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EVALUATION OF THE HYDROCHEMICAL REGIME OF THE VILIYA RIVER IN THE CONTEXT OF ENVIRONMENTAL PROBLEMS OF THE BALTIC SEA

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Abstract

The article assesses the transformation of the hydrochemical regime of the river Viliya, belonging to the Baltic Sea basin. The dynamics of average annual values for the period from 1994 to 2017 according to 14 indicators of surface water quality is considered. The statistical parameters of the hydrochemical regime are calculated.

Key words: surface water, hydrochemical regime, quality indicators, river Viliya

INTRODUCTION

Under the conditions of increasing technogenic influence, transformations of the chemical composition of the components of natural waters, their influence on the environment and the identification of the patterns of formation of the hydrochemical regime are of increasing interest. The transformation of the composition of natural waters occurs in two directions: the variation of the background concentrations of substances that are components of these waters, and the contamination of waters by uncharacteristic substances (xenobiotics). The solution of practical tasks to identify formation patterns of the chemical regime of natural waters is necessary for the rational water use. This will make it possible to identify the magnitude of the anthropogenic impact, assess the quality of water conservation measures and predict the further development of the situation. That will allow a more detailed approach to the issues of water use.

The Baltic Sea is the second largest brackish (low salinity) in the world water body and has a total area of about 415 thousand km^2. Its territory is divided into several parts: the Sea of Bothnia and the Gulf of Bothnia stretch to the north, the Gulf of Finland and the Gulf of Riga stretch to the east, the central part forms the Baltic Sea itself, the area between the Baltic Sea and the Sea of Bothnia is called the Aland Sea and the Archipelago Sea, in the south is Gdańsk Bay (Fig. 1). The connection with the North Sea is carried through the rather narrow Danish straits and the Kattegat strait, therefore the Baltic Sea is considered as a half-closed sea (Take a look… 2009).

Fig. 1. Baltic Sea (HELCOM 2007)

The geographical features of the Baltic Sea are shallow water, low salinity of sea water, difficult water exchange with the North Sea. They cause extremely low self-cleaning ability with an average time of complete water replacement of about 30-50 years and high sensitivity to anthropogenic influence from adjacent developed regions (Lass and Matthäus 2008). This fact significantly affects the ecological situation in the region, since slows down the speed of self-cleaning processes, leading to pollution of sea water.

The countries with river basin areas flowing into this sea have the greatest influence on the hydrochemical regime formation of the Baltic Sea (Fig. 1).

These countries include almost the entire North-West of Russia, parts of the North and the Center Russia, as well as the Kaliningrad region, Lithuania, Latvia and Estonia, almost the whole of Poland, the main parts of Sweden and Finland, more than half of the territory of Denmark and almost half of Belarus, north-east Germany, part of Norway, small parts of Ukraine, the Czech Republic and Slovakia (Table 1).

Table 1

Characteristics of the countries affecting the Baltic Sea

The country	Area of the country (km^2)	Area of the adjacent waters of the Baltic Sea (km^2)
Countries of the Baltic region		
Poland	312,700	311,900
Russia	17,100,000	314,800
Sweden	450,000	440,000
Finland	338,200	301,300
Denmark	43,100	31,100
Lithuania	65,200	65,200
Germany	357,000	28,600
Latvia	64,600	64,600
Estonia	45,100	45,100
Countries that are not part of the Baltic region, but are in close proximity to the Baltic Sea		
Belarus	207,600	83,850
Ukraine	603,700	11,200
Czech	78,900	7,200
Slovakia	49,000	2,000
Norway	323,900	13,400

The Baltic Sea is constantly replenished with fresh water (about 660 km^3 per year), coming from more than 250 rivers, the largest of which are the Odra (Oder), the Vistula, the Neman, the Western Dvina, and the Neva rivers, as well as from the result of precipitation. As a result, sea water is brackish with salinity from 3 to 8 ‰, which is significantly lower than ocean salinity (about 35‰) (HELCOM 2007).

Environmental problems in the Baltic Sea region are of paramount social, economic, and socio-political importance. They are due to the industrial and economic spheres of human activity by the production and consumption of atomic energy, industry, agriculture, transport, fishing and wastewater discharge (Pawlak J., 1980. Land). The bulk of pollution is constituted by industrial and household waste and agricultural waste, oil and oil product, military production waste, radionuclides and heavy metals (Brugmann and Kullenberg 1981).

According to HELCOM the current annual total input of nutrients to the Baltic Sea amounts to about 826,000 tonnes of nitrogen and 30,900 tonnes of phosphorus (HELCOM 2018). Most of the input is riverine for both nitrogen and phosphorus. Atmospheric inputs account for about 30% of the total nitrogen inputs, originating mainly from combustion processes related to shipping, road transportation, energy production and agriculture. The largest relative decreases in inputs of nitrogen and phosphorus over recent decades have occurred in direct sources, which currently account for 4-5% of the total loads. Natural sources constitute about one third of the riverine inputs of nitrogen and phosphorus to the Baltic Sea. A major part of the anthropogenic part originates from diffuse sources, mainly agriculture, while point sources, dominated by municipal waste water treatment plants, contribute with 12% and 24% of the riverine nitrogen and phosphorus loads, respectively. The ecosystem remains impacted by hazardous substances. Mercury, polybrominated diphenyl ethers, and the radioactive isotope cesium-137 show particularly high contamination scores in the integrated assessment.

All of the above factors lead to a significant pollution of the waters of the Baltic Sea, which adversely affects both the marine ecosystem and human industrial and economic activity (Bianchi TS.P., Westman T., Andren2000).

The general condition of the water area is determined primarily by the purity of the river flow. The Baltic Sea serves as a receiving basin of more than two hundred rivers. More than half of the total area of the basin is drained by large rivers: the Neva, Vistula, Zapadnaya Dvina (Daugava), Neman (Nemunas) (Table 2), and it is fact that most of the pollutants from anthropogenic activities in the area flow into the Baltic Sea from these rivers (Kabalkkeite 2003).

Table 2

Characteristics of the largest rivers flowing into the Baltic Sea (Bianchi et al. 2000*, Kabalkkeite 2003**, Frumin and Fitisova 2017***, Dębska and Rutkowska 2017****)

Name of the river	Length, km	Basin area, thousand km^2	Flow to the Baltic Sea, m^3/s	Quality indicators		Countries in the river basin	Big cities
Neva***	74	281	2,530	suspended solids, mg/dm^3	5-10	Russia Finland	St. Petersburg, Petrozavodsk, Velikiy, Novgorod
				Total Dissolved Solids (TDS), mg/dm^3	50-60		
				pH	7.0		
				hardness, mg/eq	0.4-0.8		
				permanganate acidity, mgO$_2$/dm^3	7-9		
				BOC$_5$, mgO$_2$/dm^3	1-2		
Vistula****	1,068	193	1,030	pH	7.7-8.4	Poland, Belarus, Ukraine, Slovakia	Warsaw, Bydgoszcz, Toruń, Lublin, Kraków, Brest
				COD$_{Mn}$, mgO$_2$/dm^3	1.74-8.91		
				ammonium ion, mgN/dm^3	0.04-0.24		
				nitrite ion, mgN/dm^3	0.21-1.74		
				phosphate ion, mgP/dm^3	0.000-0.072		

Western Dvina (Daugava)**	1,020	88	730	suspended solids, mg/dm^3	4.4-5.1	Latvia, Belarus, Russia	Riga, Daugavpils, Polotsk, Vitebsk
				pH	7.3-8.0		
				BOC$_5$, mgO$_2$/dm^3	1.8-2.3		
				dissolved oxygen, mgO$_2$/dm^3	8.5-9.1		
				phosphate ion, mgP/dm^3	0.051-0.069		
				ammonium ion, mgN/dm^3	0.15-0.18		
				nitrite ion, mgN/dm^3	0.005-0.009		
Neman (Nemunas)	937	86	620	suspended solids, mg/dm^3	7.8-11.1	Lithuania, Belarus, Russia	Kaunas, Vilnius, Grodno
				pH	7.5-8.2		
including Viliya	498	25	-	BOC$_5$, mgO$_2$/dm^3	1.7-2.6		
				COD$_{Mn}$, mgO$_2$/dm^3	9.0-9.9		
				phosphate ion, mgP/dm^3	0.041-0.049		
				ammonium ion, mgN/dm^3	0.09-0.44		
				nitrite ion, mgN/dm^3	0.016-0.023		
Narva*	78	56	400	pH	6.1-8.2	Russia, Estonia, Latvia, Belarus	Narva, Pskov, Tartu
				BOC$_5$, mgO$_2$/dm^3	0.7-2.8		
				phosphate ion, mgP/dm^3	0.6-2.4		
				ammonium ion, mgN/dm^3	0-0.90		

Baseline data and research methods

The river Viliya is the longest right-hand tributary of the Neman River, which flows into it on the territory of Lithuania. The total length of the river is 498 km, 264 km of which is on the territory of Belarus. The river flows through the territory of the Vitebsk, Minsk and Grodno regions and crosses the border with Lithuania 2 km north-west of the Zhorneli Village of the Ostrovets district and flows into the Neman near Kaunas. Neris (Lithuanian name of the river Viliya) is the second longest river in Lithuania. The Nemencine, Vilnius, Grigiskes, Jonava and Kaunas cities are located on the river (Alekin 1950, Mironenko 1966).

The main tributaries of the Viliya River are Servich, Naroch, Stracha, Dvinosa, Elijah, Usha and Oshmyanka Rivers. The average slope of the water surface is 0.3‰, which is significantly greater than that of the most major rivers of the republic and it

causes the high flow velocity. The rapid course and shallow depths (from 0.2 to 4.0 m) determine the presence of a large number of sandy islands, shoals, middlelands and rapids (Alekin 1950, Mironenko 1966).
The data of the State Water Cadaster of the Republic of Belarus for the period from 1994 to 2017 were used for the research. The transformation of the hydrochemical regime was investigated by the following indicators: suspended solids, dissolved oxygen, total iron, copper, zinc, nickel, ammonium ion, nitrite ion, phosphate ion, synthetic surfactants (SSAS), substance pollution index (SPI), oil products, biochemical oxygen consumption for 5 days (BOC_5) (State Water Cadaster 2018).
The main criterion for assessing the physicochemical quality of surface water in Belarus is the maximum permissible concentration (MPC) of chemical substances established for water objects of various categories. (Infrastruktura i Ekologia Terenów Wiejskich, II/2, 849-861).
Decree of the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus. Postanovlenie ministerstva prirodnyh resursov i ohrany okruzhayushchej sredy Respubliki Belarus' ot 30 marta 2015 g. № 13 Ob ustanovlenii normativov kachestva vody poverhnostnyh vodnyh ob'ektov (Decree of the Ministry of Natural Resources).
The average minimum and maximum value of the indicator, and coefficient of variation and coefficient of asymmetry were used to assess the dynamics of changes in hydrochemical parameters.
The average value of the studied indicator was defined as:

$$\bar{x} = \frac{\sum_{i=1}^{i=n} x_i}{n}. \quad (1)$$

where x – is the concentration of the studied indicator;
n – is the number of years of observation.

The coefficient of variation:

$$C_v = \sqrt{\frac{\sum_{i=1}^{i=n}(K_i - 1)^2}{(n-1)}}. \quad (2)$$

Asymmetry coefficient:

$$C_s = \frac{\sum_{i=1}^{i=n}(x_i - \bar{x})^3}{(n-1)} \sigma_x^3. \quad (3)$$

A feature of the Viliya River hydrological regime is the regulation of the flow as a result of the creation of the Vileyka reservoir. The Vileyka reservoir is the largest artificial reservoir of Belarus (the water surface area at the NPS is 73.6 km^2), which was created to supply water to the city of Minsk as part of the Vileyka-Minsk water system. The construction of this reservoir was started in 1973. The reason for construction was the need to increase the volume of water supply in Minsk, for which it was necessary to transfer part of the runoff of more affluent rivers of Belarus to the Svisloch River (Mironenko 1966).
The river Viliya flows through the Vileyka buried protrusion and the Baltic monocline. In the upper reaches, the Vendian sediments are covered with Devochian aleu-

rites, marls, dolomites; on average, Cambrian sands, sandstones and siltstones; in the lower one, by Ordovician and Silurian dolomites and limestones. On the right bank the chalk rocks have become widespread. In the structure of the anthropogenic cover the moraine and water-glacial sands, sandy loams, and loamy sand played the main role (Matveev et al. 1988).

The combination of factors and conditions of soil formation in the Viliya river basin contributes to the development of the podzolic, sod and marsh processes (Kulikovskaya 1974). The lower course of the river is located on sod-podzolic soils on moraine loams and clays (Table 3). Lowland peatlands in the catchment area of the Viliya River are characterized by a high content of manganese and copper; floodplain peatlands of the Elijah and Servicheski rivers – strong iron, low chromium and nickel content.

Table 3

The distribution of soil differences in the basin, Viliya (Mironenko 1966)

Area under soil differences, %			
sandy loam on sand and clay	loam on sand sandy	sandy loam and loam on a moraine	peat
24	27	37	12

The Viliya River basin is located in the temperate climate zone. The humid Atlantic air transforming into continental is dominated most of the year.

Water regime determines the conditions of spring water dilution, the proportion of groundwater, and the salinity of river runoff. The change in chemical composition is influenced by the length of rivers, the presence of tributaries, reservoirs (Alekin 1950). The runoff of the Viliya River is 5% (2.2 km^3) for year in the total runoff of the rivers of Belarus (Kirvel et al. 2018). The observed stock for 2016 is presented in Table 4, and the average annual ad characteristic flow – in the Table 5 (National Environmental Monitoring… 2017).

Table 4

River flow resources of the Viliya River (km^3) for 2016 in comparison with long-term values (State Water Cadaster 2018)

Section of the river basin (lower range)	Observed flow									
	year		winter (Dec-Feb)		spring (March-May)		summer (Jun-Sept)		autumn (Oct-Nov)	
	value	in % of many years	value	in % of many years	value	in % of many years	value	in % of many years	value	in % of many years
V. Steshitsy	0.182	71	0.062	116	0.059	57	0.048	76	0.022	62
V. Mikhalishki	1.78	93	0.594	134	0.552	80	0.492	99	0.226	77

The river flow resources according to the report on the implementation of activities 3.3 of the Detailed Work Plan "Analysis of the state of forest resources and proposals for their management" are given in Table 4. If seasonal variations in river flow are considered, then winter is high water level, and spring is low water level. On the whole, the year is shallow compared to long-term observations.

Table 5

Average annual runoff and typical levels of water for 2015 (runoff in m^3/s, levels in cm* – stations with data on levels)

Water object	Item	Average for many years	Average annual 2014/2015	Maxi-mum	Date	Mini-mum	Date	K	Wateriness
R. Viliya	Vileyka town	20.8	15.8/14.3	23.9	27.05	9.68	21.07	0.69	low
Reservoir Vileyka*	Vileyka town	503	520/515	603	28-31.05	441	04.11	1.02	average

The hydrological regime observations have been conducted since 1924. Currently the control is carried out on three hydrological stations: the Vileyka Town, the Steshytsy Village, and the Mihalishki Village. The hydrochemical observations of surface waters have been conducted since 1948, and hydrobiological observations – since 1974. Today the Viliya River is equipped with the following observation stations of the state network for observing surface water on hydrochemical and hydrobiological indicators (Fig. 2):

- the Bystritsa River – cross-border point;
- the Smorgon Town: 4.0 km NE to the town and 6.0 km NE to the town;
- the Vileyka Town: 0.9 km above the city and 0.5 km below the city.

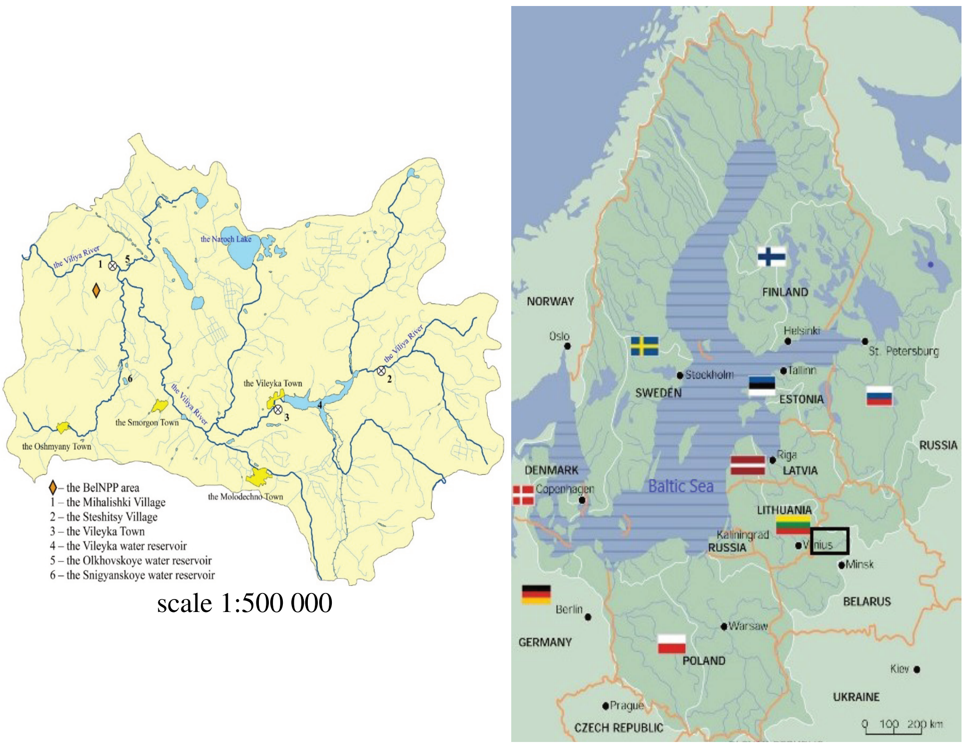

Fig. 2. The basin of the Viliya River

RESULTS AND DISCUSSION

The products of vital activity and decomposition of animals and plant organisms are sources of organic matter in the natural water, which affect the state and stability of the carbonate system, ionic and phase equilibria and the distribution of migration forms of microelements. The increased content of organic substances can have a negative effect on the development of aquatic plant and animal organisms as a result of a sharp decrease in the concentration of dissolved oxygen in a body of water, which leads to their oxidation, and their destructive effect on the stability of vitamins. At the same time a significant amount of products that are valuable for aquatic organisms is formed, and their organic-mineral complexes represent the most easily digestible form of plant nutrition with microelements.

The total removal of water-soluble compounds from forest and treeless watersheds is very different (Table 6). On the watersheds with natural forest vegetation, the aggressiveness of soil waters, good soil permeability, seepage of rain and melt waters, and weak soil freezing create favorable conditions for the dissolution and removal of salts, as a result of which the soil is well washed. Water from the forest watershed is poorer than alkaline earth and alkaline elements, hydrocarbonate ions, nitrates, but richer in organic substances, ammonium nitrogen and iron (Klyueva 1971).

Table 6

Forest cover and boggy of the Viliya River basin (Kolmakova 2009, Klyueva 1971)

River basin	Forest cover, %			Marshes, %	Wetlands, %
	1963	2001	2013		
Vilia	33	41.2	34.8	9	2
Usha	24	33.4	22.7	11	1

The natural hydrochemical background is understood as the quality of the water mass of a river stream, the hydrochemical regime of which is not disturbed by human activity (Karausheva 1987). It is almost impossible to find an intact regime that could characterize the hydrochemical background of watercourses and water bodies at the present stage. Therefore, for the background hydrochemical mode, you can take a period with a determining natural factor of influence and the availability of information for this period. Data hydrochemical background of the Viliya River presented in Table 7. Values for all indicators are below the maximum permissible values.

Currently there is an increase in the anthropogenic load on aquatic ecosystems, which leads to the transformation of the hydrochemical regime and the deterioration of the quality of natural waters. According to the research report, refinement stock characteristics Viliya River and the development of measures to regulate flow in the river basin. Viliya in the operation of the Belarusian NPP, the current state of natural

Table 7

Total Dissolved Solids (TDS) and chemical water composition of the Viliya River at the Vileyka Town (Klyueva 1971)

Date	pH	TDS, mg/dm^3	mg/dm^3						
			HCO_3^-	SO_4^{2-}	Cl^-	NO_3^-	Ca^{2+}	Mg^{2+}	Na^++K^+
during the peak flood period									
19/04/1956	-	56.7	37.8	3.5	0.7	0.35	10.7	1.1	2.5
2/03/1961	7.75	142.9	97.0	11.4	0.1	0.65	25.6	5.6	2.5
during the summer low water									
11/07/1962	7.55	269.4	201.9	5.8	0.0	0.00	48.1	11.4	2.2
22/08/1959	8.30	293.1	220.2	4.5	1.5	0.10	50.1	13.5	3.2
12/07/1960	8.20	271.8	204.4	4.2	0.5	0.90	46.9	12.4	2.5
during the period of summer-autumn floods									
12/11/1960	7.40	132.0	90.3	8.4	1.9	0.30	24.1	5.5	1.5
during the winter flood period									
26/02/1958	-	219.4	158.7	6.0	1.8	1.60	37.3	9.0	5.0

water of the Viliya River are given in Table 8. Observation data indicate an increase in river water salinity.

Table 8

Water quality indicators in the river Viliya

Indicator dimension	03-06/02/2014	20-23/03/2014	21/06/2014
pH	7.43	7.59	7.73
Total hardness, mgO_2/dm^3	4.38	5.8	3.93
Nitrates, mg/dm^3	6.8	5.7	2.6
Chlorides, mg/dm^3	12.7	18.1	11.3
Sulfates, mg/dm^3	20.5	16.6	16.1
Bicarbonates, mg/dm^3	274	373	259
Calcium, mg/dm^3	59	80	57
Magnesium, mg/dm^3	17.4	21.6	13.2
Sodium, mg/dm^3	7.9	5.5	7.7
Potassium, mg/dm^3	3.0	0.65	0.75

Figs 3-16 show the dynamics of the average annual indicators of the quality of natural waters of the Viliya River for the period 1994-2017 (State Water Cadaster 2018), on the sections 0.5 km below the Vileyka Town and 6.0 km NE to the Smorgon Town.

The dynamics of the average annual values of dissolved oxygen (Fig. 3) is fairly uniform. There is a tendency for some decrease in this parameter; however, the concentration of dissolved oxygen does not decrease below the MPC (8 mgO_2/dm^3 for the open period).

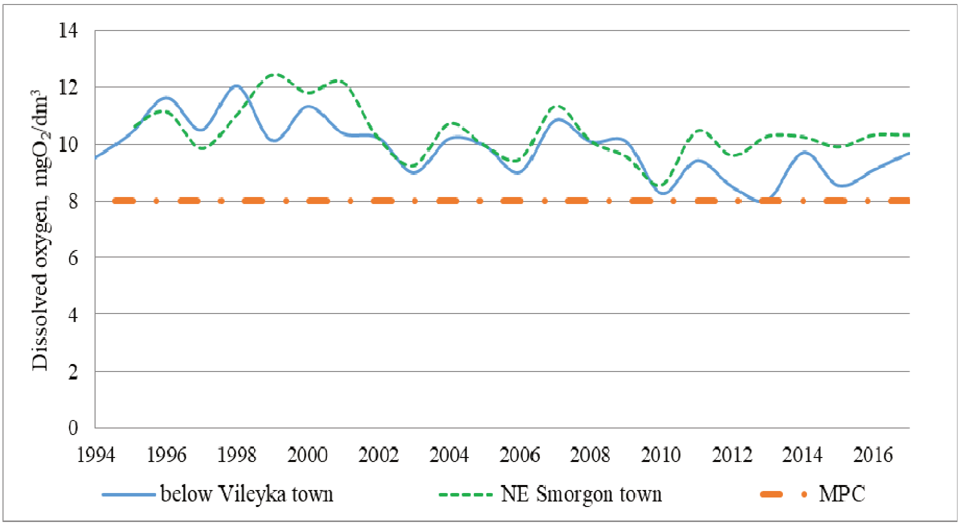

Fig. 3. Dynamics of average concentrations of dissolved oxygen

The distribution of the COC (Fig. 4) varies predominantly with exceeding the MPC during the observed period. This indicates the ingress of chemically oxidized substances into natural waters. In recent years the trend of changes in the COC of the river sections is multidirectional; however, the indicators for both river stations exceed the MPC (25 mgO_2/dm^3).

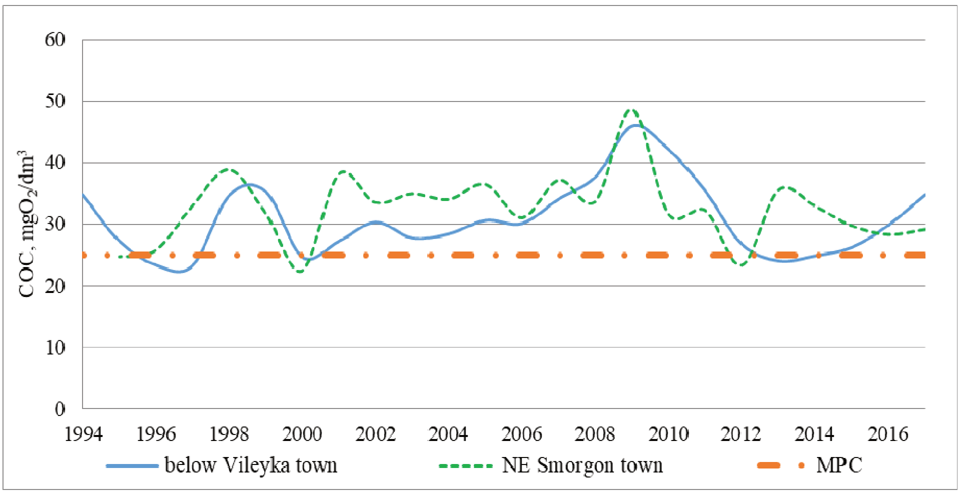

Fig. 4. Dynamics of average COC indices

In recent years there has been a decrease in the BOC_5 indicator (Fig. 5) below the Vileyka Town and a slight increase NE of the Smorgon Town. Excess MPC (no more than 3 mgO_2/dm^3) are recorded for the entire observation period at both stations: in 1995 and 2005 – below the Vileyka Town; in 1995 and 2004 – NE to the Smorgon Town.

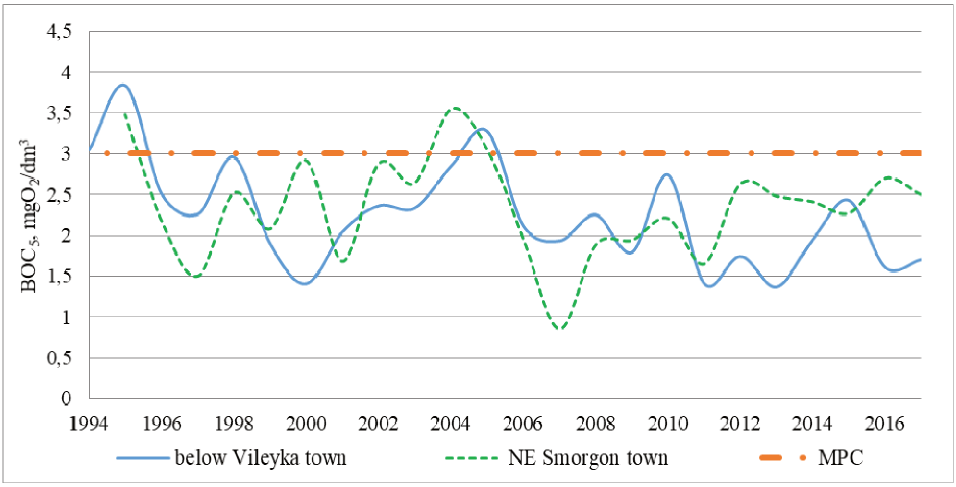

Fig. 5. Dynamics of average annual indicators of BOC_5

There was some unevenness in annual concentrations of suspended substances (Fig. 6). Some years are characterized by peak concentrations of these substances, however, these values do not exceed the MPC (no more than 25 mg/dm^3).

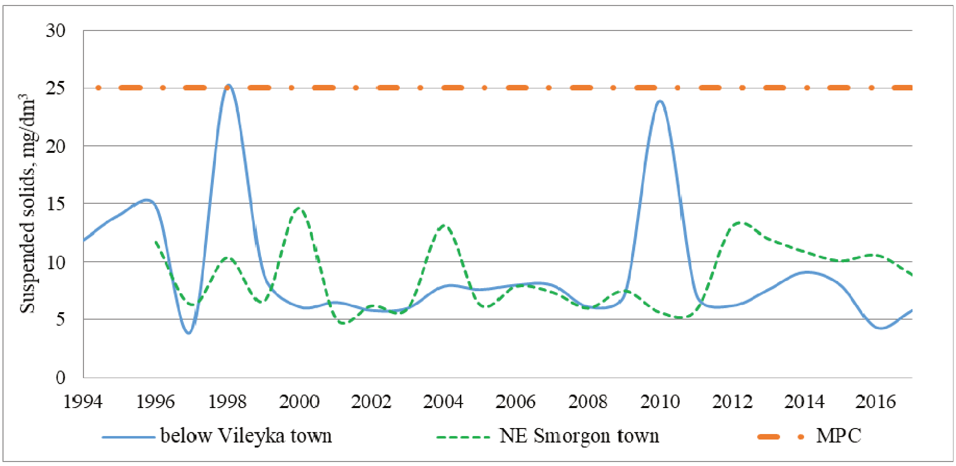

Fig. 6. Dynamics of average annual concentrations of suspended substances

The long-term distribution of ammonium ion (Fig. 7) is uneven. Peak values were recorded at both cross-sections. In 2011 there was a tendency of decreasing of this indicator and further variation is within the maximum permissible concentration (0.39 mgN/dm^3) in the flesh to the present.

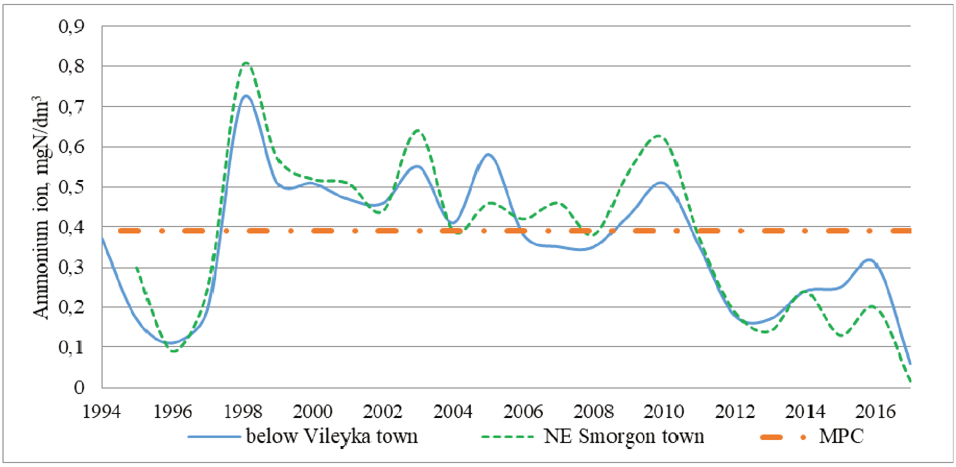

Fig. 7. Dynamics of average annual concentrations of ammonium ion

The dynamics of the distribution of nitrite ion (Fig. 8) at the alignment below the Vileyka Town is uniform and does not exceed the MAC (0.024 mgN/dm^3). The distribution of nitrite ion at the NE border to the Smorgon Town looks different. Excess peak values were recorded here in 1997 and 2003, where the concentration of nitrite ion exceeded MAC in 10 times and 1.5 times, respectively. In recent years the nature of the distribution is more uniform and average annual concentrations do not exceed the MAC.

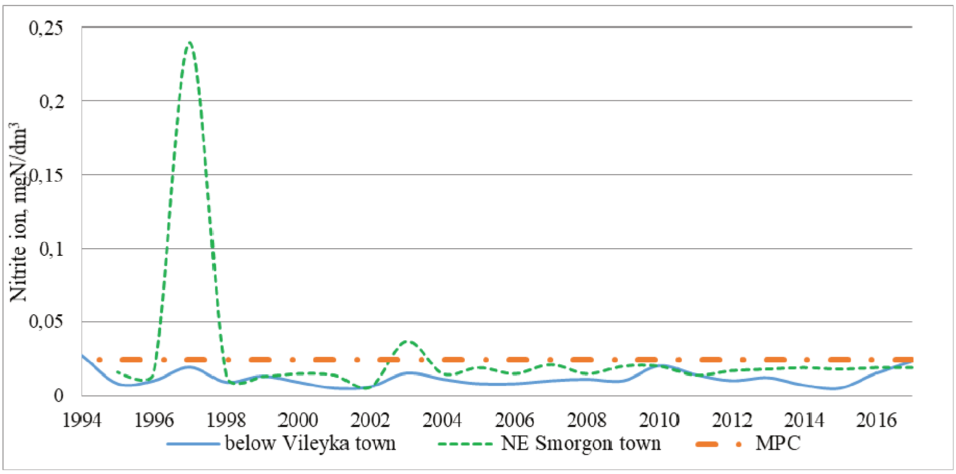

Fig. 8. Dynamics of average annual concentrations of nitrite ion

There was a slight tendency of increasing in the content of phosphate ion (Fig. 9) at both cross-sections, however the excess of the MPC (0.066 mgP/dm^3) is observed once at the NE border to the Smorgon Town. The distribution of phosphate ion is uneven.

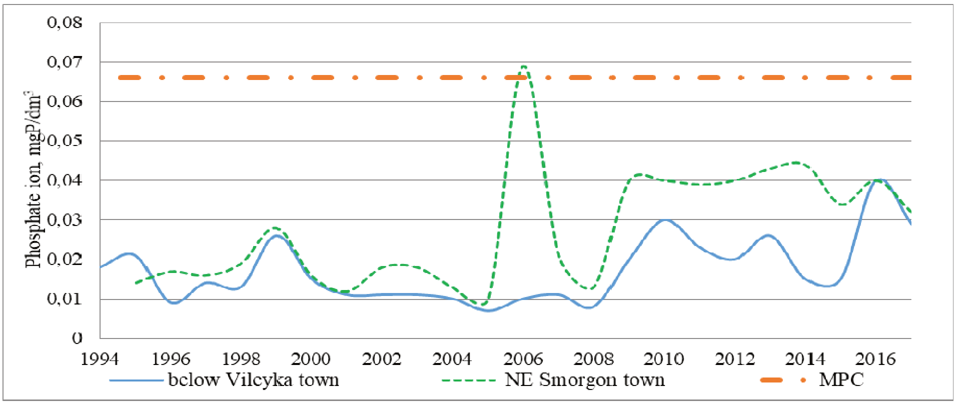

Fig. 9. Dynamics of average annual concentrations of phosphate ion, mgP/dm^3

Considering the dynamics of the SPI (Fig. 10) it can be concluded that the quality of surface waters is improved in terms of this indicator. According to a study in 2015, the WPI was 0.6 below the Vileyka Town and 0.7 NE to the Smorgon Town. According to this indicator the water of the Viliya River belongs to class II and is relatively clean.

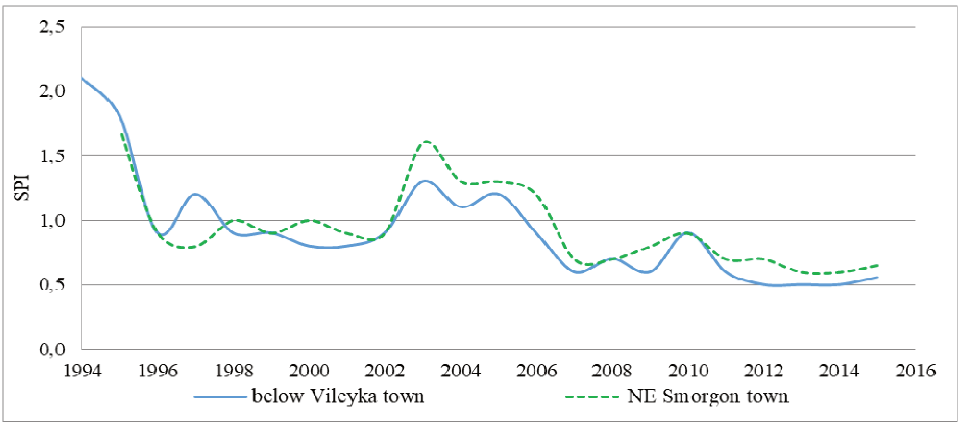

Fig. 10. Dynamics of SPI

The mode of distribution of total iron (Fig. 11) in the Viliya River is characterized by unevenness in the observed gauges. Excess MPC (0.195 mg/dm^3) was observed for almost the entire observed period.

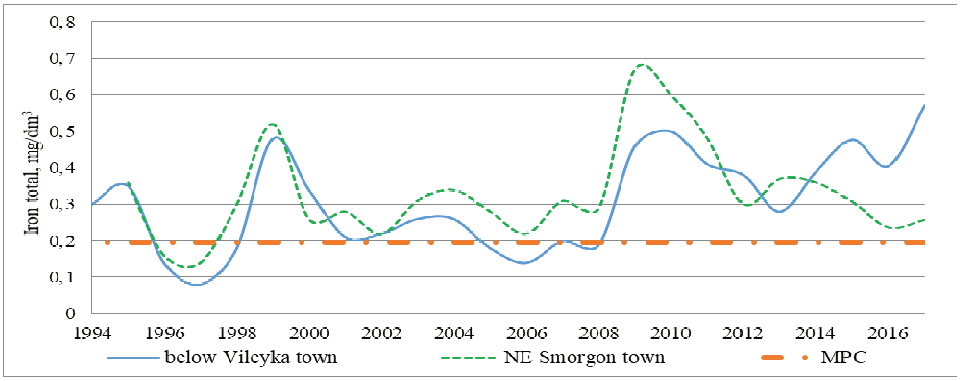

Fig. 11. Dynamics of average annual concentrations of total iron, mg/dm^3

The Viliya River is characterized by the uneven distribution of copper (Fig. 12) and zinc (Fig. 13). The observed period is characterized by peak values, copper exceeding MPC in 2.1 times and zinc in 2.6 times. Recently, there has been a trend of decreasing the concentration of copper and zinc at both river sections.

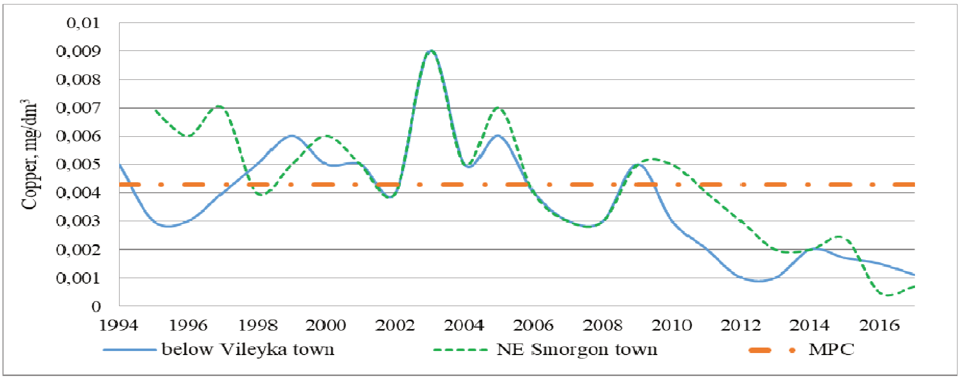

Fig. 12. Dynamics of average annual concentrations of copper, mg/dm^3

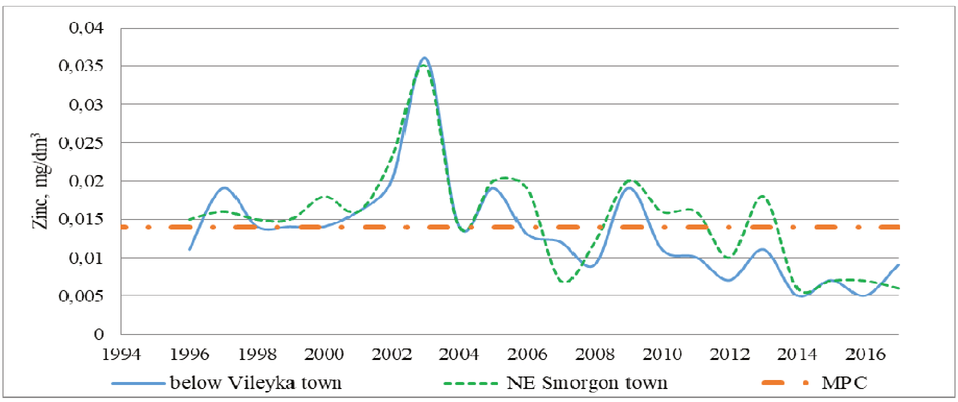

Fig. 13. Dynamics of average annual concentrations of zinc, mg/dm^3

The distribution of nickel (Fig. 14) in river waters is also uneven. The peak values were observed in 2005, where the MPC excess was 2.6 times below the Vileyka Town and 2.4 times NE to the Smorgon Town. The period from 2010 to 2015 characterized by the complete absence of this substance below the Vileyka Town. A for the Smorgon Town, this period was observed from 2011 to 2015.

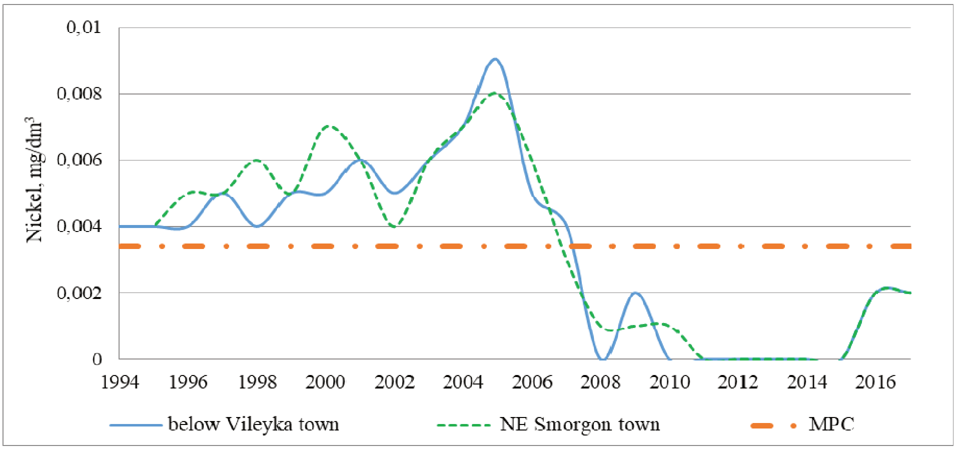

Fig. 14. Dynamics of average annual nickel concentrations, mg/dm^3

The tendency of oil products decreasing (Fig. 15) in river water is traced along all the observed sections.

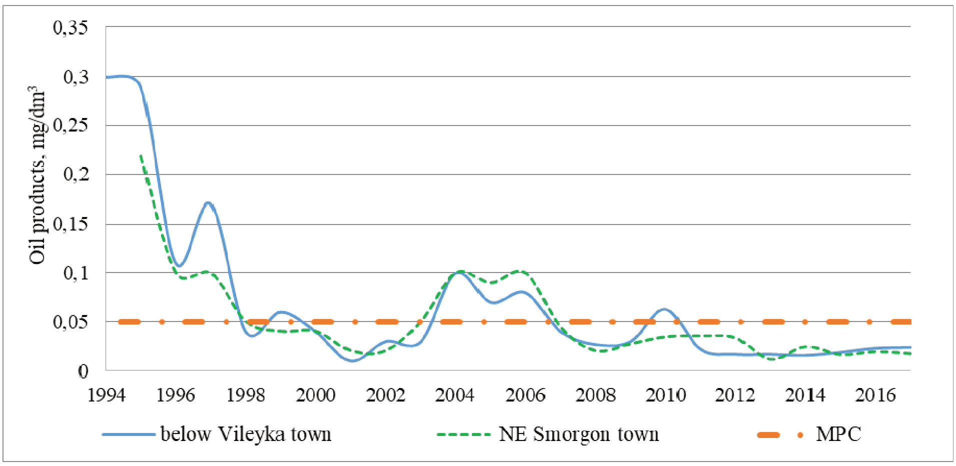

Fig. 15. Dynamics of average annual concentrations oil products, mg/dm^3

Distribution of synthetic surfactants (anion) in the Viliya River is uneven, however for the entire observed period the MPC excess (0.1 mg/dm^3) was not recorded (Fig. 16).

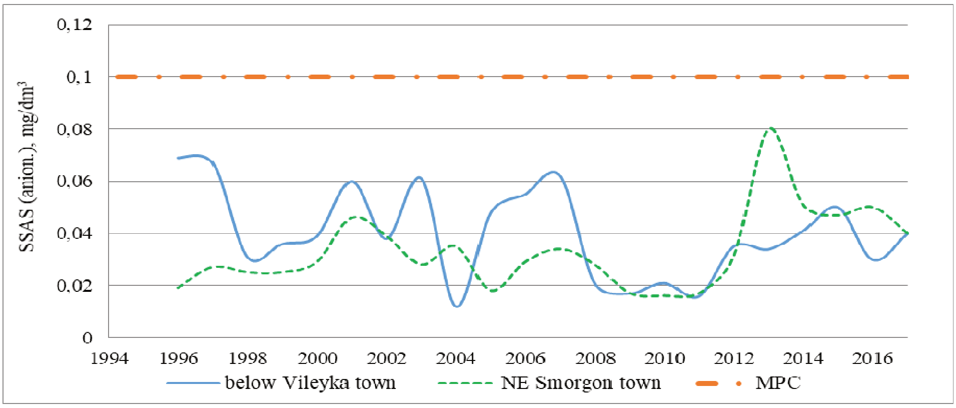

Fig. 16. Dynamics of the concentration of surfactants, mg/dm^3

Table 9 shows the statistical parameters of the hydrochemical regime of the Viliya River.

Table 9

Statistical parameters

Indicator	Stream	Average value	Maximum value	Minimum value	Amplitude of variation	Coefficient of variation	Coefficient of asymmetry
Dissolved oxygen	below the Vileyka Town	9.86	12.05	8.04	4.01	0.104	0.090
	NE to the Smorgon Town	10.39	12.43	8.54	3.89	0.090	0.500
COC	below the Vileyka Town	30.79	45.94	23.20	22.74	0.194	0.837
	NE to the Smorgon Town	32.44	48.54	22.40	26.14	0.176	0.573
BOC_5	below the Vileyka Town	2.24	3.84	1.36	2.48	0.283	0.720
	NE to the Smorgon Town	2.35	3.55	0.85	2.70	0.269	-0.165
Suspended substances	below the Vileyka Town	9.16	25.20	4.00	21.20	0.590	2.135
	NE to the Smorgon Town	9.30	21.80	5.10	16.70	0.423	1.546
Ammonium ion	below the Vileyka Town	0.36	0.72	0.06	0.66	0.459	0.080
	NE to the Smorgon Town	0.38	0.80	0.09	0.71	0.527	0.067

Nitrite ion	below the Vileyka Town	0.012	0.027	0.005	0.022	0.473	1.231
	NE to the Smorgon Town	0.027	0.240	0.006	0.234	1.734	4.696
Phosphate ion	below the Vileyka Town	0.017	0.040	0.007	0.033	0.484	1.063
	NE to the Smorgon Town	0.028	0.069	0.010	0.059	0.538	0.947
SPI	below the Vileyka Town	0.92	2.1	0.5	1.6	0.446	1.537
	NE to the Smorgon Town	0.95	1.7	0.6	1.1	0.329	1.178
Total iron	below the Vileyka Town	0.308	0.570	0.080	0.490	0.433	0.212
	NE to the Smorgon Town	0.329	0.670	0.140	0.530	0.393	1.238
Copper	below the Vileyka Town	0.0037	0.0090	0.0010	0.0080	0.530	0.670
	NE to the Smorgon Town	0.0043	0.0090	0.0005	0.0085	0.490	0.135
Zinc	below the Vileyka Town	0.014	0.036	0.005	0.031	0.503	1.497
	NE to the Smorgon Town	0.015	0.035	0.006	0.029	0.445	0.980
Nickel	below the Vileyka Town	0.0033	0.009	0	0.009	0.799	0.124
	NE to the Smorgon Town	0.0034	0.008	0	0.008	0.789	0.033
Oil products	below the Vileyka Town	0.068	0.300	0.010	0.290	1.169	2.223
	NE to the Smorgon Town	0.053	0.220	0.011	0.209	0.906	2.205
Synthetic surface active substances (anion)	below the Vileyka Town	0.039	0.069	0.007	0.062	0.468	0.045
	NE to the Smorgon Town	0.033	0.080	0.016	0.064	0.453	1.479

An important factor in the formation of the hydrochemical regime is the water content of the river basin. This parameter determines the concentration of a chemical element and is an important factor determining the ability of the river to self-purification. Currently there is a decreasing in water consumption throughout the Viliya River basin (Fig. 17). The use of water for various needs is shown in Fig. 18.

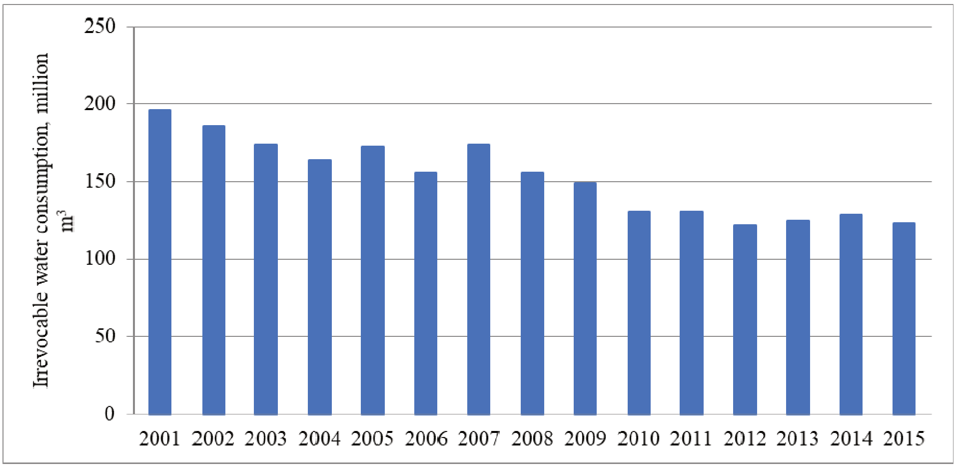

Fig. 17. Dynamics of non-returnable water consumption in the Viliya River for 2001-2015 (within the Republic of Belarus)

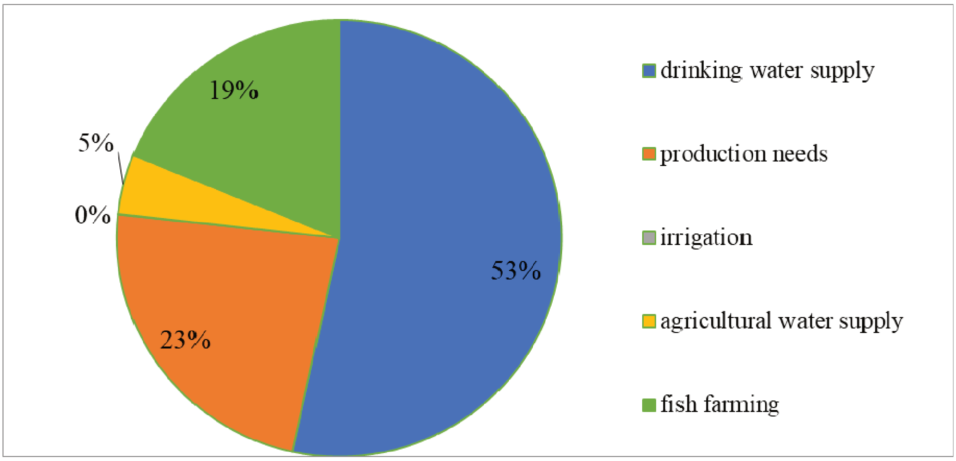

Fig. 18. The use of fresh water for various needs in the Viliya River basin for 2015

One of the main reasons for the change in the chemical composition of natural waters is the discharge of insufficiently treated wastewater. Sewage from residential buildings, municipal and industrial enterprises is supplied to the city treatment facilities. Treatment facilities designed for household wastewater do not cope with the specific composition of wastewater from industrial enterprises. Thus, under-treated wastewater is discharged into watercourses, making changes in the chemical composition of natural waters. Fig. 19 shows the dynamics of discharged wastewater.

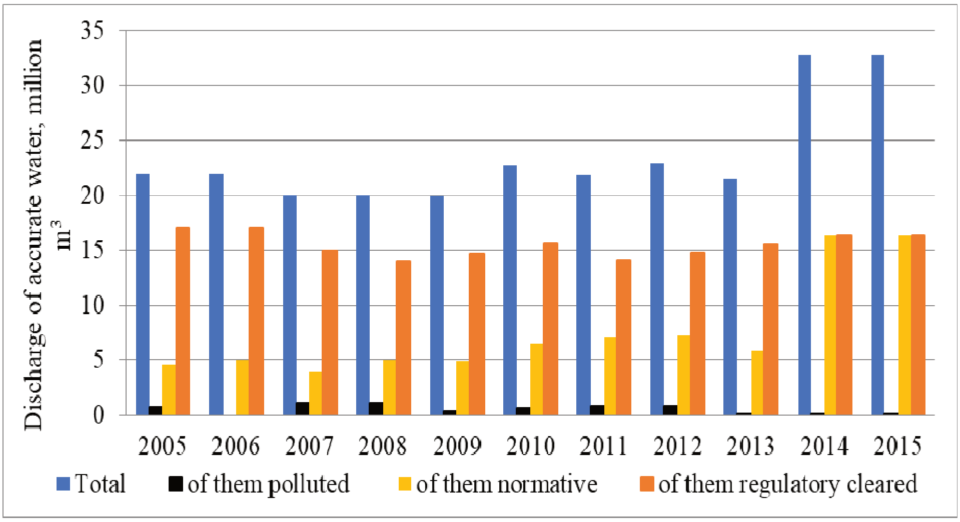

Fig. 19. Discharge of waste and other waters in the Viliya River basin for the period 2005-2015, million m^3

The sources of pollution in the Viliya River basin include a ceramic factory at the Radoshkovichi Village, furniture factory and WCS at the Vileyka Town. Optic plant and feed mill at the Smorgon Town. Wastewater comes to the Usha River from the water supply and drainage system of the Molodechno Town, JSC Zabudova, and railway station. The Naroch and Oshmyanka Rivers take household sewage from the Naroch Village and Oshmyany Town.

CONCLUSIONS

At present the quality of natural water in the Viliya River belongs to class II, according to assignment of chemical status ecosystem, and is relatively clean. The distribution of most quality indicators is uneven, but almost all annual concentrations of ingredients do not exceed the MAC values. The exceptions are COC and iron in common. In recent years the upward trend in content is observed in terms of ammonium-ion and phosphate-ion, but the maximum permissible concentration does not exceed these values for the year 2017. One of the reasons for the increasing of these ingredients in river waters can be an increase in the volume of discharged wastewater. With an increasing of the considered components in the Viliya River basin, the intake of these substances into the Baltic Sea will also increase. Even a small amount of pollutants can aggravate the already very difficult ecological condition of the region.

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OCENA REŻIMU HYDROCHEMICZNEGO RZEKI WILII W KONTEKŚCIE PROBLEMÓW ŚRODOWISKOWYCH MORZA BAŁTYCKIEGO

Streszczenie

W artykule dokonano oceny przekształcenia reżimu hydrochemicznego rzeki Wilii, należącej do basenu Morza Bałtyckiego. Uwzględniono dynamikę średnich rocznych wartości dla okresu od 1994 do 2017 roku według 14 wskaźników jakości wód powierzchniowych. Obliczono parametry statystyczne reżimu hydrochemicznego.