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STATE AND QUALITY OF WATER IN THE DESNA RIVER BASIN (WITHIN THE CHERNIGIV REGION)

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Abstract. The Desna River is a tributary of the Dnieper with a total length of 575 km within Ukraine. 468 km of them flows through the Chernihiv region. The main pollution sources of the water bodies in the Chernihiv region are utilities. Continuous monitoring of the surface water state is relevant and necessary, as it allows to give a reliable water quality assessment, to identify the anthropogenic impact factors and to assess the technogenic loading in order to establish the level of water use and to develop a set of measures to improve the state of water and the environment in general. The materials of monitoring observations of the water quality indicators of the Desna river for a long-term period, as well as the materials of the Ecological passports of the Chernihiv region concerning the water use indicators, were used as the initial data in the work. The analysis of the hydrochemical regime of the Desna River over a long period was performed using a graphical method. The assessment of the technogenic impact on the water bodies of the region was performed using the method of assessing the efficiency of water use based on the water consumption and sewerage efficiency coefficients. The analysis of the content of the water quality indicators showed that constant exceedance of the MPC (Maximum Permissible Concentrations) in the waters of the Desna River within the Chernihiv region was observed in the content of phosphates and nitrites, as well as total iron and manganese. The results of the assessment of the technogenic impact on the water basin of the Desna River showed that the drainage coefficient underwent certain changes with the best indicators in 2015–2016. No sharp fluctuations in the values of the water supply coefficient were observed. The best values of the water use efficiency complex coefficient were noted in 2015–2016. In general, in recent years the efficiency of water using indicators of the Desna River water in the Chernihiv region has corresponded to the average indicators. The results of the assessment of the technogenic impact on all components of the environment in the Chernihiv region showed that in recent years there has been a tendency to reduce the technogenic impact complex indicator. In general, the Chernihiv region can be attributed to the second ecological district with a moderate technogenic loading level.

Keywords: water quality, graphic method, technogenic loading, water use, drainage.

1. Introduction

The Desna is a tributary of the Dnieper, whose catchment area is 88.900 km^2. The total length of the river within Ukraine is 575 km, 468 km of which it flows through the Chernihiv region. The main pollution sources of the water bodies in the Chernihiv region are public utilities, which constantly discharge a large amount of insufficiently treated wastewater (99 % of the total amount of contaminated wastewater). About 22 % of the surface runoff of the Dnieper River and 15 % of the runoff of all rivers of Ukraine are formed in the basin of the Desna River (Department of Ecology and Natural Resources of Chernihiv..., 2020).

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Therefore, constant monitoring of the water state is relevant and very important because it provides an opportunity to analyze the existing changes and provide a reliable assessment of the water quality with the help of the obtained data. In environmental planning, along with the qualitative assessment of the water bodies, an important factor is the assessment of the technogenic impacts on the water bodies and the environment in order to establish the level of water use and develop a set of measures to improve the environment in the regions.

2. Materials and Methods

The long-term monitoring materials of the Dnieper river basin and the Desna sub-basin by the hydrochemical indicators, as well as the materials of the Ecological passports of the Chernihiv region (Department of Ecology and Natural Resources of Chernihiv..., 2020; Department of Ecology and Natural Resources of Chernihiv..., 2019 Department of Ecology and Natural Resources of Chernihiv..., 2018; Department of Ecology and Natural Resources of Chernihiv..., 2017; Department of Ecology and Natural Resources of Chernihiv..., 2016) concerning the content of the certain pollutants and water use indicators, were used as the initial data.

The analyses of the long-term hydrochemical regime of the Desna River, as well as the assessment of the pollutants in the river waters, were performed using a graphical method. The method is based on drawing up a graphical model of a surface water quality, which is a pie chart with scales-radii corresponding to a certain hydrochemical index. The division value of each radius is equal to the maximum value of the indicator concentration (in our case, the concentrations are determined in the MPC fractions) (Igoshin, 2009).

The assessment of the technogenic impact on the water bodies of the region was performed using the method of assessing the water use efficiency based on the water consumption and drainage efficiency coefficients. The method (Kulakov, Shafigullina, 2016) allows calculating the water use efficiency complex coefficient (K). Its components (the water supply efficiency coefficient (K_1) and the drainage efficiency coefficient (K_2) take into account the data on the water intake, the water loss during the transportation, the wastewater discharge into the water bodies, including the waters without treatment and the regulatory clean wastewater. The values of the coefficients vary from 0 to 1, respectively, their best values are close to 1. The calculations are performed according to the following formulas:

– the water supply efficiency coefficient

$$K_1 = \frac{Q_{int.} - Q_{los.trans.}}{Q_{int.}}, \quad (1)$$

– the drainage efficiency coefficient

$$K_2 = 1 - \frac{Q_{without/tr.}}{Q_{dis.} - Q_{n/clean}}, \quad (2)$$

– the complex coefficient

$$K = K_1 \cdot K_2, \quad (3)$$

where $Q_{int.}$ is the water intake from the natural water sources for using, million m^3; $Q_{los.trans.}$ is the water losses during the transportation, million m^3; $Q_{without/tr.}$ is the wastewater discharge without treatment, million m^3; $Q_{dis.}$ is the wastewater discharge into the water bodies, million m^3; $Q_{n/clean}$ is the volume of the normatively clean (which does not require treatment) wastewater discharged into the hydrogen objects, million m^3 (Kulakov, Shafigullina, 2016).

The aim of the work is to assess the state and quality of the Desna river basin waters (within the Chernihiv region), as well as the technogenic impact on the surface waters using certain impact indicators.

3. Results and Discussion

The analysis of changes in the hydrochemical parameters was performed according to the observations at 33 posts, starting from the Belous post (Chernihiv) and up to the Znamenki River (Bili Berezky township, below the city). The content of ammonium, nitrite, nitrate, sulfates, phosphates, chlorides, dissolved oxygen and BOC5 was analyzed. The data for 2004, 2009, 2014 and 2019 are given for the comparative analysis (Fig. 1). As it can be seen, during the study period, constant and maximum exceedance of the MPC in the waters of the Desna River was observed in the content of phosphates and nitrites (up to 3 MPC in 2004, 2014 and 2019, 4–6 MPC in 2009). There was also an excess of the standards for ammonium nitrogen (2009–2019), BOC5 (2009), sulfates and nitrates (2019).

The content of 5 pollutants in the water was also analyzed, namely oil products (OP), Fe, Mn, Cu and Zn. It should be noted that in different years the number of pollutants varied (from 3 in 2015-2016 to 5 in subsequent years). The results of the analysis are shown in Fig. 2. As can be seen from the presented graphs, constant exceedance of the MPC was observed in the content of Fe and Mn. Moreover, the Mn content was maximum, and the excess was 3.5–6.34 MPC in different years. An increase in the OP content in the waters of the Desna during the study period and a slight decrease in the Fe content were noted.

The analysis of the dynamics of changes in the pollutants in the waters of the Desna River within the study region is also shown in Fig. 3. As it can be seen, there is a clear tendency to reduce the content of *Mn* and *Fe*. The data on other indicators were unsystematic, which does not allow to draw the clear conclusions about the dynamics of changes in their concentrations in the Desna River water.

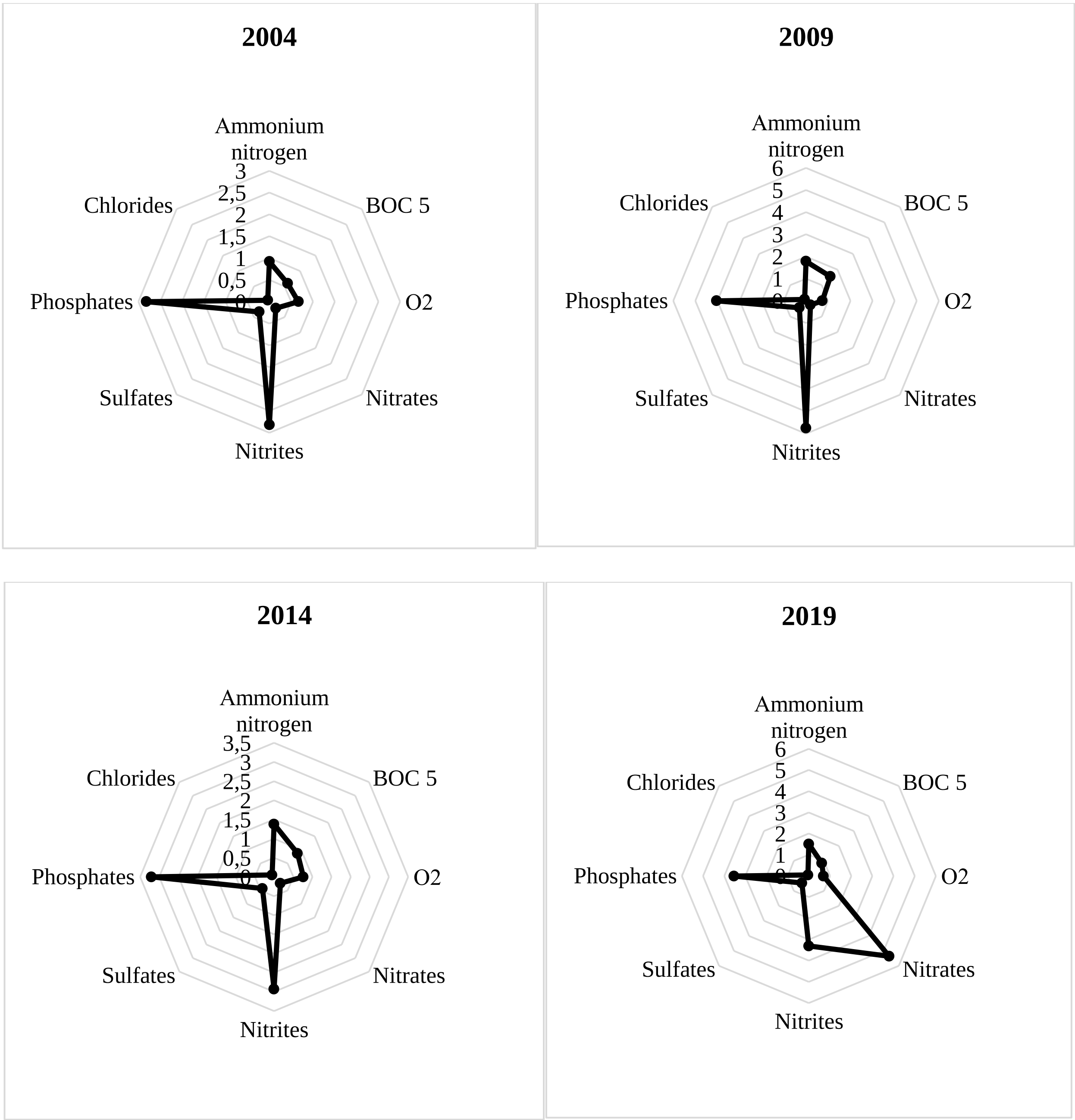

Fig. 1. The water quality of the Desna River within the Chernihiv region by the hydrochemical parameters (in the units of *MPC*)

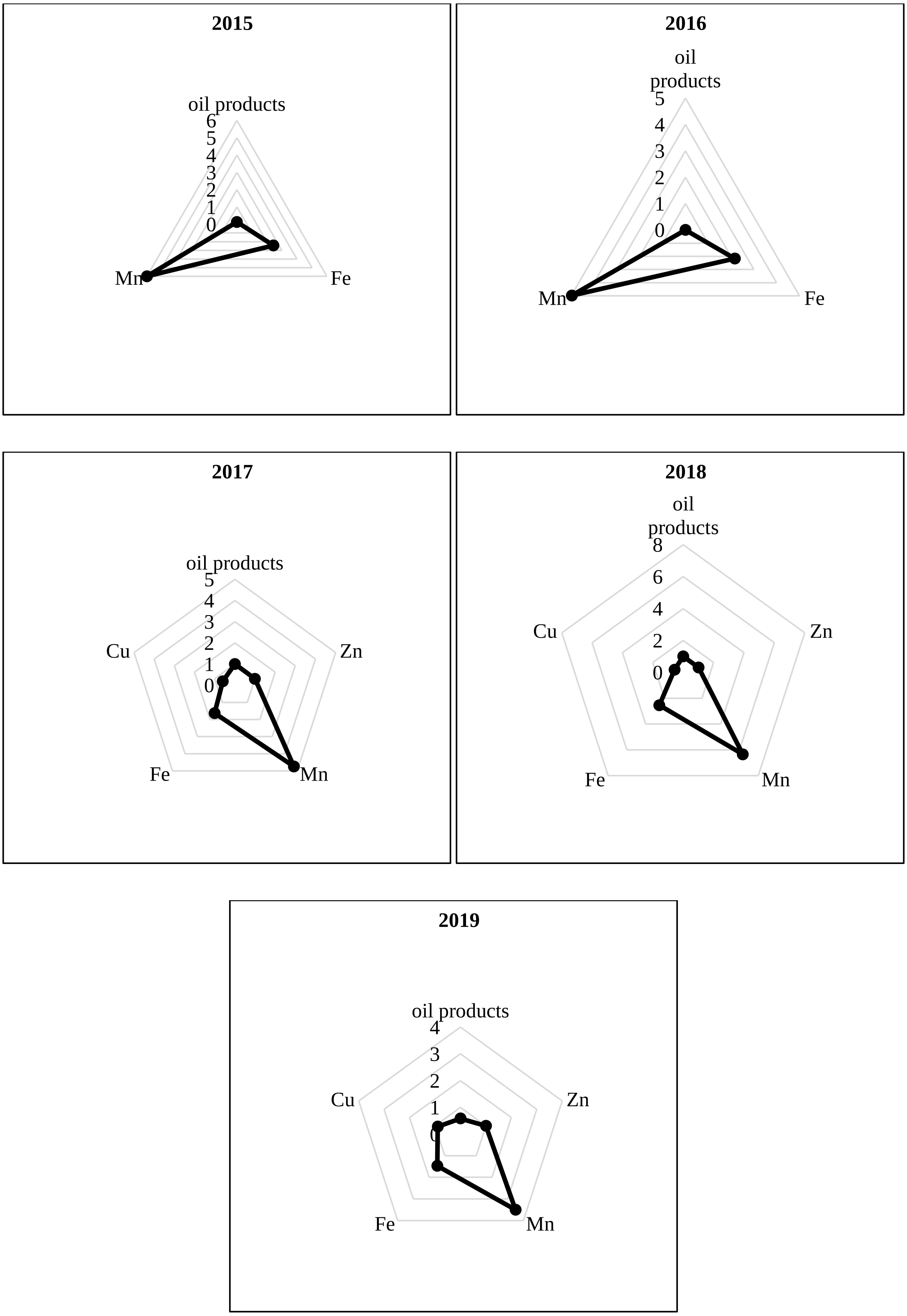

Fig. 2. The water quality of the Desna River within the Chernihiv region by the pollutants content (in the units of *MPC*)

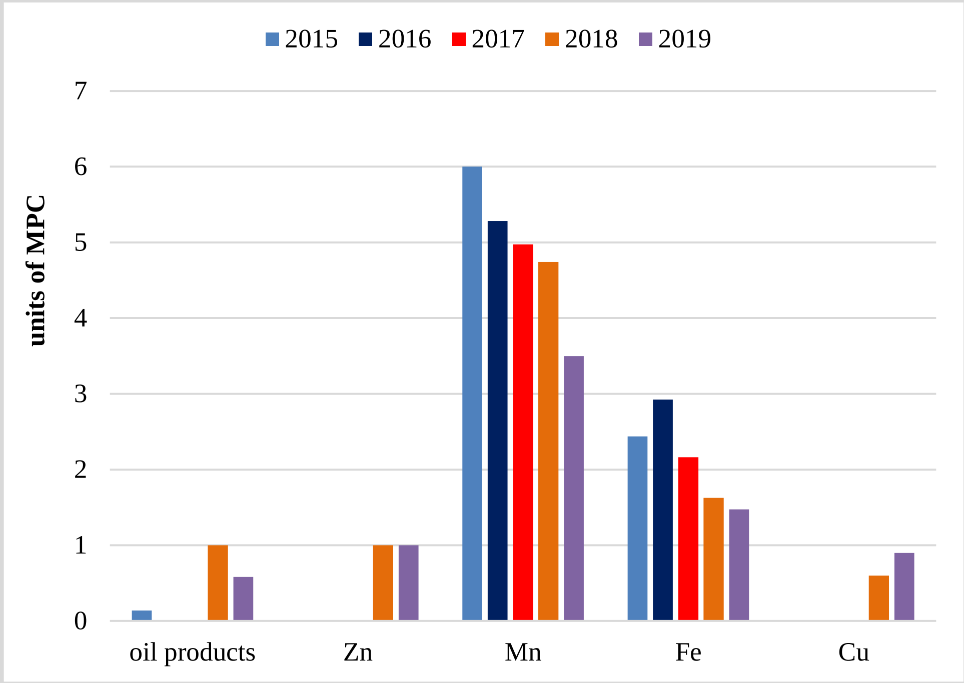

Fig. 3. Dynamics of changes in the content of pollutants in the waters of the Desna River within the Chernihiv region in 2015 – 2019

Fig. 4–5 present the results of assessing the technogenic impact on the Desna River water basin within the Chernihiv region by the water use efficiency indicators. The analysis of the dynamics of changes in the water supply and drainage coefficients (Fig. 4) has shown that the best value of the drainage coefficient K2 was observed in 2015. In general, since 2010, there has been a tendency to improve the values of the coefficient with a sharp decline in 2017. According to the water supply coefficient K1, the situation is stable, sharp fluctuations in the values are not observed.

The best values of the water using efficiency complex coefficient K (Fig. 5) were noted in 2015–2016 (0.79 and 0.75, respectively), and the worst ones were in 2010 (0.34). The situation from 2010 to 2014 was almost stable. In 2015, the maximum K value was monitored, followed by a further sharp decrease in 2017. The general deterioration of the situation is due to a decrease in the value of the drainage efficiency coefficient. In general, in recent years, the indicators of the Desna River water use efficiency in the Chernihiv region have corresponded to the average value of the coefficient K.

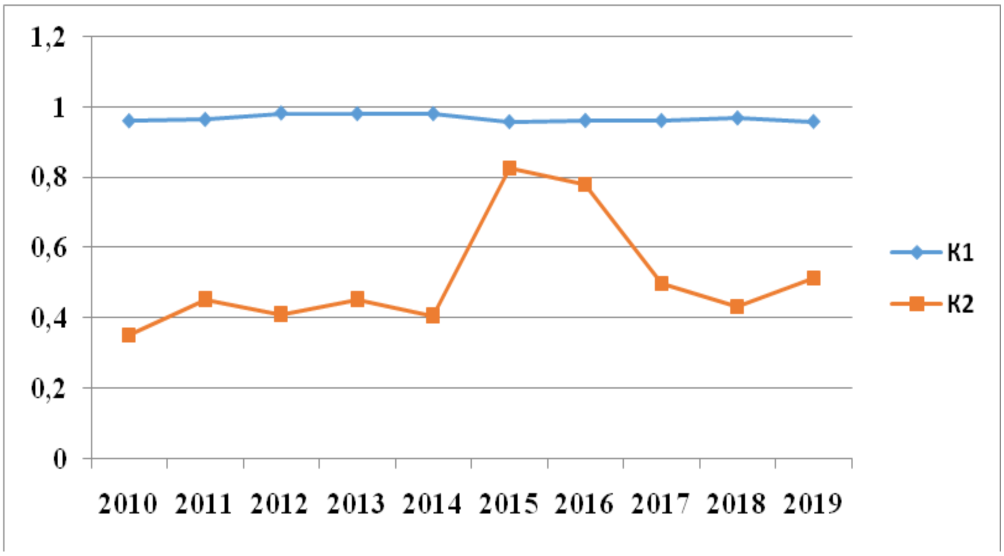

Fig. 4. Dynamics of changes in the water supply and drainage

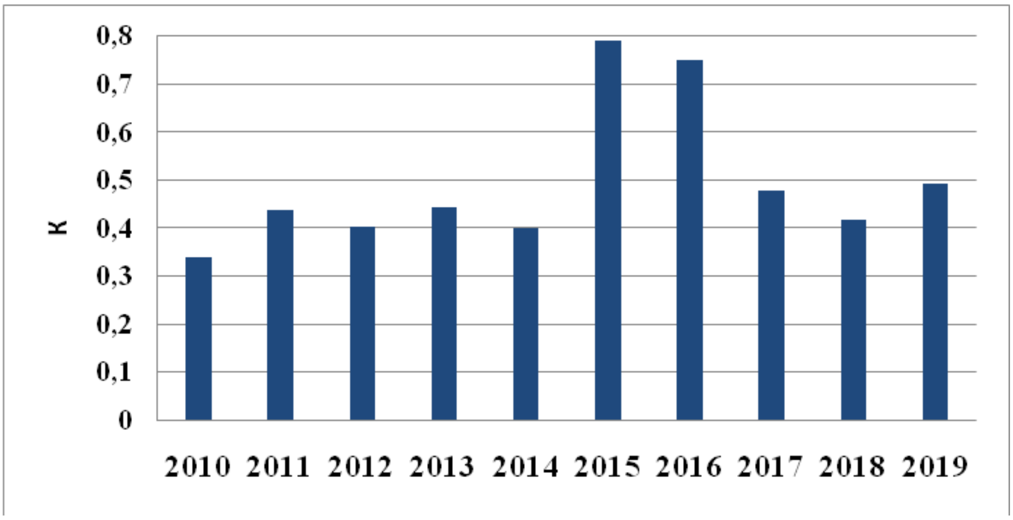

Fig. 5. The assessment of the water using efficiency within the Chernihiv region in 2010 – 2019

In work (Chugai, Hlod, 2021), an assessment of the technogenic impact on the environment of the Chernihiv region as a whole was performed taking into account the indicators of the water intake and the wastewater discharges according to the methods presented in works (Mylarshchikov, 2012; Gamm, Kalie, 2004). It is determined that from 2015 to 2020 there is a tendency to reduce the technogenic impact complex indicator Kk almost 2 times, which indicates a corresponding decrease in the level of technogenic loading. Such results are primarily due to a significant reduction in the amount of waste generated in the region. Also, in 2019–2020, the volumes of the total water intake and the wastewater discharges decreased compared to 2015–2016. The Chernihiv region can be attributed to the second ecological region with a moderate level of technogenic loading.

4. Conclusions

As a result of the research, the following conclusions can be drawn:

1) the analysis of the content of the water quality indicators showed that constant exceedance of the MPC in the waters of the Desna River was observed in the content of phosphates and nitrites (up to 3–6 MPC), as well as Fe and Mn. Mn concentrations ranged from 3.5 to 6.34 MPC in different years. At the same time, there is a clear tendency to reduce the content of these pollutants;

2) the results of the assessment of the technogenic impact on the Desna River water basin within the Chernihiv region showed that the drainage coefficient underwent certain changes with the best indicators in 2015–2016. No sharp fluctuations in the values of the water supply coefficient were observed;

3) the best values of the water use efficiency complex coefficient were noted in 2015–2016. In general, in recent years the efficiency of water use indicators of the Desna River in the Chernihiv region have corresponded to the average values of the coefficient K;

4) the results of the assessment of the technogenic impact on all components of the environment in the Chernihiv region showed that in recent years, there had been a tendency to reduce the technogenic impact complex indicator by almost 2 times. In general, the Chernihiv region can be attributed to the second ecological district with a moderate level of technogenic loading.

The obtained results are a part of a comprehensive study devoted to the assessment of the quality and level of technogenic loading on the waters of the Desna River within the Chernihiv region.

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