic and coastal aquatic vascular plants was investigated during the vegetation seasons of 2018 and 2019 at 9 observation points located along the rivers from the source to the mouth. The most numerous species composition, 57 species, was found in the Turia River, 36 in the Vyzhivka River, and 28 species were identified in the Tsyr River. The macrophyte index for rivers (Pol.: makrofitowy indeks rzeczny – *MIR*) was determined from the results, and the ecological state of the rivers was assessed according to the methodology of the macrophyte assessment of rivers (Pol.: makrofitowa metoda oceny rzek – MMOR). The investigation showed that water quality in the Turia River on sites No. 1, 3 and 4 belongs to class III, satisfactory category. The surface water quality on site No. 2 of the Turia River belongs to class II, a good category. The water quality in the Vyzhivka River on all test sites belongs to class II, a good category, which testifies to favourable ecological conditions for the development of higher aquatic plants along the whole course. The water quality in the Tsyr River on test site No. 8 (Kamin-Kashyrskyi, upper course) corresponds to class II, good category. On test site No. 9 (middle course), the quality of surface waters of the Tsyr River worsens to the class III, satisfactory category.

Keywords: ecological condition of surface waters, macrophytes, macrophyte index, observation point, water quality category

INTRODUCTION

The organisation of a system of research on the qualitative and quantitative state of surface and groundwater in order to predict the risks of the river ecosystem functioning is relevant [Odnorih *et al.* 2020]. Analysis of monitoring results allows to predict the introduction of promising technologies for wastewater treatment from biological contaminants [Nykyforov *et al.* 2016], heavy metal contaminants [Sakalova *et al.* 2019a, 2019b], ammonium ions [Malyovanyy *et al.* 2013] and other hazardous pollutants.

In recent decades, monitoring and indication of the quality of the environment using macrophytes has improved significantly and gained official recognition. Phytoindication research is included in the state system of ecological monitoring of many countries of the world. The Water Framework Directive [Directive 2000/60/EC] ratified by Ukraine also provides methods of biological monitoring [Boiaryn *et al.* 2019; Klymenko *et al.* 2005].

Phytoindication methods have been used in EU countries for quite a long time. For instance, the mean trophic rank (MTR) system is widespread in the United Kingdom, which includes 128 species of macrophytes, among which the main ones are higher plants, mosses and algae are less represented. This technique is used in many European countries (Poland, Spain, the Czech Republic, etc.). The MTR methodology is used in scientific research for many years, and the river nutrient macrophyte index system [Willby 2012] has also been used in macrophyte

monitoring in the UK since 2008 [Ciecierska *et al.* 2001; Korobkova 2018].

The river monitoring and assessment of the ecological status of surface waters in EU is governed by the EU Water Framework Directive [Directive 2000/60/EC]. The studies in France use the macrophyte biological index for rivers (Fr.: indice biologique macrophytique riviere – IBMR) methodology which combines two calculated bioindicators [AFNOR 2003]. One indicator shows the level of trophic environment, the second determines the degree of ecological tolerance (steno- and eurybiontic). This system is valued among scientists of various European countries for the exhaustive list of indicators and the weight of each indicator [Szoszkiewicz *et al.* 2002; 2018].

The ecological condition of the rivers of the Scandinavian countries is assessed by an original method developed by Danish scientists. It is based on biodiversity indices calculated from the Shannon–Weaver indicators.

The studies in Belarus are based on the IBMR method [Savitskaya 2014]. A version of the classification scheme of small rivers was developed taking into account the phytodiversity of vegetation and assessment of their ecological status.

The macrophyte method of river assessment (Pol.: makrofitowa metoda oceny rzek – MMOR) is used in Poland, which is based on the English MTR and the French IBMR. This technique was first described in 2006 and published in 2010 as a textbook. It is based on quantitative and qualitative indicators of assessment of aquatic and coastal aquatic vascular plants which are presented on the studied segment of the water body. The macrophyte index (*MIR*) is calculated by species composition which allows one to assess the ecological status in accordance with the EU Water Framework Directive [Ciecierska *et al.* 2013; Directive 2000/60/EC; Korobkova 2018; Szoszkiewicz *et al.* 2020]. The same technique is being introduced to assess the ecological status of watercourses in Kazakhstan, in Bulgaria, in Russia [Gyosheva *et al.* 2020; Muratov *et al.* 2015; Zuyeva *et al.* 2007].

Phytoindication studies in Ukraine are performed at the Ukrainian Scientific Research Institute of Ecological Problems (Ukr.: Ukrainskyi naukovo-doslidnyi instytut ekolohichnykh problem – UKRNDIEP) where the MMOR was adapted by developing the "Classification table for calculating the macrophyte index for rivers (*MIR*) for plain rivers of Ukraine", and by the newly established biological monitoring laboratories of the Ukrainian Hydrometeorological Center (Ukr.: Ukrainskyi hidrometeorolohichnyi tsentr – UkrHMTs). The UkrHMTs studies are also based on the macrophyte technique (MMOR). For the purposes of environmental monitoring, it is justified to develop local methods of evaluating the ecological state of the rivers to more accurately detect threats to the ecological status of rivers in the area.

The objective of this study is the determination of the species composition of aquatic and coastal aquatic vascular plants and the evaluation of the surface water ecological status of the upper reaches of the Pripet River (the Turia, the Vyzhivka, and the Tsyr rivers) using the macrophyte technique (MMOR).

MATERIALS AND METHODS

Macrophytes help determine the degree of degradation of surface waters, primarily in terms of their ecological status. Chemical and physical (instrumental) methods for assessing the surface water quality determine the pollution at the time of the study while biological research methods determine the impact of pollutants in the long perspective. According to the MMOR method, because aquatic organisms are constantly under pressure from the environment and knowing their sensitivity to certain pollutants, one-time field research makes it possible to determine the average level of pollutants throughout the growing season [Ciecierska *et al.* 2013; Korobkova 2018; Szoszkiewicz *et al.* 2020].

Research on the flora was held over two years (2018–2019). Test sections were identified, with water sampling points tied to the existing sites of state monitoring observations, which are characterised by different levels of anthropogenic load and satisfy the conditions of representation of hydroecological research regarding the impact of point and diffuse sources. A total of nine test sites were selected on the right-bank tributaries of the upper reaches of the Pripet River which are typical river hydroecosystems of Ecoregion 16 [Tsos 2021]. Hereafter, the numbering of test sections and representative sampling points is according to Table 1.

The next step was to determine the macrophyte index for the river (*MIR*). According to MMOR, each aquatic plant species is assigned two index numbers. The first index, *L*, indicates the average trophic level of the environment of the species. The trophic index *L* ranges from 1 (for advanced eutrophic processes) to 10 (for oligotrophic waters). The second index, *W*, is the weighting factor. This one shows the ecological tolerance of the species (from 3 for stenotopic to 1 for eurytopic). The value of the index, *L*, and the weighting factor, *W*, for each species, were taken from the methodology, namely from the list of indicative species

Table 1. Test sections for phytoindication studies and representative heads for water sampling

Area No.	Administrative location of the test site	Distance from the river mouth (km)	Substantiation of representativeness
The Turia River			
1	village of Zaturtsi, near the source of the river	176.90	background head, the source of the river
2	city of Kovel, 500 m above KOS "Kovelvodokanal" intake	79.29	control point, the impact of agricultural development of the basin, the middle part of the river
3	village of Bakhiv, 500 m below the KOS "Kovelvodokanal" outflow	78.29	control point, the impact of wastewater discharge of KOS "Kovelvodokanal", the middle part of the river
4	village of Buzaki	20.26	control point, a section near the mouth of the river

cont. Tab. 1

Area No.	Administrative location of the test site	Distance from the river mouth (km)	Substantiation of representativeness
The Vyzhivka River			
5	villages of Hvorostiv and Ruda, near the source	70.18	background head, the source of the river
6	town of Stara Vyzhivka, 500 m above the Stara Vyzhivka wastewater outflow	34.58	control point, the impact of agricultural development of the basin, the middle part of the river
7	near the town of Ratne, after crossing the Kovel–Ratne highway	6.45	control point, a section near the mouth of the river
The Tsyr River			
8	town of Kamin-Kashyrskyi	41.33	background head, before the recreation area
9	near the village of Vyderta of Kamin-Kashyrskyi district	26.60	control point, the effect of the Tsyr drainage system, the middle part of the river

Explanation: KOS = Ukr.: kanalizatsiino ochysni sporudy – sewage treatment facilities.
Source: own elaboration.

to determine the *MIR* index and their assigned values of *L* and *W* [Ciecierska, Dynowska 2013].

The projective coverage of each species was also determined on a 9-point scale.

The macrophyte index *MIR* was calculated from the field research data by the formula:

$$MIR = \frac{\sum_{i=1}^{n} L_i W_i P_i}{\sum_{i=1}^{n} W_i P_i} \, 10 \qquad (1)$$

where: *MIR* = the macrophyte index for the river, L_i = the *L* index value for the found species *i*, W_i = the weighting factor for the species *i*, P_i = the coverage ratio for the species *i* on a 9-point scale.

According to the used method, the *MIR* index ranges from 10 (worst values) to 100 (best). In the case of plain rivers, the highest values of *MIR* do not exceed 60. Different types of indicators were identified for different types of rivers [Ciecierska *et al.* 2013]. The calculated values of the *MIR* index are graded by classes corresponding to the water assessment system according to the Water Framework Directive [Directive 2000/60/EC].

RESULTS AND DISCUSSION

Geobotanical studies were performed in the basins of the Vyzhivka, the Turia, and the Tsyr rivers during July–September of 2018 and 2019, and the ecological status of river basins of the upper Pripet River in the Volyn Oblast was assessed using macrophyte method MMOR. A classification table for four types of rivers used in the Polish technique MMOR was used to calculate the *MIR* [Ciecierska *et al.* 2013].

The species composition of the identified indicative species of the tributaries of the upper reaches of the Pripet River is presented in Table 2.

Our research determined that the flora of aquatic and coastal aquatic vascular plants of the Turia, the Vyzhivka and the Tsyr rivers includes 69 species (47 of which are indicative) which belong to 44 genera, 25 families, 4 classes, 3 divisions [Tsos 2016; 2021]. In the descriprion of the flora, we also used the principles of classification of higher aquatic plants by Dubyna [1986] and

Table 2. Species composition of indicative species of the upper tributaries of the Pripet River

No.	Plant name	L_i	W_i	The Turia	The Vyzhivka	The Tsyr
1	*Equisetum fluviatile* L.	6	2	+		
2	*Equisetum palustre* L.	5	2	+	+	
3	*Berula erecta* (Huds.) Coville	4	2	+		
4	*Cicuta virosa* L.	6	2	+	+	
5	*Sium latifolium* L.	7	1		+	
6	*Myosotis scorpioides* L.	4	1	+	+	+
7	*Rorippa amphibia* (L.) Bess.	3	1	+	+	
8	*Ceratophyllum demersum* L.	2	3	+	+	
9	*Ceratophyllum submersum* L.	2	3	+		
10	*Mentha aquatica* L.	5	1	+	+	+
11	*Veronica anagallis-aquatica* L.	4	2	+		+
12	*Veronica beccabunga* L.	4	1		+	+
13	*Nuphar lutea* (L.) Smith.	4	2	+	+	+
14	*Persicaria amphibia* (L.) S.F. Gray	4	1	+	+	+
15	*Persicaria hydropiper* (L.) Delarb.	3	1	+		+
16	*Polygonum persicaria* L.	2	2	+		
17	*Lysimachia vulgaris* L.	4	1	+		
18	*Caltha palustris* L.	6	1		+	
19	*Ranunculus circinatum* Spach	5	2		+	
20	*Ranunculus sceleratus* L.	2	1	+		
21	*Myriophyllum spicatum* L.	3	2	+	+	
22	*Acorus calamus* L.	2	3	+	+	
23	*Alisma plantago-aquatica* L.	4	2	+	+	+
24	*Sagittaria sagittifolia* L.	4	2	+	+	+
25	*Lemna gibba* L.	1	3	+		
26	*Lemna minor* L.	2	2	+	+	+
27	*Lemna trisulca* L.	4	2	+	+	+

cont Tab. 2

No.	Plant name	L_i	W_i	The Turia	The Vyzhivka	The Tsyr
28	*Spirodela polyrrhiza* (L.) Schleid	2	2	+	+	+
29	*Elodea canadensis* Michx.	5	2	+	+	+
30	*Hydrocharis morsus-ranae* L.	6	2	+	+	
31	*Stratiotes aloides* L.	6	2		+	
32	*Potamogeton crispus* L.	4	2	+		
33	*Potamogeton lucens* L.	4	3	+		
34	*Potamogeton natans* L.	4	1	+		
35	*Potamogeton pectinatus* L.	1	1	+		
36	*Iris pseudacorus* L.	6	2	+		
37	*Carex acuta* L.	5	1	+	+	+
38	*Carex acutiformis* Ehrh.	4	1	+	+	
39	*Carex riparia* Curtis	4	2	+	+	+
40	*Scirpus lacustris* L.	4	2	+	+	
41	*Scirpus sylvaticus* L.	5	2	+		+
42	*Eleocharis palustris* (L.) Roem. and Schult.	6	2	+	+	
43	*Glyceria maxima* (Hartm.) Holmb.	3	1	+	+	+
44	*Phalaris arundinacea* L.	2	1	+		+
45	*Sparganium erectum* L.	3	1	+		
46	*Typha angustifolia* L.	3	2	+		+
47	*Typha latifolia* L.	2	2	+	+	+
Total				**42**	**29**	**20**

Explanations: L_i = the L index value for the found species i, W_i = the weighting factor for the species i.
Source: own study.

Dubyna and Sheliag-Sosonko [1989] and identified the following types: coastal aquatic plants, plants with floating leaves, semi-submerged, and submerged species.

The aquatic flora is dominated by *Magnoliophyta* – 95.65% (66 species), and the distribution of *Magnoliopsida* and *Liliopsida* is relatively close – 44.93% and 50.72% of the total number of species. *Equisetophyta is* represented by two species or 2.90% of the total, and *Polypodiophyta* by one species (1.45%).

Seven leading families of the flora (*Polygonaceae*, *Ranunculaceae*, *Araceae*, *Cyperaceae*, *Hydrocharitaceae*, *Roaceae*, *Potamogetonaceae*) combine 49.28% of all species. The other 23 families of the aquatic flora of the upper Pripet basin are represented by 1–8 species.

The test areas of the Turia River contain 56 species of aquatic and coastal aquatic plants belonging to 3 divisions (*Equisetophyta*, *Polipodiophyta* and *Magnoliophyta*), 24 families and 36 genera.

The data on indicator values of the species by Ciecierska *et al.* [2013] was used. The results of the analysis of the floristic composition of higher aquatic and coastal aquatic plants of the Turia show that 42 out of 56 existing species have indicative significance (Tab. 2). Among them are the following species: *Potamageton crispus* L., *Sparganium erectum* L., *Rorippa amphibia* (L.) Besser, *Hydrocharis morsus-ranae* L., which are indicators of eutrophic waters, and *Spirodela polyrhiza* (L.) Schieid, which is an indicator of waters with strong eutrophication of anthropogenic origin. *Lemna gibba* L. is an indicator of polluted mesosaprobic waters rich in nitrogen compounds.

On research site No. 1, in the village of Zaturtsi, 24 macrophyte species indicative of ecological status were found. They are dominated by coastal plants and plants with floating leaves. On site No. 2, by the bridge of the city of Kovel, 23 indicative macrophyte species were found, among which coastal and submerged forms, as well as plants with floating leaves, predominate.

On site No. 3 (500 m away from the wastewater treatment facility discharge) in the middle section of the Turia River, 26 indicative macrophyte species were identified. All ecological groups of plants are represented relatively evenly here – coastal, submerged, and with floating leaves. The same situation is on site No. 4, in the village of Buzaki (the river mouth), where 21 macrophyte species, which are indicative of ecological status, were found, although the number of typical swamp macrophytes has increased.

The following species were found everywhere: *Hydrocharis morsus-ranae* L., *Alisma plantago-aquatika* L., *Sagittaria sagittifolia* L., *Carex riparia* Curtis, *Phragmites australis* (Cav.) Trin. ex Steud., *Acorus calamus* L., *Lemna minor* L., *Lemna trisulca* L., *Spirodela polyrrhiza* (L.) Schleid, *Ceratophyllum demersum* L., *Myosotis palustris* L., *Mentha aquatic* L.

Some species are present in certain parts of the river: *Equisetum fluviatile* L., *Potamageton natans* L., and *Veronica anagallis-aquatica* L. – in the middle part of the Turia River in Kovel; *Potamageton crispus* L., *Scirpus sylvaticus* L., *Sparganium erectum* L., *Typha latifolia* L., *Ranunculus sceleratus* L., *Lysimachia vulgaris* L., and *Rorippa amphibia* (L.) Bess are common in the upper reaches of the Turia river, and *Eleocharis palustris* L. was found in the lower part of the river.

The *MIR* calculations were averaged based on the data of 2018 and 2019, and the ecological status of surface waters was assessed by the MMOR methodology (Tab. 3).

Figure 1 shows a map of the surface water ecological status of the Turia River on the basis of *MIR* in accordance with the above results.

The flora of the Vyzhivka River includes 36 species of higher aquatic and coastal aquatic plants belonging to 31 genera, 20 families, 14 orders, 3 classes (*Equisetopsida*, *Liliopsida* and *Magnoliopsida*) and 2 divisions (*Equisetophyta* and *Magnoliophyta*).

Analysis of the floristic composition of higher aquatic and coastal aquatic plants of the Vyzhivka River shows that 29 out of 36 found species have indicative value (Tab. 2). Among them are such species as *Sium latifolium* L., *Veronica beccabunga* L., *Lemna minor* L., which are indicators of eutrophic waters. Indicator species of waters with strong eutrophication of anthropogenic origin were practically not found.

The research on site No. 5, near the village of Khvorostiv, identified a total of 23 macrophyte species, 17 of which are indicative of ecological status. Among them, plants with floating leaves *Nuphar lutea* (L.) Smith., semi-submerged *Sagittaria sagittifolia* L., submerged *Elodea canadensis* Michx., and coastal species *Glyceria maxima* (Hartm.) Holmb. dominated.

On site No. 6, in the town of Stara Vyzhivka, a total of 22 macrophyte species were found, 21 of which are indicative of ecological status. The species composition of plants was dominated by plants with floating leaves *Nuphar lutea* (L.)

Table 3. Ecological status assessment of surface waters of tributaries of the upper Pripet River based on *MIR*

No.	Section of the river	*MIR*[1)]	Class	Category
1	village of Zaturtsi (upper river)	32.40/33.30 32.9	II (44.5–35.0⟩	satisfactory
2	city of Kovel (bridge)	39.80/40.65 40.2	III (35.0–25.4⟩	good
3	village of Bachiv (500 m away from the wastewater treatment discharge, middle river)	33.90/33.40 33.7	III (35.0–25.4⟩	satisfactory
4	village of Buzaki (near river mouth)	32.65/33.55 33.1	II (44.5–35.0⟩	satisfactory
5	village of Khvorostiv (upper river)	39.90/36.00 37.9	II (44.5–35.0⟩	good
6	town of Stara Vyzhivka (middle river)	38.90/40.90 39.6	II (44.5–35.0⟩	good
7	town of Ratne (near river mouth)	37.70/37.70 37.7	II (44.5–35.0⟩	good
8	town of Kamin-Kashyrskyi (upper river)	39.00/38.80 39.9	III (35.0–25.4⟩	good
9	village of Vyderta (middle river)	33.50/32.70 33.1	II (44.5–35.0⟩	satisfactory

[1)] Values above the line are *MIR* values (2018/2019), values below the line are the average data.
Source: own study.

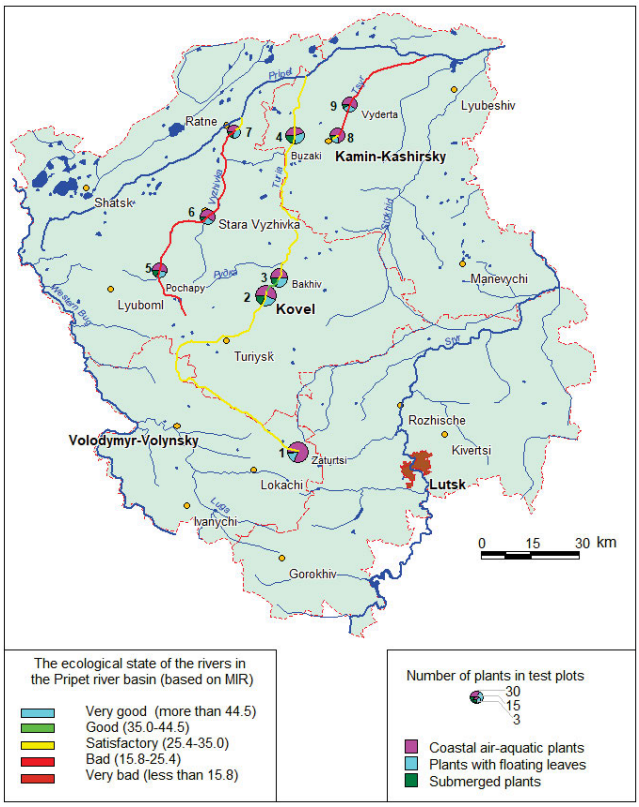

Fig. 1. A map of the ecological status of surface waters of the Turia River on the basis of *MIR*; source: own elaboration based on Tsos [2021].

Smith., semi-submerged plants *Stratiotes aloides* L., and coastal plants *Glyceria maxima* (Hartm.) Holmb.

At area No. 7, near the town of Ratne, a total of 19 macrophyte species were found, including 18 which are indicative of the ecological status of surface waters. The species composition of higher aquatic plants was dominated by the plants with floating leaves *Nuphar lutea* (L.) Smith. and semi-submerged species *Sagittaria sagittifolia* L.

Cicuta virosa L. was found infrequently in all parts of the Vyzhivka River. *Myosotis scorpiodes* L., *Ranunculus aquatile* (L.) Dumort, *Vallisneria spiralis* L. and *Eleocharis palustris* (L.) Roem and Schult. were also rare and found mainly in the upper part of the river. Ubiquitous species, such as *Lemna minor* L., and *Sagittaria sagittifolia* L. were also found at all sites.

Thus, the water quality in the Vyzhivka River in all test sites belongs to class II, good category, with mesotrophic status, which indicated favourable ecological conditions for the development of higher aquatic plants along the entire course.

The macrophyte flora of the Tsyr River includes 28 species, including 20 indicative species (Tab. 2) belonging to the division *Magnoliophyta*, classes *Magnoliopsida* and *Liliopsida*, which include 13 families and 22 genera. The leading families of flora are *Cyperaceae* and *Poaceae*, each of them making up 14.28% of all species. Other families have 1–3 representatives.

The results of the analysis of the floristic composition of higher aquatic and coastal aquatic plants of the Tsyr River show the smallest number of species of higher aquatic plants in comparison with other studied rivers – only 28.

At research area No. 8, near the town of Kamin-Kashyrskyi, a total of 15 macrophyte species were found, 11 of them – indicative of ecological status. They are dominated by coastal plants and plants with floating leaves: *Lemna minor* L., *Elodea canadensis* Michx., and *Scirpus sylvaticus* L., *Veronica anagallis-aquatica* L. and *Veronica beccabunga* L. had the smallest area of projective coverage within this test site.

On site No. 9, a total of 17 macrophyte species were identified, 13 of which are indicators of ecological status. The species composition was dominated by coastal forms and plants with floating leaves. The most common were *Nuphar lutea* (L.) Smith., *Sagittaria sagittifolia* L., *Carex pseudocyperus* L., *Phrag-*

mites australis (Cav.) Steud., *Typha latifolia* L., *Juncus sguarrosus* L., and *Juncus effuses* L.

Among the species diversity of macrophytes, the most numerous are populations of the following species in the test areas: *Alisma plantago-aquatica* L., *Sagittaria sagittifolia* L., *Carex riparia* Curtis, *Phragmites australis* (Cav.), *Acorus calamus* L., *Lemna minor* L., *Lemna trisulca* L., *Spirodela polyrrhiza* (L.) Schleid, *Ceratophyllum demersum* L., *Myosotis palustris* L., and *Mentha aquatica* L.

The following species of macrophytes were found at both test sites (No. 8 and No. 9): *Glyceria maxima* (Hartm.) Holmb., *Phalaroides arundinacea* (L.) Rausch., and *Lemna minor* L.

The results of calculating the macrophyte index of the river show that the water quality in the Tsyr River at test area No. 8 (Kamin-Kashyrskyi, upper course) has a good ecological status with a *MIR* value of 39.9, which refers to the surface waters of class II, good category, with mesotrophic status. On test site No. 9 (near Vyderta, middle course), the surface water quality of the Tsyr River worsens to class III, satisfactory category, with eutrophic status.

CONCLUSIONS

The composition of the flora of aquatic and coastal aquatic vascular plants of the right-bank tributaries of the upper Pripet River, namely the Turia, the Vyzhivka, and the Tsyr rivers, includes 69 species belonging to 44 genera, 25 families, 4 classes, and 3 divisions.

The most numerous species composition, 57 species, was observed at the Turia River, 36 and 28 species were identified in the Vyzhivka and the Tsyr rivers, respectively. According to the indicative value, the macrophytes of the Vyzhivka River had the largest range (from oligotrophic to eutrophic). Coastal and submerged forms, as well as plants with floating leaves, had the highest projective coverage (from 10 to 30%) along the studied rivers.

The ecological condition of the Turia River at test areas No. 1, 3 and 4 belonged to class III, a satisfactory category. On site No. 2, the surface water quality of the Turia was class II, a good category.

The ecological status of the Vyzhivka River at the test sites No. 5–7 was class II, a good category, indicating favourable environmental conditions for the development of higher aquatic plants along the entire river.

The ecological status of the Tsyr River in test area No. 8 is good, *MIR* – 39.9, which refers to surface water class II, a good category. Test site No. 9 shows that the surface water quality of the Tsyr deteriorates to class III, satisfactory category.

The results of the *MIR* assessment indicate a variation in the ecological status of surface waters on test sites of rivers from class II – good quality, to class III – satisfactory quality.

The quality of water, the species composition of macrophytes and their projective coverage on test sites No. 1, 5, 6, 7, 8 are affected by the drainage systems in the basins of the Turia, Vyzhivka and Tsyr rivers, where riverbeds are partially straightened by canals, and also significantly affected by surface runoff from agricultural lands. Test site No. 2 is impacted by the created reservoir which has led to shallowing of the riverbed and a decrease in the speed of the river flow, and also by the lack of sewage treatment from private residential development. The main reason for the change in water quality and the deterioration of the water quality class on test sites No. 3, 4 and 9 is the impact of effluents from sewage treatment plants in the cities of Kovel and Kamin-Kashyrskyi.

The use of this technique provides an algorithm of the investigation of other rivers located in the Polesia lowlands that belong to the basins of the Pripet or the Western Bug. This also enables the creation of the atlas of the indicator species of the macrophytes for the assessment of the ecological status of the rivers.

REFERENCES

AFNOR 2003 Qualite de l'eau – Determination de l'indice biologique macropfytique en rivier (IBMR) – Norm francaise NF T90–395 [Quality of water – Determination of macrophyte biological index for rivers (IBMR) – French standard NF T90–395]. Assosiation Francaise de Normalisation pp. 28.

Boiaryn M., Tsos O. 2019. Ocena stanu ekologicznego powierzchniowych wód rzeki Turia na podstawie makrofitowego indeksu rzecznego (MIR) [Assessment of the ecological status of the surface waters of the Turia river based on macrophyte index for rivers (MIR)]. Chemistry, Environment, Biotechnology. Vol. 22 p. 7–12. DOI 10.16926/cebj.2019.22.01.

Boyaryn M.V., Netrobchuk I.M. 2016. Osnovy hidroekolohiyi: Teoriya y praktyka [Basics of hydroecology: Theory and practice]. Lutsk. Vezha-Druk pp. 365.

Ciecierska H., Dynowska M. 2013. Biologiczne metody oceny stanu środowiska. T. 2. Ekosystemy wodne [Biological methods of the assessment of the state of the environment. V. 2. Water ecosystems]. Olsztyn. Wydaw. Mantis. ISBN 978-83-62860-19-7 pp. 312.

Directive 2000/60/EC of The European Parliament and of The Council of 23 October 2000 establishing a framework for Community action in the field of water policy. OJ L 327/122. 12.2000 pp. 72.

Dubyna D.V. 1986. Klasyfikatsiya vil'noplavayuchoyi roslynnosti vodoym Ukrayiny [Classification of free-floating vegetation of water bodies of Ukraine]. Ukrayinskyi botanichnyi zhurnal. Vol. 43(5) p. 1–15.

Dubyna D.V., Sheliag-Sosonko Y.R. 1989. Printsypy klassifikatsii vysshey vodnoy rastitelnosti [Principles of classification of higher aquatic vegetation]. Gidrobiologicheskiy zhurnal. Vol. 25(2) p. 1–17.

Gyosheva B., Kalchev R., Beshkova M., Valchev V. 2020. Relationships between macrophyte species, their life forms and environmental factors in floodplain water bodies from the Bulgarian Danube River Basin. Ecohydrology & Hydrobiology. Vol. 20(1) p. 123–133. DOI 10.1016/j.ecohyd.2019.06.003.

Klymenko M.O., Hrokhovs'ka Y.R. 2005. Otsinka ekolohichnoho stanu vodnykh ekosystem richok baseynu Pryp'yati za vyshchymy vodnymy roslynamy [Estimation of ecological condition of aquatic ecosystems of rivers of the Pripyat basin by higher plants]. Rivne. NUVHP pp. 194.

Korobkova G.V. 2017. Vykorystannia makrofitnykh indeksiv dlia otsinky ekolohichnoho stanu poverkhnevykh vod Ukayiny [The use of macrophytic indices to assess the ecological status of surface waters of Ukraine]. Lyudyna ta dovkillya. Problemy neoekolohiyi. Vol. 27. No. 1–2 p. 62–70.

Korobkova G.V. 2018. Ekolohichne normuvannia yakosti poverkhnevykh vod na prykladi baseynu richky Siverskyi Donets

(v mezhakh Kharkivskoyi oblasti) [Ecological measurement of surface water quality on the example of the Seversky Donets river basin (within the Kharkiv region)]. PhD Thesis summary. Kharkiv pp. 22.

Malyovanyy M., Sakalova, G., Chornomaz N., Nahurskyy O. 2013. Water sorption purification from ammonium pollution. Chemistry and Chemical Technology. Vol. 7(3) p. 355–358. DOI 10.23939/chcht07.03.355.

Muratov R., Zhamangara A., Beisenova R., Akbayeva L. 2015. An attempt to prepare Macrophyte Index for Rivers for assessment watercourses in Kazakhstan. Meteorology Hydrology and Water Management. Vol. 3(2) p. 27–32. DOI 10.26491/mhwm/59592.

Netrobchuk I.M. 2007. Otsinka yakosti poverkhnevykh vod pravoberezhnykh prytok baseunu Pryp'yati u Volynskiy oblasti [Assessment of surface water quality of right-bank tributaries of the Pripyat basin in Volyn Region]. Naukovyy visnyk Volyns'koho derzhavnoho universytetu imeni Lesi Ukrayinky. Heohrafichni nauky. No. 2 p. 260–265.

Nykyforov V., Malovanyy M., Kozlovska T., Novokhatko O., Digtiar S. 2016. The biotechnological ways of blue-green algae complex processing. Eastern-European Journal of Enterprise Technologies. Vol. 5(10) p. 11–18. DOI 10.15587/1729-4061.2016.79789.

Odnorih Z., Manko R., Malovanyy M., Soloviy K. 2020. Results of surface water quality monitoring of the Western Bug river basin in Lviv Region. Journal of Ecological Engineering. Vol. 21(3) p. 18–26. DOI 10.12911/22998993/118303.

Sakalova H., Malovanyy M., Vasylinych T., Kryklyvyi R. 2019b. The research of ammonium concentrations in city stocks and further sedimentation of ion-exchange concentrate. Journal of Ecological Engineering. Vol. 20. Iss. 1 p. 158–164. DOI 10.12911/22998993/93944.

Sakalova H., Malovanyy M., Vasylinycz T., Palamarchuk O., Semchuk J. 2019a. Treatment of effluents from ions of heavy metals as display of environmentally responsible activity of modern businessman. Journal of Ecological Engineering. Vol. 20 (4) p. 167–176. DOI 10.12911/22998993/102841.

Savitskaya K.L. 2014. Otsenka ekologicheskogo sostoyaniya malykh rek na osnove biologicheskogo indeksa makrofitov [Estimation of the ecological condition of small rivers on the basis of the biological index of macrophytes]. Vestnik BGU. Khimiya. Biologiya. Geografiya. Ser. 2(3) p. 22–27.

Schaumburg J., Schranz C., Foerster J., Gutowski A., Hofmann G., Meilinger P., Schneider S., Schmedtje U. 2004. Ecological classification of macrophytes and phytobenthos for rivers in Germany according to the Water Framework Directive. Limnologica. Vol. 34 p. 283–301.

Szoszkiewicz K., Jusik S., Lewin I., Czerniawska-Kusza I., Kupiec J.M., Szostak M. 2018. Macrophyte and macroinvertebrate patterns in unimpacted mountain river of two European ecoregions. Hydrobiologia. Vol. 808 p. 327–342. DOI 10.1007/s10750-017-3435-5.

Szoszkiewicz K., Jusik S., Pietruczuk K., Gebler D. 2020. The macrophyte index for rivers (MIR) as an advantageous approach to running water assessment in local geographical conditions. Water. Vol. 12. Iss. 1(108) p. 1–15. DOI 10.3390/w12010108.

Szoszkiewicz K., Karolewicz K., Ławniczak A., Dawson F. 2002. An assessment of the MTR aquatic plant bioindication system for determining the trophic status of Polish rivers. Polish Journal of Environmental Studies. Vol. 11(4) p. 421–427.

Tsos O.O. 2016. Indykatorna flora richky Turiya [Indicative flora of the Turia River]. Visnyk Kharkivs'koho natsional'noho universytetu imeni V.N. Karazina, seriya "Ekolohiya". No. 14 p. 71–77.

Tsos O.O. 2021. Fitoindykatsiya v systemi monitorynhu ekolohichnoho stanu prytok verkhiv'ya r. Pryp'yat' [Phytoindication in the system of monitoring the ecological condition of the tributaries of the upper reaches of the Pripyat River]. PhD Thesis summary. Rivne. NUVHP pp. 24.

Willby N., Pitt J.A., Phillips G. 2012. Evidence. The ecological classification of UK rivers using aquatic macrophytes. Report – SC010080/R1. Bristol, UK. Environment Agency. ISBN 978-1-84911-287-1 pp. 221.

Zuyeva N.V., Galtsova V.V., Dmitriyev V.V., Stepanova A.B. 2007. Ispolzovaniye strukturnykh kharakteristik soobschestv makrofitov kak indikatora ekologicheskogo sostoyaniya malykh rek Leningradskoy oblasti [Use of structural characteristics of macrophyte communities as an indicator of the ecological condition of small rivers in the west of the Leningrad region]. Vestnik SPbGU. Nauki o Zemle. No. 4 p. 60–71.