OA Assessment of Environmental Risks from the Impact of Domestic and Industrial Effluents

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By V. Bezsonnyi[1]

View Affiliations

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Summary

A comprehensive assessment of the ecological state of the surface water body in the study area was carried out using the method of calculating the water pollution index, which allows obtaining an integral assessment of the ecological state of surface waters based on the frequency of exceeding the MPC of individual components. It was established that the wastewater of the utility enterprise worsens the water condition of the Siverskyi Dinets River, since the values of the water pollution index of the WPI 500 m before the discharge site (fluctuations in the range from 6. 30 to 8. 08) are greater than the WPI values at the same time 500 m below the site reset (fluctuations in the range from 6. 93 to 8. 15), especially this applies to the warm period of the year.

The environmental risk assessment depends entirely on the values of the WPI, and is obtained by arithmetic operations with an index and certain constants. The results of the calculation of environmental risk show that the impact of wastewater of a municipal enterprise increases the value of the environmental risk for the Siverskyi Dinets River, in particular for July–September - from acceptable to unacceptable (values from 0. 000000881 to 0. 00000157).

Introduction

The problem of water pollution in Ukraine is extremely acute. The increase in the technogenic load on the catchment areas with a reduction in the volume of water protection measures leads to an increase in surface water pollution. Contaminated water bodies become unsuitable for drinking and often technical water supply, lose their fishery value and become unsuitable for the needs of agriculture.

The ecological risk of water is the likelihood of events caused by human activity or the interaction of human activity and natural processes that will harm the aquatic environment *(Diet al., 2018).* Awareness of the catastrophic consequences of disturbing the ecosystem balance has prompted national governments to legislate acceptable levels of environmental pollution. Today, hydrosphere pollution is one of the main causes of premature mortality in the world. Due to diseases caused by environmental pollution, 9 million people die prematurely in the world every year *(Nekos et al., 2019).* In this regard, the assessment of environmental risk for natural water bodies, which can be caused by anthropogenic impact of various origins, is an important and urgent problem.

Method and Theory

Determination of indicators of environmental risk (risk of impact of the object or planned activity on the components of the environment) is carried out according to the formula (1) *(DBN, 2005):*

Determination of environmental risks is carried out for objects where such risks may be actually present

(1)

$$R = A \cdot e^{B \cdot e^{D}}$$

where *R* – environmental risk to the environmental component, dimensionless; *A, B* – constants (*A* = 4.99•10−6, *B* = −7.557); *D* – a value calculated by the formula (2) *(DBN, 2005):*

(2)

$$D = -e^{I-1}$$

where *I* – is the pollution index of the environmental component, dimensionless, is defined as 0.2·WPI (WPI – water pollution index) *(Bezsonnyi et al., 2021).*

The assessment of the level of environmental risk is carried out in accordance with the criteria given in Table 1.

Table 1

Classification of risk levels of planned activities and environmental impact (DBN, 2005)

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Risk level	Risk value
Inappropriate	$>10^{-6}$
Acceptable	$10^{-6} – 10^{-8}$
Definitely acceptable	$< 10^{-8}$

The calculation of the value of the pollution index (WPI) and the relative assessment of the ecological state of surface waters is carried out in two stages: first, for each individual studied ingredient and an indicator of the ecological state of surface waters. At the next stage, the whole complex of pollutants is considered simultaneously and the resulting assessment is displayed.

For each ingredient for the estimated period of time for the selected object of study, the following characteristics are determined *(Bezsonnyi et al, 2021):*

➢ repeatability of cases of contamination α_{ij}, that is, the frequency of detection of concentrations exceeding the MPC:

(3)

$$\alpha_{ij} = \frac{n'_{ij}}{n_{ij}} \cdot 100\,\%,$$

where n'_{ij} - the number of results of chemical analysis for the i-th ingredient in the *j*-th creation for the period of time under consideration, in which their content or values exceed the corresponding MPC; n_{ij} - the total number of results of chemical analysis for the period of time under consideration, according to the *i*-th ingredient in the *j*-th creation.

➢ The average value of the multiplicity of excess MPC, calculated only from the results of the analysis of water samples, where such an excess is observed. The results of the analysis of water samples in which the concentration of the pollutant was lower than the MPC are not included in the calculation. The calculation is carried out according to the formula

(4)

$$\bar{\beta}'_{ij} = \frac{\sum_{f=1}^{n''_{ij}} \beta_{ifj}}{n'_{ij}},$$

where β_{ifj} = C_{ifj}/MPC_i - the multiplicity of exceeding the MPC by the *i*-th ingredient in the *f-th* result of chemical analysis for the *j*-th control point; C_{ifj} - concentration of *i*-th ingredient in the *f*-th result of chemical analysis for *j*-th control point, mg/dm^3.

According to the values of the average multiplicity of excess of the MPC, a partial estimated score is calculated on the multiplicity of excess of $S_{\beta' ij}$. Determination of points is carried out using linear interpolation.

➢ The generalized estimated score of S_{ij} for each ingredient is calculated as the product of partial estimated scores on the repeatability of pollution cases and the average multiplicity of excess of the MPC:

(5)

$$S_{ij} = S_{aij} \cdot S_{\beta ij},$$

where S_{aij} - partial estimated score on the repeatability of cases of contamination of the *i*-th ingredient in the *j*-th control point for the period of time under consideration; $S_{\beta ij}$ - partial estimated score on the multiplicity of excess of the MPC *i*-th ingredient in the *j*-th control point for the period of time under consideration.

The generalized estimated score makes it possible to take into account simultaneously the values of the studied concentrations of pollutants and the frequency of detection of cases of excess MPC for each of the ingredients.

The value of the generalized estimated score for each ingredient separately can vary for different types of surface water from 1 to 16. Its greater value corresponds to a higher degree of water pollution.

➢ Next, the water pollution index *Sj* is determined by the following formula *(Bezsonnyi et al, 2021):*

(6)

$$S_j = \sum_{i=1}^{Ni} S_{ij},$$

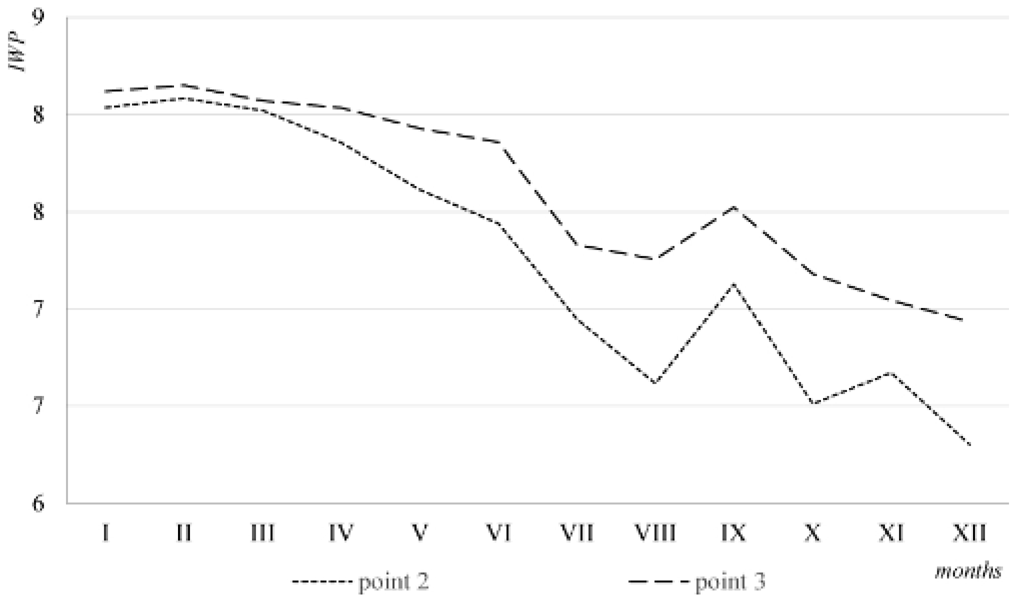
where S_j – index of water pollution in *j*-m control point; N_j – the number of ingredients taken into account in the assessment.

Examples

The ecological risk of a natural surface water body is determined on the basis of real averaged data of many years of observations on the site of the Siverskyi Dinets river, located in the area of the city of Izyum in the area of the discharge of wastewater from the utility-production water supply and sewage enterprise. According to the data of long-term observations, the seasonal dynamics of WPI at 3 control points was studied. The 1st control point is at the place of discharge of wastewater of the municipal water supply and sewage enterprise, the 2nd - 500 m above and the 3rd - 500 m below the place of discharge (Fig. 1).

Figure 1

Seasonal average annual dynamics of WPI at month control points



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As can be seen from the above graphs (Fig. 1), the wastewater of the municipal water supply and sewerage enterprise worsens the water condition of the Siverskyi Donets River, since the values of WPI 500 m before the discharge site are greater than the WPI values 500 m below the discharge site (fluctuations within 6.30 to 8.08) are greater than the WPI values 500 m below the discharge site (fluctuations in the range from 6.93 to 8.15), especially in the warm period of the year.

The results of the calculation of the environmental risk from the influence of the communal water supply and sewage enterprise show (Table 1, Fig. 2) that the influence of wastewater increases the environmental risk for Siversky Dinets for the regions of the North-East, in particular for July–September - from acceptable to unacceptable (values from $8.81{\bullet}10^{-7}$ to $1.57{\bullet}10^{-6}$). But this technique does not give correct indicators for values of environmental risk exceeding the value of $4.99{\cdot}10^{-6}$.

Table 1

Results of calculations of risk indicators (Bezsonnyi V. et al, 2021).

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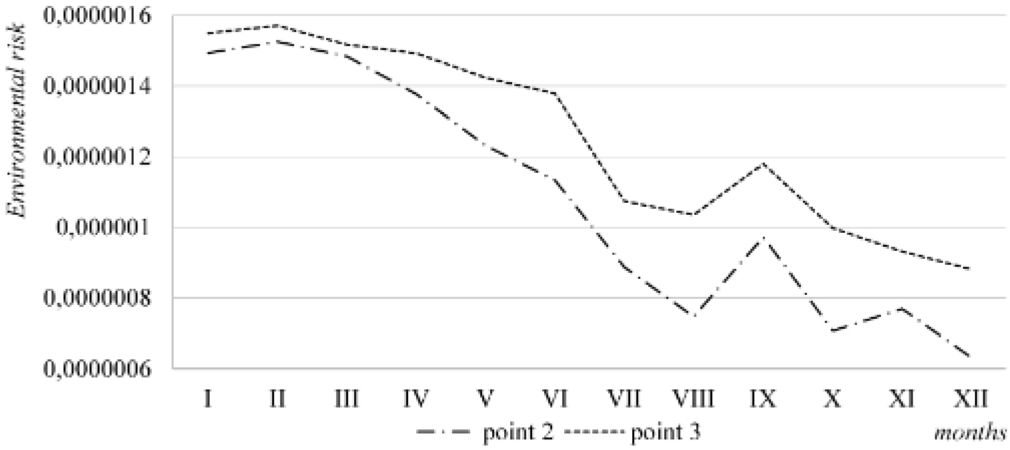
Miss.	Point 1	Definition	Point 2	Definition	Point 3	Definition
I	4,99•10^{-6}	Unaccepted	1,49•$^{10-6}$	Unaccepted	1,55•$^{10-6}$	Unaccepted
II	4,99•10^{-6}	Unaccepted	1,53•$^{10-6}$	Unaccepted	1,57•$^{10-6}$	Unaccepted
III	4,99•10^{-6}	Unaccepted	1,48•$^{10-6}$	Unaccepted	1,52•$^{10-6}$	Unaccepted
IV	4,99•10^{-6}	Unaccepted	1,38•$^{10-6}$	Unaccepted	1,49•$^{10-6}$	Unaccepted
V	4,99•10^{-6}	Unaccepted	1,23•$^{10-6}$	Unaccepted	1,42•$^{10-6}$	Unaccepted
VI	4,99•10^{-6}	Unaccepted	1,13•$^{10-6}$	Unaccepted	1,38•$^{10-6}$	Unaccepted
VII	4,99•10^{-6}	Unaccepted	8,87•$^{10-7}$	Acceptable	1,08•$^{10-6}$	Unaccepted
VIII	4,99•10^{-6}	Unaccepted	7,47•$^{10-7}$	Acceptable	1,04•$^{10-6}$	Unaccepted
IX	4,99•10^{-6}	Unaccepted	9,72•$^{10-7}$	Acceptable	1,18•$^{10-6}$	Unaccepted
X	4,99•10^{-6}	Unaccepted	7,07•$^{10-7}$	Acceptable	9,98•$^{10-7}$	Acceptable
XI	4,99•10^{-6}	Unaccepted	7,70•$^{10-7}$	Acceptable	9,32•$^{10-7}$	Acceptable
XII	4,99•10^{-6}	Unaccepted	6,32•$^{10-7}$	Acceptable	8,81•$^{10-7}$	Acceptable

Figure 2

Seasonal average annual dynamics of environmental risk at above and below the wastewater discharge site



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The results shown in Fig. 2 show that the value of environmental risk depends entirely on the integral indicator of water pollution of the WPI (graphs are identical with the graphs (Fig. 1)), which, in turn, depends on the indicators of pollutants, the value of which exceeds the MPC.

Conclusions

A comprehensive assessment of the ecological state of the surface water body in the study area was carried out using the method of calculating the water pollution index, which allows obtaining an integral assessment of the ecological state of surface waters based on the frequency of exceeding the MPC of individual components. It was established that the wastewater of the utility enterprise worsens the water condition of the Siverskyi Dinets River, since the values of the water pollution index of the WPI 500 m before the discharge site (fluctuations in the range from 6.30 to 8.08) are greater than the WPI values at the same time 500 m below the site reset (fluctuations in the range from 6.93 to 8.15), especially this applies to the warm period of the year.

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