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Assessment of surface water pollution in Western Bug River within the cross-border section of Ukraine

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Abstract

Monitoring of surface waters within the transboundary section of the Western Bug River showed, that during 2014–2018, a significant excess of the maximum permissible concentration (MPC) was observed for some substances for fish ponds. As a result of this, the water in the river for these substances was rated as "dirty" in terms of purity and corresponded to water quality class IV, namely: phosphorus was observed to exceed the MPC at the observation point Ambukiv village in 2015 (9.7 times), for manganese – an excess of the MPC at the observation point Ambukiv village in 2018 (9.7 times) and in point Zabuzhzhia village in 2014 (7.9 times), 2015 (8.0 times), 2017 (7.1 times), 2018 (8.3 times); for the total iron – the exceeding of MPC at the observation point Ambukiv village in 2016 (5.95 times) and 2017 (6.13 times); at the observation point Ustilug town in 2016 (5.23 times); in the observation point Zabuzhzhia village in 2016 (9.44 times) and 2017 (5.27 times). The assessment of the surface waters based on the determination of the pollution factor showed that during the study period their quality did not deteriorate but did not meet the norms. In general, surface waters of the river correspond to the second class of quality and are characterized as "poorly polluted" waters by the level of pollution.

Key words: *pollutants, pollution coefficient, river basin, surface water, the Western Bug River, water quality*

INTRODUCTION

Currently, when environmental problems related to pollution of natural waters become more and more acute and, therefore, make the humanity more vulnerable, research regarding the quality of water resources gains paramount importance. The Law of Ukraine "On the National Targeted Programme for Water Management, Development and the Environmental Rehabilitation of the Dnieper River Basin for the Period Till 2021" [2012] provides for the implementation of the integrated water resources management system according to the basin principle. Thus, the assessment of the existing ecological status of river basins becomes especially important due to the increasing anthropogenic load on water bodies. The main causes of surface water pollution include the following: discharges of contaminated municipal and industrial wastewater directly into water bodies through the city sewer system; inflow of pollutants into water bodies in the process of surface runoff from built-up areas and agricultural land, as well as soil erosion in the water intake area [ANPILOVA 2013; CHMIELOWSKI *et al.* 2016; HAGEMANN *et al.* 2014a; MARTYNOV *et al.* 2018; SOVHIRA *et al.* 2016; YATSYK *et al.* 2017b].

Given that not only by Ukraine but also by Poland and Belarus use the water resources of the Western Bug basin, there is a need for scientific substantiation of rational water use and development of actions, activities or measures aiming to protect surface water from pollution. As we have to consider migration of pollutants with river water flows from one country to another. It results in harmful consequences for the environment, health and human safety. Hence, it is not just one of the major national problems; it is truly an international issue. This phenomena also confirms the need for combined efforts and means of the states for the protection and restoration of cross-border rivers, in particular the approximation and harmonisation of national and international legal norms, as well as the implementation of international environmental cooperation [Directive 2000/60/EC 2000; YATSYK *et al.* 2017a; ZABOKRYTSKA 2011].

Therefore, in order to analyse and summarize the data on the status of water bodies, to predict its changes and to develop scientifically sound recommendations for making appropriate managerial decisions regarding water resources use and protection, there is a need to conduct timely monitoring of the surface water quality in the river basin. In addition, considering the necessity to improve cross-border monitoring of surface water quality, it is necessary to coordinate managerial decisions in the field of water management with other countries that have common cross-border water passageways, to disseminate environmental and water management information, to develop common criteria for assessing the ecological status of river basins. [YATSYK *et al*. 2017a; ZABOKRYTSKA *et al.* 2006].

Numerous scientific studies on the ecological status of the transboundary river have been undertaken through the creation of the Euroregion Bug Cross-Border Association. The status of the surface water quality of the river basin, the analysis of natural and anthropogenic sources of surface water pollution, and the need for joint transboundary monitoring were investigated by BODNARCHUK [2006; 2009], HAGEMANN *et al.* [2014b], KHILCHEVSKYI *et al.* [2016a; 2016b], KOYNOVA *et al.* [2012], KOYNOVA [2015], ZABOKRITSKA *et al.* [2006]; ZABOKRITSKA [2011] and others.

The research object is the cross-border section of the Western Bug River basin within its Ukrainian part, which has a common border with the Republic of Poland.

The overall objective of the research is to evaluate the surface water quality of the Western Bug River basin by the level of pollution within the cross-border area with the Republic of Poland.

MATERIALS AND METHODS

STUDY AREA

The Western Bug (in Ukraine) or the Bug (in Poland) is a river flowing in Ukraine (27.4% of the total basin area), Poland (49.2%) and Belarus (23.4%). It is international transboundary river. The total area of the Western Bug River basin is 73,470 km^2. Area of the basin within Ukraine is 11,205 km^2, including 4,619 km^2 in Volyn Oblast (region) and 6,586 km^2 in Lviv Oblast. The length of the river is 772 km (within Ukraine – 404 km), 185 km of wich form the border between Ukraine and Poland, and 178 km forms the border between Belarus and Poland.

The Western Bug River is a mixed-type river that feeds from the melted spring and summer rainfall with little groundwater. The highest water level is observed in March and April during snowmelt, as well as in the first half of summer, when the highest rainfall occurs. The lowest water level is in August–September and December–February. The main tributaries of the Western Bug River within the boundaries of Ukraine, where experts monitor surface water quality, are the Rata, Poltva, Luha and Hapa Rivers. In the lower reaches the Western Bug River is inflowing into the Zegrze Lake, a large reservoir which was built as the main source of drinking water for Warsaw [KHILCHEVSKYI *et al.* 2016a; 2016b; YATSYK *et al.* 2017a].

The total river flow in the Western Bug basin in the average water year is 3,885 mln m^3, including in Ukraine – 1,317 mln m^3, in Belarus – 1,131 mln m^3, in Poland – 1,437 mln m^3. Long-term average mean flow of water in Ukraine vary from 1,3 to 30,3 m^3·s^{-1}, in Belarus it is 44 m^3·s^{-1}, on the border between Belarus and Poland – about 50 m^3·s^{-1}; in the lower part of the river the average discharge is increased to 157 m^3·s^{-1} [KHILCHEVSKYI *et al.* 2016a].

The river creates many flood areas and shallow waters. In Ukraine within Volyn region the Western Bug River is plain with asymmetric valley 2.5 km in width, low left bank and higher right bank. The river bed is very undulated. The river width varies between 10 and 80–100 m, river depth – between 0.5 and 4.5 m, current velocity – 0.3–0.6 m·s^{-1} [BODNARCHUK 2006; 2009].

METHODS OF ESTIMATION

The first stage of the research included collection, systematisation and processing of the available initial hydrochemical information on water quality within the cross-border section of the Western Bug River, which runs along the riverbed. The experts carried out water quality control of the pollution level of the Western Bug surface waters at three approved sites (monitoring sections) of the state water quality monitoring (Tab. 1).

Table 1. State water quality monitoring sites at the cross-border section of the Western Bug River Basin

Site name	km	Longitude	Latitude
Ambukiv village (500 m lower than the Khuchva River confluence)	584	23°58'E	50°48'N
Town of Ustyluh (500 m lower than the Luha River confluence)	569	24°08'E	50°52'N
Zabuzhzhia village	468	23°69'E	51°38'N

Source: ZABOKRYTSKA *et al.* [2006].

The study was conducted basing on the average annual values of hydrochemical parameters from 2014 to 2018. At the same time, we viewed the results of systematic hydro-ecological observations on the river water quality, performed by the analytical control and monitoring services of the Ministry of Ecology and Natural Resources of Ukraine (Ukr. Ministerstvo zachystu dovkillja ta pryrodnych resursiv Ukraïny), State Agency of Water Resources of Ukraine (Ukr. Deržavne ahenstvo vodnych resursiv Ukraïny), Ministry of Health of Ukraine (Ukr. Ministerstvo ochorony zdorov″ja Ukraïny), Basin Department of Water Resources of the Western Bug and Sian Rivers (Ukr. Basejnove upravlinnja vodnych resursiv ričok Zachidnoho Buhu ta Sjanu) and also materials of reconnaissance research of the Ukrainian Research Institute of Water and Environmental Problems (Ukr.

Ukraïns′kyj naukovo-doslidnyj instytut vodohospodars′ko-ekolohičnych problem) [GOPCHAK *et al.* 2019; ZABOKRYTSKA *et al.* 2006] as initial data.

The measurements of the water quality indicators at the points of state monitoring are carried out quarterly by the laboratory of the Basin Department of Water Resources of the Western Bug and Sian Rivers (Ukr. Basejnove upravlinnja vodnych resursiv ričok Zachidnoho Buhu ta Sjanu). Hydrochemical and radiological control of the surface water quality is carried out by according to for such indicators: temperature, odour, points, transparency, hydrogen index, suspended solids, alkalinity, hardness, calcium, magnesium, potassium + sodium, hydrocarbonates, chlorides, sulphates, dry residue, ammonium ions, nitrite ions, nitrate ions, phosphates, total iron, *COD*, BOD_5, and dissolved oxygen.

The researchers conducted an overall assessment of surface water status according to pollution level in accordance with the methodology for calculating the pollution coefficient (*PC*) [KND 211.1.1.106-2003; SNIZHKO 2001]. This method is regarded as the basis for compilation of observation programmes, data analysis, characterisation of Ukraine's surface water from ecological point of view and obtaining information on the status of water bodies.

Based on common environmental criteria, the method allows comparing the quality of water in separate areas of water bodies in time and space, determining the impact of anthropogenic load on aquatic ecosystems, assessing changes in the status of water resources. From our point of view, it fully complies with the EU Water Framework Directive [Directive 2000/60/EC].

Using methodics acc. to KND 211.1.1.106-2003 allows us to calculate by not only the overall *PC* for a number of water quality indicators (dry residue; *COD*; BOD_5; dissolved oxygen; ammonium saline; nitrites; nitrates; total phosphorus; manganese; total iron), but also the level of contamination using any particular indicator, which plays a decisive role in water pollution.

We used a somewhat simplified equation for calculating *PC* [KND 211.1.1.106-2003]:

$$PC = \sum_{i=10}^{10} \left(\frac{1}{N_i} \sum_{n=1}^{N_i} x_{in} \right) \tag{1}$$

$$x_{in} = \begin{cases} \text{if } C_{in} > MPC_i \rightarrow x_{in} = \frac{C_{in}}{MPC_i} \\ \text{if } C_{in} \leq MPC_i \rightarrow x_{in} = 1 \end{cases} \tag{2}$$

Where: i = an indicator sequence number; N_i = the total number of measurements for the i^{th} indicator; x_{in} = the multiplicity of the MPC excess in case of the n^{th} measurement of the i^{th} indicator; C_i = the actual concentration of the i^{th} substance in water; MPC_i = the maximum permissible concentration of the i^{th} substance in water.

In order to assess the quality of water in rivers and basins, they are divided into five water quality classes. The classes are based on intervals of *PC* values. The value of the *PC* is determined in accordance with the frequency and multiplicity of cases when the value exceeds MPC by several indicators. In waters of varying levels of pollution it may vary from 1 to >10 (for pure water it is 1). Higher *PC* values correspond to poorer water quality and higher levels of water pollution. Basing on the obtained numerical values of the pollution coefficients *PC* it is possible to estimate the status of surface waters according to the pollution level (Tab. 2).

Table 2. Surface water pollution levels

Pollution coefficient values *PC*	Pollution level	Water quality class
<1.0	unpolluted (clean)	I
1.01–2.50	slightly polluted	II
2.51–5.00	moderately polluted	III
5.01–10.00	polluted	IV
>10.0	highly polluted	V

Source: YATSYK *et al.* [2006].

RESULTS AND DISCUSSION

On the whole, a variety of factors, which are closely interrelated at the same time, have an impact on the ecological status of the surface waters of the Western Bug basin. For the most part, wastewater discharges into surface water without proper treatment, which cause surface water pollution, play into the status of the surface water resources of the Western Bug River to the greatest extent [KOZYTSKA, MUZYCHENKO 2015; ZABOKRYTSKA *et al.* 2006].

Basin Department of Water Resources of the Western Bug and Sian Rivers (Ukr. Basejnove upravlinnja vodnych resursiv ričok Zachidnoho Buhu ta Sjanu) [Informatsiinyi… 2019] revealed the long-term dynamics of the amount of pollutants, which had been discharged with wastewater into the surface reservoirs of the Western Bug River. Basing on its analysis, we discovered that municipal and industrial enterprises of Lviv Oblast have a major influence on the quality of the basin surface waters. The influence of the companies of Volyn Oblast on the river water quality is insignificant. For instance, the volume of backwaters discharged into the surface water from the objects of Volyn Oblast is only 5% of the total discharge into the surface water bodies of the basin [GOPCHAK *et al.* 2019]. In general, there are two types of sources of pollution of the surface waters of the Western Bug River: point (wastewater from enterprises and water utilities / municipal wastewater treatment plants) and diffuse sources (pesticides and mineral fertilizers of farmland, livestock farms, landscape transformation, bank unauthorized waste landfills) [ODNORIH *et al.* 2020].

It is worth mentioning that in recent years, there has been a decrease in the discharge of pollutants into the surface waters of the river basin. However, it is surely a must to continue implementing activities and measures aimed at restoring the water quality of the river basin by further reducing wastewater discharges of settlements, construction of new and modernisation of existing complete cycle wastewater treatment plants, sewage networks, introduction of a system of penalties for non-compliance with existing requirements of water protection legislation.

Hence, during the period of research at the cross-border section passing along the riverbed of the Western Bug River, we recorded an excess of MPC for fishery reservoirs by the content of the following substances (Fig. 1, Tab. 3):

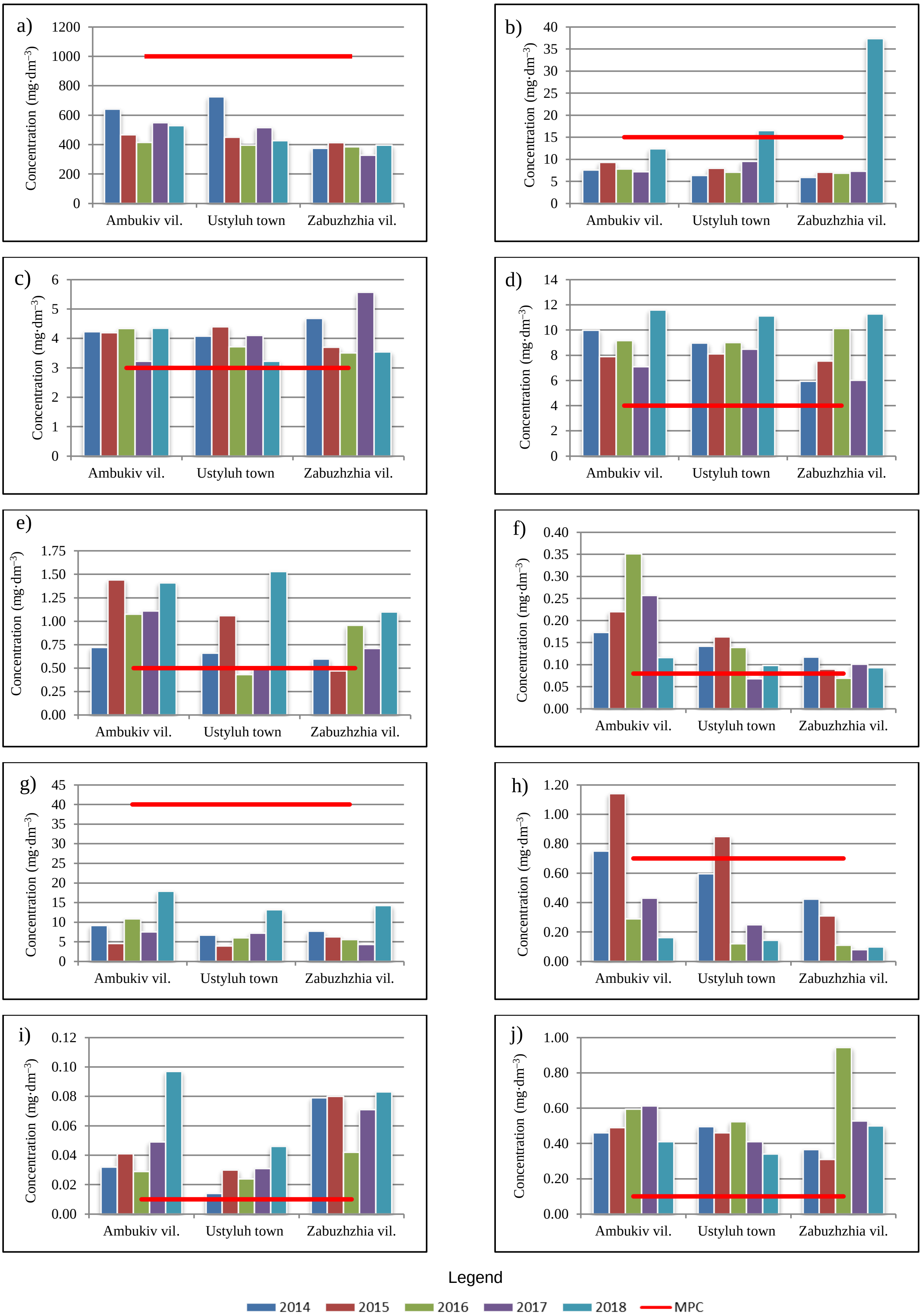


Fig. 1. Content dynamics at the cross-border section passing along the riverbed of the Western Bug River: a) dry residue; b) *COD*; c) BOD_5; d) dissolved oxygen; e) ammonium saline; f) nitrites; g) nitrates; h) total phosphorus; i) manganese; j) total iron; *MPC* = maximum permissible concentration; source: own study

Table 3. Calculation of surface water pollution coefficient of the Western Bug River

Site	Year	Measurement unit	Rated indicators										
		x_{in}	dry residue	*COD*	BOD_5	dissolved oxygen	ammonium saline	nitrites	nitrates	total phosphorus	manganese	total iron	*PC*
Ambukiv village	2014	mg·dm^{-3}	640.8	7.58	4.23	9.98	0.72	0.173	9.19	0.75	0.032	0.460	
		x_{in}	1	1	1.86	1	1.85	2.16	1	4.43	3.2	4.597	2.21
	2015	mg·dm^{-3}	466.5	9.3	4.20	7.9	1.44	0.22	4.6	1.14	0.041	0.49	
		x_{in}	1	1	1.86	1	3.69	2.75	1	6.71	4.10	4.90	2.80
	2016	mg·dm^{-3}	415.5	7.79	4.34	9.17	1.075	0.351	10.863	0.29	0.029	0.595	
		x_{in}	1	1	1.45	1	2.15	4.39	1	1	2.90	5.95	2.18
	2017	mg·dm^{-3}	549.5	7.22	3.22	7.09	1.11	0.257	7.51	0.43	0.049	0.613	
		x_{in}	1	1	1.07	1	2.22	3.21	1	1	4.9	6.13	2.25
	2018	mg·dm^{-3}	530	12.4	4.35	11.59	1.41	0.116	17.91	0.162	0.097	0.41	
		x_{in}	1	1	1.45	1	2.82	1.45	1	1	9.7	4.1	2.45
Town of Ustyluh	2014	mg·dm^{-3}	725.0	6.38	4.08	8.97	0.66	0.142	6.703	0.596	0.014	0.496	
		x_{in}	1	1	1.81	1	1.69	1.77	1	3.51	1.4	4.96	1.91
	2015	mg·dm^{-3}	451	8	4.40	8.1	1.06	0.163	3.94	0.85	0.03	0.46	
		x_{in}	1	1	1.95	1	2.72	2.04	1	5.00	3.00	4.60	2.33
	2016	mg·dm^{-3}	396.3	7.08	3.72	9.01	0.43	0.139	6.038	0.12	0.024	0.523	
		x_{in}	1	1	1.24	1	1	1.74	1	1	2.40	5.23	1.66
	2017	mg·dm^{-3}	516.5	9.53	4.1	8.49	0.503	0.068	7.215	0.25	0.031	0.41	
		x_{in}	1	1	1.37	1	1.01	1	1	1	3.1	4.1	1.56
	2018	mg·dm^{-3}	427	16.53	3.22	11.11	1.53	0.098	13.16	0.143	0.046	0.34	
		x_{in}	1	1.1	1.07	1	3.06	1.23	1	1	4.6	3.4	1.85
Zabuzhzhia village	2014	mg·dm^{-3}	374.5	5.93	4.68	5.93	0.596	0.117	7.687	0.424	0.079	0.365	
		x_{in}	1	1	2.07	1	1.53	1.46	1	2.49	7.9	3.65	2.31
	2015	mg·dm^{-3}	413.3	7.1	3.7	7.54	0.47	0.09	6.3	0.31	0.08	0.31	
		x_{in}	1	1	1.64	1	1.21	1.13	1	1.82	8.00	3.10	2.09
	2016	mg·dm^{-3}	384.4	6.85	3.51	10.13	0.956	0.069	5.558	0.11	0.042	0.944	
		x_{in}	1	1	1.17	1	1.91	1	1	1	4.20	9.44	2.27
	2017	mg·dm^{-3}	328.5	7.28	5.57	6.01	0.71	0.101	4.327	0.08	0.071	0.527	
		x_{in}	1	1	1.86	1	1.42	1.26	1	1	7.1	5.27	2.19
	2018	mg·dm^{-3}	396	37.38	3.54	11.27	1.10	0.093	14.27	0.098	0.083	0.50	
		x_{in}	1	2.49	1.18	1	2.2	1.16	1	1	8.3	5	2.43
In general in the cross-border river section	2014	$\sum x_n$	3	3	5.74	3	5.07	5.39	3	10.43	12.5	13.207	
		PC	1	1	1.91	1	1.69	1.80	1	3.48	4.17	4.40	2.14
	2015	$\sum x_n$	3	3	5.45	3	7.62	5.92	3	13.53	15.1	12.6	
		PC	1	1	1.82	1	2.54	1.97	1	4.51	5.03	4.20	2.41
	2016	$\sum x_{in}$	3	3	3.86	3	5.06	7.13	3	3	9.5	20.62	
		PC	1	1	1.29	1	1.69	2.38	1	1	3.17	6.87	2.04
	2017	$\sum x_{in}$	3	3	4.30	3	4.65	5.47	3	3	15.1	15.5	
		PC	1	1	1.43	1	1.55	1.82	1	1	5.03	5.17	2.00
	2018	$\sum x_{in}$	3	4.59	3.70	3	8.08	3.84	3	3	22.6	12.5	
		PC	1	1.53	1.23	1	2.69	1.28	1	1	7.53	4.17	2.24

Explanations: unpolluted (clean), slightly polluted, moderately polluted, polluted; x_{in} as in Eqs (1) and (2).
Source: own study.

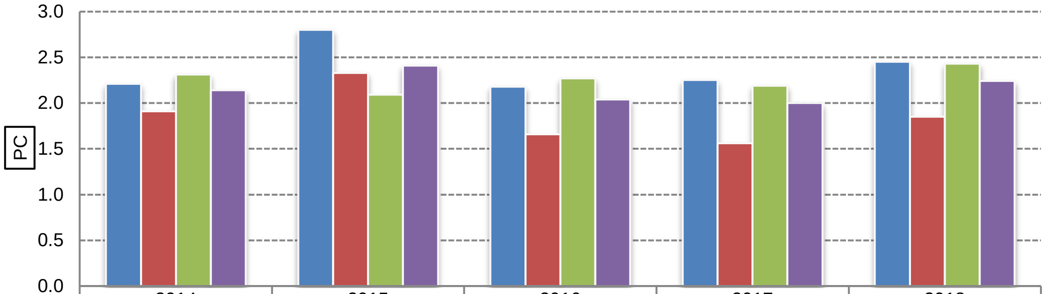
BOD_5 (value ranges from 3.22 to 5.57 mg O_2·dm^{-3}); ammonium saline (0.43–1.53 mg·dm^{-3}); nitrites (0.068–0.351 mg·dm^{-3}); phosphates (0.08–1.14 mg·dm^{-3}); manganese (0.014–0.097 mg·dm^{-3}); total iron (0.31–0.944 mg·dm^{-3}). The reason for such excessing of *MPC* at the transboundary part is the influx of pollutants from the territory of the Lviv region.

High content of BOD_5, ammonium saline ammoniacal and phosphates can be explained by the inflow explain that the wastewater collection for settlements not connected to the sewage network is carried out in individual septic tanks or sinkhole, the sewage of which is not treated. This can be one of the potential sources of pollution of aquifers and surface waters [ODNORIH *et al.* 2020].

The high content of nitrites and phosphates demonstrates the contamination of the reservoir with organic substances is explained by the highly concentrated domestic effluent containing detergents and cleanser items, as well as by the use of excessive fertilizers by agricultural farms in the spring (Fig. 1, Tab. 3).

These pollutants cause the active development of algae and plants and lead to the eutrophication of the reservoir [SKORBIŁOWICZ *et al.* 2016]. The calculation of the surface water pollution coefficient for the Western Bug River is given is made according to Equation (1) and is given in Table 3).

We carried out the calculation of the pollution coefficient value and the relative assessment of water quality in two stages: at first for each investigated ingredient and



	2014	2015	2016	2017	2018
Ambukiv vil. (584 km)	2.21	2.8	2.18	2.25	2.45
Ustyluh town (569 km)	1.91	2.33	1.66	1.56	1.85
Zabuzhzhia vil. (468 km)	2.31	2.09	2.27	2.19	2.43
On the average at river section	2.14	2.41	2.04	2.0	2.24

Fig. 2. Assessment of surface water quality of the Western Bug River Basin according to pollution coefficients; source: own study

water pollution indicator, and then they considered the entire complex of pollutants simultaneously and determined the assessment results.

Analysing the research results (Tab. 3) on the observation points, it was found, that for the water of Western Bug River, the *MPC* was significantly exceeded for some substances, resulting in water responds the IV class of quality and characterized as "dirty":

- observation point Western Bug River – Ambukiv village – total phosphorus exceeds by (6.71 times in 2015), manganese (9.7 times in 2018), total iron (5.95 and 6.13 times in 2016 and 2017, respectively);
- observation point Western Bug River – Ustilug town – total iron (5.23 times in 2016);
- observation Point Western Bug River – Zabuzhzhia village – manganese (7.1 to 8.3 times in 2014, 2015, 2017, 2018), total iron (9.44 times in 2016 and 5.27 times in 2017).

While analysing and summarising the long-term monitoring data (Tab. 3), we found that, throughout the cross-border section of the Western Bug River, during the entire study period (from 2014 to 2018), deviations from the *MPC* norm were observed for the following indicators: *COD* (maximum values exceed 1.53 times in 2018, class II of water quality); BOD_5 (1.91 times in 2017, class II); ammonium saline (2.54 times in 2015, class III); nitrites (2.38 times in 2016, class II); phosphorus (4.51 times in 2015, class III); manganese (5.03 times in 2015 and 2017, class IV); total iron (6.87 times in 2016, class IV).

Conducted calculations of the pollution coefficient revealed that, according to its numerical values, the surface waters of the studied cross-border area in all monitoring sites belong to the slightly polluted and correspond to the II class of water quality (Fig. 2, Tab. 3). Only in 2015 PC was 2.8 in the monitoring Western Bug River – Ambukiv village, which characterises surface water as moderately polluted and corresponds to the III class of water quality. However, in general, during the entire observation period, the surface water status within the cross-border area in terms of pollution corresponds to water quality class II, which characterises surface water as slightly polluted.

In general, from the averaged data, during the study period (from 2014 to 2018), the surface waters of the Western Bug River in the transboundary area corresponded to the II class of water quality and characterized as poorly polluted (Tab. 3).

To identify more detailed trends in surface water quality of the Western Bug River, in further studies it is supposed to analyse the data of hydrochemical monitoring and to assess the level of pollution of surface waters by season. After all, such an analysis will allow us to specify periods with maximum and minimum concentrations of pollutants during the year.

CONCLUSIONS

Therefore, according to the average research results, that were conducted during 2014–2018, and calculations for determining the coefficient of pollution, it was found that the surface waters of the transboundary section of the Western Bug basin as a whole belong to the second class of quality, which characterizing surface waters as poor polluted by the level of contamination.

The results of the pollution coefficient calculations showed that the formation of surface water quality of the Western Bug River was significantly influenced by substances such as manganese and total iron, which during the whole period of the study surface water quality corresponded to the III–IV classes, that responds accordingly moderately polluted–dirty of pollution levels.

In order to improve the quality of surface water, we consider it necessary to take the following actions: a) reconstruct the existing treatment facilities, or construct new ones; b) control and complete cessation of untreated domestic water discharges by private households, farms etc.; c) bringing protected shoreline belts and water intake areas into proper condition; d) compliance with current legislation on the protection of environment in general and water bodies in particular.

One of the ways to improve the work of the Western Bug River water basin management is to equip the control facilities with automated remote hydrological posts.

Proper assessment of the water quality of the Western Bug River is essential for determining the ecological situation and the main directions of water conservation activities for the rehabilitation of each water body and setting environmental standards for water quality.

REFERENCES

ANPILOVA Y. 2013. Informatsiini tekhnolohii dlia upravlinnia ekolohichnoiu bezpekoiu poverkhnevykh vod: monohrafiia [Information technologies for the management of surface water ecological safety: monograph]. Kiev. Azymut-Ukraina. ISBN 978-966-1541-49-7. pp. 104.

BODNARCHUK T. 2006. Zabrudnennia spetsyfichnymy rechovynamy poverkhnevykh vod ta donnykh vidkladiv u baseini richky Zakhidnyi Buh [Contamination of specific substances of surface water and sediments in the Western Bug River basin]. Hidrolohiia, hidrokhimiia i hidroekolohiia. T. 11. p. 250–257.

BODNARCHUK T. 2009. Doslidzhennia stiikykh orhanichnykh zabrudniuvachiv u baseinakh richok Zakhidnyi Buh ta San [Investigation of persistent organic pollutants in the Western Bug and San River basins]. Hidrolohiia, hidrokhimiia i hidroekolohiia. T. 16. p. 144–153.

BUVRRZBS 2019. Informatsiinyi biuleten pro yakisnyi stan poverkhnevykh vod baseinu richky Zakhidnyi Buh u 2018 rotsi. [The in-formational bulletin on the qualitative condition of surface waters of the basin of the Western Bug River in 2017]. Lutsk. Basejnove upravlinnja vodnych resursiv ričok Zachidnoho Buhu ta Sjanu pp. 50.

CHMIELOWSKI K., BUGAJSKI P., KACZOR G.B. 2016. Comparative analysis of the quality of sewage discharged from selected agglomeration sewerage systems. Journal of Water and Land Development. No. 30 p. 35–42. DOI 10.1515/jwld-2016-0019.

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 p. 1–73.

GOPCHAK I., BASIUK T., BIALYK I., PINCHUK O., GERASIMOV I. 2019. Dynamics of changes in surface water quality indicators of the Western Bug River basin within Ukraine using GIS technologies. Journal of Water and Land Development. No. 42 p. 67–75. DOI 10.2478/jwld-2019-0046.

HAGEMANN N., BLUMENSAAT F., TAVARES WAHREN F., TRÜMPER J., BURMEISTER C., MOYNIHAN R., SCHEIFHACKENF N. 2014b. The long road to improving the water quality of the Western Bug River (Ukraine) – A multi-scale analysis. Journal of Hydrology. Vol. 519. P. C p. 2436–2447. DOI 10.1016/j.jhydrol.2014.01.013.

HAGEMANN N., KLAUER B., MOYNIHAN R., LEIDEL M., SCHEIFHACKEN N. 2014a. The role of institutional and legal constraints on river water quality monitoring in Ukraine. Environmental Earth Sciences. Vol. 72 p. 4745–4756. DOI 10.1007/s12665-014-3307-5.

KHILCHEVSKYI V., HREBIN V., ZABOKRYTSKA M. 2016b. Otsinka hidrohrafichnoi merezhi raionu richkovoho baseinu Visly (Zakhidnoho Buhu ta Sanu) na terytorii Ukrainy zghidno typolohii Vodnoi Ramkovoi Dyrektyvy YeS [Assessment of the hydrographic network of the Vistula River basin (Western Bug and San) in the territory of Ukraine according to the typology of the EU Water Framework Directive]. Hidrolohiia, hidrokhimiia i hidroekolohiia. T. 1 (40) p. 29–41.

KHILCHEVSKYI V., ZABOKRYTSKA M., SHERSTYUK N. 2016a. Hydrography and hydrochemistry of the transboundary river Western Bug on the territory of Ukraine. Journal of Geology, Geography and Geoecology. No. 27 (2) p. 232–243. DOI 10.15421/111848.

KND 211.1.1.106-2003. Orhanizatsiia ta zdiisnennia sposterezhen za zabrudnenniam poverkhnevykh vod: Metodyka rozrakhunku koefitsiienta zabrudnenosti pryrodnykh vod [Organization and monitoring of surface water pollution: Method of calculating the pollution factor of natural waters]. Kyiv. Minekobezpeky Ukrainy pp. 30.

KOYNOVA I. 2015. Heoekolohichni naslidky roboty komunalnoho hospodarstva v baseini richky Zakhidnyi Buh [Geoecological consequences of communal services in the basin of the Western Bug River]. Liudyna ta dovkillia. Problemy neoekolohii. Nr 3–4 p. 96–102.

KOYNOVA I., ROZHKO I., BLAZHKO N. 2012. Ecological threats to the valley of the Bug River (Lviv region). In: Natural human environment. Dangers, protection, education: Monograph. Eds. K.H. Dyguś. Warszawa. Ofic. Wydaw. WSEiZ p. 55–64.

KOZYTSKA L., MUZYCHENKO O. 2015. Intehralna otsinka ekolohichnoho stanu poverkhnevykh vod richky Zakhidnyi Buh v mezhakh Volynskoi oblasti [Integral assessment of the ecological condition of surface waters of the Western Bug River within the Volyn region]. Liudyna ta dovkillia. Problemy neoekolohii. Nr 3–4 p. 78–83.

MARTYNOV S., FYLYPCHUK V., ZOSHCHUK V., KUNYTSKYI S., SAFONYK A., PINCHUK O. 2018. Technological model of water contact iron removal. Journal of Water and Land Development. No. 39 (X–XII) p. 93–99. DOI 10.2478/jwld-2018-0063.

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. Iss. 3 p. 18–26. DOI 10.12911/22998993/118303.

SKORBIŁOWICZ E., SKORBIŁOWICZ M., MALINOWSKA D. 2016. Accumulation of heavy metals in organs of aqueous plants and its association with bottom sediments in Bug River (Poland). Journal of Ecological Engineering. Vol. 17. Nr 4 p. 295–303. DOI 10.12911/22998993/63308.

SNIZHKO S. 2001. Otsinka ta prohnozuvannia yakosti pryrodnykh vod [Assessment and forecasting of natural water quality]. Kyiv. Nika-Tsentr. ISBN 966-521-078-5. pp. 264.

SOVHIRA S., HONCHARENKO H., HONCHARENKO V., BERCHAK V. 2016. Metodyka doslidzhennia ekolohichnoho stanu baseiniv malykh richok: monohrafiia [Methods of research of ecological status of small river basins: monograph]. Uman. VPTs «Vizavi». ISBN 978-966-304-143-8. pp. 288.

YATSYK A., PASHENIUK I., GOPCHAK I., BASIUK T. 2017a. Ekologicheskaya otsenka ispolzovaniya vodnyih resursov reki Zapadnyiy Bug. In: Materialyi dokladov V Mezhdunarodnogo Vodnogo Foruma. Vodnyie resursyi i klimat. Chast 1 [Environmental assessment of the use of water resources of the Western Bug River. In: Materials reports of the V International Water Forum. Water resources and climate. Part 1]. Minsk. Minsk. BGTU p. 218–223.

YATSYK A., PASHENIUK I., GOPCHAK I., BASIUK T. 2017b. Vodohospodarsko-ekolohichne raionuvannia yak osnova zberezhennia i vidnovlennia vodnykh resursiv [Water-ecological zoning as a basis for conservation and restoration of water resources]. Zbirka dopovidei Mizhnarodnoho Konhresu «ETEVK-2017». Kyiv, TOV "PRAIM-PRINT" p. 167–171.

YATSYK A. ZHUKYNSKYI V., CHERNIAVSKA A., YEZLOVETSKA I. 2006. Dosvid vykorystannia «Metodyky ekolohichnoi otsinky yakosti poverkhnevykh vod za vidpovidnymy katehoriiamy» (poiasnennia, zasterezhennia, pryklady) [Experience of using “Methods of environmental assessment of surface water quality in the relevant categories” (explanation, reservations, examples)]. Kyiv. Oriiany. ISBN 966-8305-55-8 pp. 44.

ZABOKRYTSKA M. 2011. Mizhderzhavne spivrobitnytstvo z monitorynhu ta upravlinnia vodnymy resursamy r. Zakhidnyi Buh [Intergovernmental cooperation on water resources monitoring and management, West Bug River]. Hidrolohiia, hidrokhimiia i hidroekolohiia. T. 2 p. 142–147.

ZABOKRYTSKA M., KHILCHEVSKYI V., MANCHENKO A. 2006. Hidroekolohichnyi stan baseinu Zakhidnoho Buhu na terytorii Ukrainy [Hydro-ecological status of the Western Bug basin in Ukraine]. Kyiv. Nika-Tsentr ISBN 966-521-397-0 pp. 184.

Zakon Ukrainy Pro zatverdzhennia Zahalnoderzhavnoi tsilovoi prohramy rozvytku vodnoho hospodarstva ta ekolohichnoho ozdorovlennia baseinu richky Dnipro na period do 2021 roku [About the statement of the National target program of development of water management and ecological improvement of the Dnieper river basin for the period till 2021] [online]. Vidomosti Verkhovnoyi Rady (VVR) 2013. No. 17. [Access 15.12.2019]. Available at: https://zakon.rada.gov.ua/laws/show/4836-17