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IMPROVING OF APPROACH TO ECOLOGICAL MONITORING OF OBJECTS OF HYDROSPHERE OF INDUSTRIAL AND AGRICULTURAL DEVELOPED REGION BY ANALYSIS OF TIME TRENDS OF INDICATORS OF TECHNOGENIC POLLUTION OF SURFACE WATERS ON EXAMPLE OF SUMY REGION

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Abstract

The purpose of the study, the results of which are described in this article, is to obtain numerical characteristics of the time trends of pollution of the main objects of water resources of Sumy region by industrial enterprises, objects of housing and communal services, as well objects of agro-industrial complex, for environmental monitoring as basics of indirect assessment of the industrial potential of the region. The object of the study is the ecological status of surface waters of Sumy region as an indicator of its industrial potential. The subject of the study is the time trends in the quantitative characteristics of the research object. The study analyzes the scientific, technical and reference literature on methods of environmental monitoring of urbanized regions with significant industrial, agro-technical potential of developed countries of the world. Using GIS technologies, the distribution of the main hydrosphere objects, their pollutants, potential sites of their monitoring in Sumy region was analyzed and maps were constructed. Based on the chemical analysis of water samples, the average pollution levels of these water bodies were obtained. A statistical analysis of the time trends of these indicators over the past 10 years was performed using the Holt-Winters method. Indicators of significance of the obtained numerical characteristics of time trends indicate the accuracy of the forecasting results. According to the results of such analysis, an indirect estimation of the time trends of the industrial potential of the indicated region was made. Thus, the approach to forecasting long-term trends in the ecological status of surface waters as part of the environmental monitoring of a region with a high degree of industrial and agricultural development based on GIS technologies and the Holt-Winters method has been further developed. The obtained quantitative and qualitative characteristics of time trends of ecological status of surface waters are suitable for indirect estimation of trends of industrial development status of the administrative-territorial unit of the state. The analysis of the obtained data showed that the industrial potential of Sumy region during the indicated period tends to decrease, however, there was a slight increase in the pollution of some rivers by some types of pollutants, which may be explained by the re-profiling of the polluting enterprises.

Key words: surface waters, Holt-Winters method, environmental monitoring, significance, time trend, pollutants, industrial potential.

Relevance of the study and analysis of literature.

To obtain a comprehensive picture of the current ecological status of sufficiently large administrative and territorial units of industrialized countries of the world, in particular Ukraine, even with the gradual decline of industrial potential, environmental monitoring is used. The main component of such monitoring is the process of obtaining the necessary raw data (eg, the results of the analysis of surface water samples). One of the main monitoring functions is to predict the development of an ecological state based on, for example, the use of statistical and mathematical methods, in particular the Holt-Winters method [1].

It is a well-known fact that the level of industrial potential that determines the level of household consumption in urban systems is closely linked to the indicators of the level of environmental safety [2, 3] major environmental components, including hydrosphere objects. It is also well known that some urban areas, apart from advanced industrial production and high population density, have a strong agro-technical potential. At the same time, all environmental components - hydrosphere, atmosphere and lithosphere - are adversely affected by all of the above sources. Although significant atmospheric pollution causes a very rapid response in the form of deterioration of the state of health of the population and spreads with the highest speed, and soil contamination - on the contrary, a long enough effect, which also has the lowest speed of diffusion of water, the effect of which is noticeable already on a macro scale and spreads at a moderate speed, is a priority for such regions of Ukraine as Sumy region in the absence of technical emergencies, genetic and natural disasters.

Therefore, it can be assumed that the assessment of trends in the industrial potential of a region may be based on the results of environmental monitoring of the recipients of pollution from such industrial sites. [5, 6].

Thus, to the deep conviction of the authors of the study, the above and substantiated theme of this study is relevant, has the features of scientific novelty, and its results are suitable for further practical use in the field of environmental protection technologies.

The above arguments for substantiating the relevance of the topic of this study are further supported by the data presented in the papers [7, 8], the authors of which propose approaches to the construction and implementation of an environmental safety management system for pollution of the environment component by energy installations. In the works [9, 10] researchers have focused their attention on ensuring the environmental safety of solid waste management. At the same time, equally important issues in ensuring environmental safety are the question of the reliability of sewage treatment plants, in particular the fight against corrosion [11]. Such studies are not possible without a detailed study of the characteristics of the chemical and component composition of surface waters [12, 13], and their results may underlie the methodology of environmental risk assessment [14], on the basis of which eventually it becomes possible to develop appropriate regulations, methodologies and regulatory documents [15].

Purpose of the study. Obtaining numerical characteristics of the time trends of the contamination of the main objects of water resources of Sumy region by industrial enterprises, objects of housing and communal services, as well as objects of agro-industrial complex, for environmental monitoring as a basis for indirect assessment of the industrial potential of the region.

Object of the study. Ecological status of surface waters of Sumy region as an indicator of its industrial potential.

Subject of the study. Time trends in the quantitative characteristics of the study object.

Methods of the study. Analysis of scientific and technical and reference literature, chemical analysis of water samples, construction of maps using GIS technologies, statistical analysis of measurement data, Holt-Winters method.

Tasks of the study.

1. Analysis of scientific and technical and reference literature on the subject of research.
2. Determination of the distribution of major water bodies, major man-made pollutants and water sampling sites in the territory of the region.
3. Obtaining a set of raw data for the study by sampling water and chemical analysis.
4. Obtaining averaged pollution of the studied water bodies.
5. Obtaining numerical characteristics of the time trends of pollution of the studied water bodies by the method of Holt-Winters.

Scientific novelty. The approach to forecasting long-term trends in the ecological status of surface waters as part of the ecological monitoring of a region with a high degree of industrial and agricultural development based on GIS technologies and the Holt-Winters method has been further developed.

Practical value. The obtained quantitative and qualitative characteristics of time trends of ecological status of surface waters are suitable for indirect estimation of trends of the state of industrial development of the administrative-territorial unit of the state.

1. Determination of the distribution of major water bodies, major man-made pollutants and water sampling sites in the territory of the region

Sumy region is located in the northeast of Ukraine. The total area is 23.8 thousand km^2. In the area there are 18 administrative districts, 15 cities (of them 7 – regional subordination: Sumy, Konotop, Shostka, Okhtyrka, Hlukhiv, Romny, Lebedin), 20 urban settlements, 1455 rural settlements. The population is close 1.1 million.

The main source of water supply in the Sumy region is groundwater of the Dnieper-Donetsk artesian basin and surface waters of the Dnipro basin within the basins of four tributaries: the rivers Desna, Sula, Psla, Vorskla.

The rivers of the region serve as a source of technical water supply for industrial enterprises in different cities of the region, as well as irrigation of garden plots of horticultural societies and lands of agricultural enterprises. 165 rivers with length over 10 km each pertaining to the Dnieper basin flow through the region. The largest of them: the river Desna with the tributary of the Seimas, Vorskla, Sula, Psel, Khorol. Their valleys are quite wide (up to 20 km on the Psel River, up to 14 km on the Sula River), with a steep relatively high (30 – 50 m, often 70 – 80 m) right slope and a gentle low (10 – 20 m) – left. There are more than 500 lakes in Sumy region. Almost all of them are in river valleys – in floodplains of rivers on low alluvial terraces. The vast majority of lakes in the area are small in area of water surface – up to 10 ha. The total area of the water mirror of the lakes of the region is about 2.04 thousand hectares, and the volume of water is about 25 million m^3 [16].

In addition, one should not overlook the fact that all the hydrosphere objects of the region are a source of irrigation for agricultural lands, which mostly consist of black earth, that is, a particularly valuable asset of the national economy. Among the agricultural land in the Sumy region there are: nature conservation land – 176. 6 thousand hectares, hayfields and pastures – 447. 2 thousand hectares, land of water fund – 30.9 thousand hectares, land of health purpose 0.1 thousand hectares, land of recreational purpose 0.3 thousand hectares, lands of historical and cultural purpose – 3.4 thousand hectares, forests – 460.9 hectares [17].

Pollution of water objects of the region is connected with the sphere of agricultural activity ambiguous, namely the quality of irrigation water directly affects the quality of products, and the degree of use of chemical agents (fertilizers, herbicides, pesticides, etc.) in its cultivation affects the quality of groundwater, which feed the surface water objects of the area.

The territory of the region has a large number of industrial sites operating in various industries. In doing so, they have a negative impact on all components of the environment with a wide range of pollutants and harmful factors. This study is devoted to the analysis of such influence.

Given the relatively high population density, as well as the saturation and density of distribution of the territory of the region by habitats (cities, towns, villages), it can also be assumed that the level of load on environmental components of the products of life (sewage, landfill, emissions of gaseous substances) is also significant.

The distribution and nomenclature of water bodies and urban areas of the Sumy region are shown in Figure 1, constructed using ArcGIS software. The information in this figure confirms and illustrates the above considerations regarding the characteristics of hydrosphere objects, land and residential development in the region.

2. Obtaining a set of raw data for the study by sampling water and chemical analysis

The authors carried out a comprehensive experimental and calculated study on the monitoring of the ecological status of the main objects of the hydrosphere of Sumy region, taking into account the peculiarities of its industrial potential. The experimental part of the study consisted of obtaining water samples from the largest waterways of the region at locations adjacent to the locations of enterprises and receiving wastewater and return water discharges. The obtained samples were subjected to chemical analysis to determine the composition of the main contaminant components in them. The calculation part of the study was to use the mathematical apparatus of statistical functions to forecast the temporal trends of environmental performance of water bodies in the period 2008 – 2017, namely the Holt-Winters method.

The distribution of the main pollutants of water bodies in the territory of the region is shown in Figure 2, which shows that such objects are large in number and are located primarily in the regional and district centers and for most water bodies, in particular rivers, distributed approximately evenly along its channel. Also, the figure shows that in places that have watersheds (for example, near Krolevets, Glukhiv, Putivl, and partially Romny), the level of saturation by enterprises-pollutants with corresponding spillway structures is lower than in other territories of the region.

Information on pollutant parameters is given in Table 1.

The necessary baseline data were obtained from the results of laboratory testing of water samples from major water bodies of Sumy region. The distribution of these objects in the territory of the region is shown in Figure 3.

Figure 3 shows that the nomenclature, the number and the geography of sampling sites cover the territory of the oblast broadly enough and agree well on the distribution of the main pollutants by them, thus ensuring the adequacy of the obtained picture to the actual state of affairs.

Figure 1 – Distribution and nomenclature of water bodies and urban areas of Sumy region

Figure 2 – Distribution of the main pollutants of water bodies in the territory of the region

Figure 3 – Distribution of water sampling sites across the Sumy region

Table 1 – Information on pollutant parameters

№	Name of water users of the region / Name of the water intake/ place of discharge from the mouth of the river, km	Polluted return water is removed, thousand m^3 Previous year NO / NDO	Current year NO / NDO	Pollutant: Title	Concentration, mg/dm^3 Factual / maximum permissible discharge / exceeding maximum permissible discharge (times)
1	2	3	4	5	6
Sula River Basin					
1.	Romensk VK №56, Perehrestivka village, Romensky district / Bobrick River, 9 km	– / 21.1	– / 21.2	phosphates	4.0 / 3.5 / 1.1
				suspended substances	18.0 / 15.0 / 1.2
2.	CJSC "SBK", village of Plavinyshche, Romny district / Sula River, 263 km	– / 18.7	– / 19.2	ammonia nitrogen	20.8 / 2.0 / 10.4
				nitrite	1.1 / 0.3 / 3.7
				suspended substances	15.7 / 15.0 / 1.0
				phosphates	3.8 / 3.5 / 1.1
3.	The Stock-Service SE, Ellips PE, Romny / Sula River, 257 km	– / 741.6	– / 878.9	suspended substances	16.4 / 15.0 / 1.1
				biological oxygen consumption$_5$	15.2 / 15.0 / 1.1
Desna River Basin					
1.	Buryn Dairy Company LLC, Buryn / Bowl River, 11 km	– / 41.4	– / 62.8	ferum	0.14 / 0.1 / 1.4
				dry residue	632.2 / 600.0 / 1.1
				suspended substances	15.9 / 15.0 / 1.1
2.	Shostkinska VC № 66, Gamaliyivka village, Shostka district / Shostka River, 25 km	– / 26.1	– / 29.9	biological oxygen consumption$_5$	60.2 / 15.0 / 4.0
				suspended substances	163.8 / 15.0 / 10.9
				chemical oxygen consumption	150.5 / 80.0 / 1.9
				nitrates	3.3 /2.0 / 1.7
3.	Aquarius-BS LLC, Yampil town / Ivotka River, 33 km	– / 51.1	– / 56.5	phosphates	6.21 / 3.0 / 2.1
				synthetic surfactants	0.26 / 0.2 / 1.3
				nitrite	2.03 / 0.6 / 3.4
				ammonia nitrogen	10.71 / 4.16 / 2.6
				ferum	0.36 / 0.3 / 1.2
				biological oxygen consumption$_5$	18.8 / 15.0 / 1.3
4.	KP Midi-Budska Town Community of Sredina-Buda / Bobrick River, 11 km	49.2 / –	53.3 / –	biological oxygen consumption$_5$	103.2 / 15.0 / 1.3
				chemical oxygen consumption	279.5 / 68.0 / 4.1
				ammonia nitrogen	15.0 / 7.0 / 2.1
				phosphates	10.3 / 7.0 / 1.5
				suspended substances	93.8 / 15.0 / 6.3
5.	KP "Vodokanal", Bilopillya / Vir River, 24 km	– / 149.3	– / 159.9	chemical oxygen consumption	182.77 / 67.03 / 2.7
				suspended substances	32.7 / 15.0 / 2.18
				biological oxygen consumption$_5$	50.0 / 15.0 / 2.18
				phosphates	50.0 / 15.0 / 3.3
				ammonia nitrogen	18.9 / 6.0 / 3.2
6.	WUWCG, Konotop (issue 2) / Doll River, 11 km	– / 187.4	– / 198.0	biological oxygen consumption$_5$	21.8 / 15.0 / 1.5
				suspended substances	23.4 / 15.0 / 1.6
				ammonia nitrogen	10.1 / 8.0 / 1.3
				synthetic surfactants	0.044 / 0.03 / 1.5
7.	VUVKG, Shostka / Shostka River, 16 km	– / 4137.8	– / 4598.3	phosphates	6.8 / 3.0 / 2.3
Vorskla River Basin					
1.	TrostianetsCommunservice, Trostyanets town / Boromlya River, 8 km	– / 209.6	– / 210.1	suspended substances	17.1 / 15.0 / 1.1
				biological oxygen consumption$_5$	1.8 / 15.0 / 1.2
				ammonia nitrogen	9.0 / 5.8 / 1.5
				chemical oxygen consumption	85.7 / 61.0 / 1.4
2.	Okhtyrsk cheese-processing plant PJSC Ros Okhtyrka town / Okhtyrka River, 6 km	– / 78.0	– / 8.0	nitrates	12.5 / 0.6 / 20.8
				chlorides	237.5 / 120.0 / 2.0

End of Table 1

1	2	3	4	5	6
Psel River Basin					
1.	KP "Miskvodokanal", Sumy / Psel River, 452 km	– / 12444.4	– / 12475.6	ammonia nitrogen	5.55 / 3.7 / 1.5
				suspended substances	17.62 / 15.0 / 1.2
				sulfates	82.08 / 75.0 / 1.1
				biological oxygen consumption$_5$	12.08 / 12.0 / 1.01
2.	Housing and Utility Company «Lipovodolyns'ke» / Khorol River, 266 km	– / 20.0	– / 21.6	phosphates	34.5 / 3.5 / 9.8
				sulfates	74.1 / 60.0 / 1.2
				ammonia nitrogen	27.7 / 3.0 / 9.2
				chemical oxygen consumption	231.5 / 80.0 / 2.9
				ferum	0.47 / 0.3 / 1.6
				biological oxygen consumption$_5$	69.4 / 15.0 / 4.6
				dry residue	1004.6 / 900.0 / 1.1
3.	Builder LLC, Khotyn town, Sumy borough / Oleshnaya River, 26 km	11.4 / –	11.8 / –	suspended substances	18.5 / 15.0 / 1.2
				biological oxygen consumption$_5$	24.6 / 15.0 / 1.6
				phosphates	1.3 / 1.2 / 1.1
				ferum	0.31 / 0.3 / 1.1
				ammonia nitrogen	25.47 / 17.5 / 1.5
4.	Teploenergo LLC, Krasnopillya town / Serum River, 45 km	– / 41.8	– / –	biological oxygen consumption$_5$	12.02 / 8.0 / 1.5
				ammonia nitrogen	6.67 / 6.2 / 1.1
				phosphates	6.76 / 6.2 / 1.1
5.	FOP Shkarupa OV, Sad village, Sumy borough / Sukhonosivka River (Ilma), 5 km (Sumka River tributary)	– / 30.9	– / 38.2	suspended substances	25.9 / 15.0 / 1.7
				biological oxygen consumption$_5$	87.4 / 15.0 / 5.8
				ammonia nitrogen	12.9 / 6.4 / 2.0
				chemical oxygen consumption	210.0 / 80.0 / 2.6
				phosphates	9.5 / 3.5 / 2.7
				sulfates	77.7 / 60.0 / 1.3
				ferum	0.48 / 0.3 / 1.6

Table 1 shows that the largest pollutants in terms of wastewater discharge, the degree of danger of pollutants in the discharge and the value of exceeding the maximum permissible discharge CJSC "SBK", p. Plavinische, Romensky district, Shostka VK № 66, p. Gamaliyivka, Shostkinskiy district, KP Housing and Utility Company "Lipovodolyns'ke". Information about other companies is evident from the table 1.

Therefore, in this study, a calculated analysis of the trends of pollution of major major rivers of Sumy region in the period from 2008 to 2017 is carried out, the results of which are summarized in Table 2, which is an integral part of environmental monitoring of pollution recipients, which are the source of such industrial objects [4] by statistical methods in order to evaluate the tendency of development of industrial potential of a given region. The mathematical apparatus for such estimation is given in a previous study by [1] the authors and is given below.

The statistical function of the time trend, calculated by the least squares method as a coefficient, was used to estimate the trends of the pollution indicators a_1 (in mg/(m^3·year)) in the regression equation (1) with an independent variable.

$$C = a_0 + a_1 \cdot t , \quad (1)$$

where C – indicator that is predicted, mg/m^3; t – time, year; a_0 – free member of the regression equation, mg/m^3.

The following statistical function was calculated to determine the significance of the time trend of the contamination index:

$$f = \frac{a_1}{\sigma_1} , \quad (2)$$

where σ_1 – error of sample estimation of coefficient value a_1, mg/(m^3·year), which is determined by the following formula:

$$\sigma_1 = \frac{\sigma_u}{S_t} , \quad (3)$$

where σ_u – standard regression error, mg/m^3; S_t – standard deviation of the variable t, year.

3. Obtaining averaged indicator pollution of the studied water bodies

The main results of the studies according to formulas (1) – (3), averaged for large rivers by major pollutants, are summarized in Table 2.

The data in the table shows that for the majority of large water bodies of Sumy region there is a tendency of reducing the level of pollution of the main harmful substances, which are the source of industrial objects, agricultural lands and household waste.

This follows from the negative values of the trend indicator, which determines the direction and intensity of the trends detected, and the acceptable values of the significance indicator, which determines the level of reliability of the calculated results obtained.

Table 2 – Results of environmental monitoring

Water object	Variant	Pollutant	Trend	Significance
Psel River	A	phosphates	-0.07	0.03
Khorol River	B	suspended substances	0.53	0.04
	C	O_2	-0.23	0.025
The river Vorskla	D	sulfates	-4.86	0.007
	E	chlorides	-3.74	0.02
	F	nitrite	- 0.004	0.01
Vorsklitsa River	G	sulfates	-2.54	0.04
the stream of Znamenka	H	suspended substances	-0.67	0.02
	I	O_2	0.28	0.02
	J	nitrates	-0.03	0.02
Znobov River	K	suspended substances	-0.58	0.01
	L	ammonium	- 0.046	0.05
	M	nitrates	-0.31	0.01
Ivotka River	N	biological oxygen consumption$_5$	0.15	0.04
	O	chlorides	-0.8	0,.02
	P	nitrates	-0.26	0.005
Shostka River	Q	nitrates	-0.46	0.001
the Seimas River	R	sulfates	-4.1	0.05
	S	ammonium	0.039	0.01

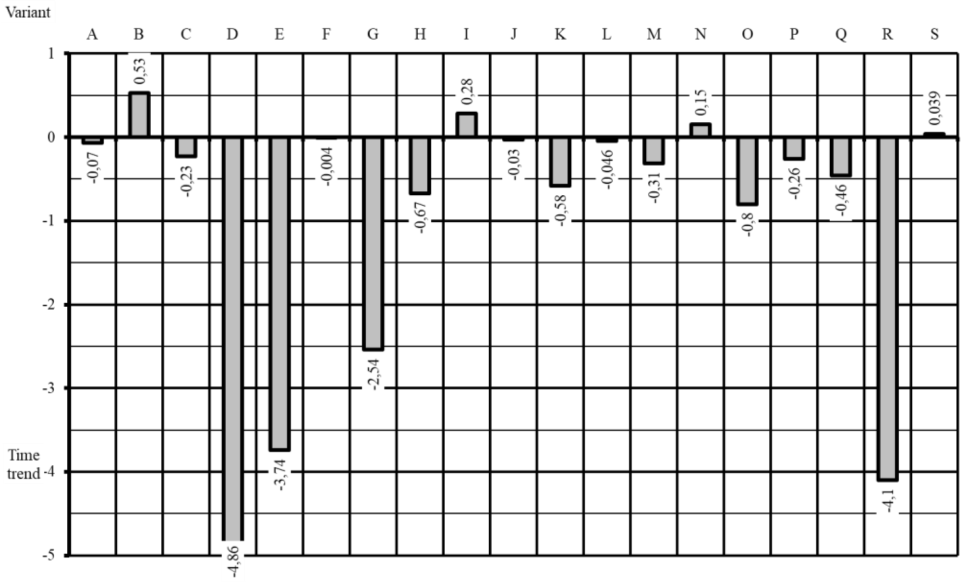

Figure 4 – Results of the calculation study. The value of time trends for all options

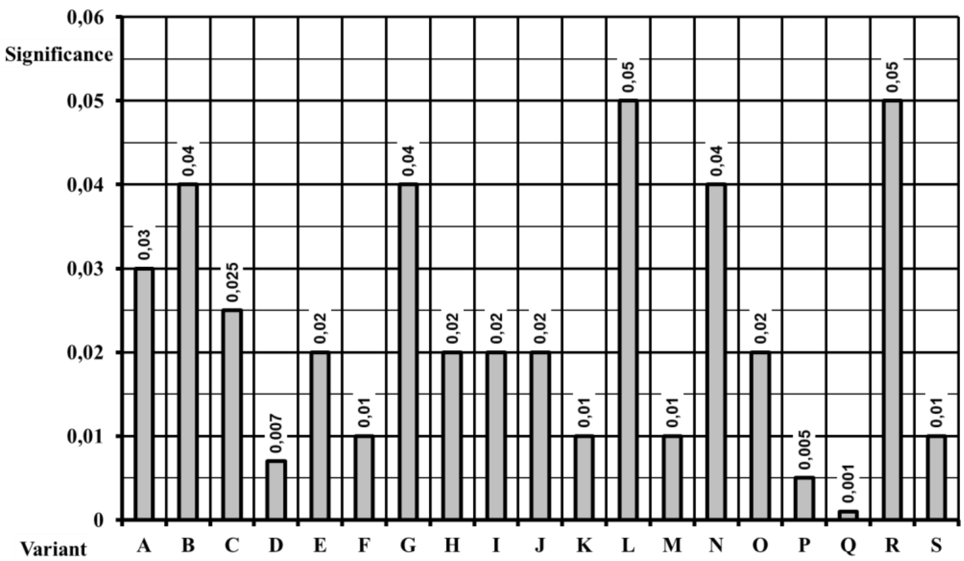

Figure 5 – Results of the calculated study.
The importance of temporal trends for all options

Figure 4 shows that water quality deterioration was observed only at selected monitoring points, first of all, on the Khorol River (248 km from the mouth). There was a significant decrease in dissolved oxygen content. Moreover, in 2017 it was well below the maximum permissible concentrations. In the upper course of the river (a formation 280 km from the mouth), this trend was not observed. That is, we can only make a logical conclusion that the deterioration of water quality in this water body is caused by pollution in the territory of Sumy region. However, this tendency is not related to the growth of industry, but to an increase in pollution of municipal wastewater, as indicated by the component composition of the pollutants. Most likely, such reduction of oxygen content is caused by pollution of sewage by the enterprise of KPP Housing and Utilities "Lipovodolinskoe", which operates and maintains municipal wastewater treatment facilities of the village of Lipova Dolina. Thus, according to the ecological passport of Sumy region for 2017, there was a significant excess of permissible concentrations of organic substances (maximum permissible concentration and biological consumption of $oxygen_5$), ammonium nitrogen and phosphates. The last two pollutants can enter the wastewater not from the municipal wastewater treatment plant, but from the rainwater and groundwater of farms where fertilizers, pesticides and herbicides are used in large quantities.

Conclusions

1. The scientific and technical and reference literature on the methods of ecological monitoring of urban regions with significant industrial, agrotechnical potential of developed countries is analyzed. It is established that an indispensable component of the monitoring is the analysis of the geographical features of the sources of negative impact on the selected component of the environment, the component itself - the hydrosphere, and potential sites for monitoring (sampling). It is also established that Sumy region is such a region of our country, characterized by a combination of significant industrial, agro-technical potential with a sufficiently high population density and construction. All of these components have interrelated effects on the hydrosphere objects of the area.

2. GIS technologies determine the distribution of major water bodies, major man-made pollutants and water sampling sites throughout the oblast, illustrated as maps that clearly show the results of the literature analysis.

3. A set of baseline data for the study was obtained by sampling water at the control points of the main waterways of the Sumy region, located in close proximity to the most powerful pollutants and performing their chemical analysis. It is established that the largest pollutants of surface water objects of the Sumy region by volume of wastewater discharge, by the degree of danger of pollutants in the discharge and by the value of exceeding the maximum permissible concentration are JSC "SBK", p. Plavinische, Romny district, Shostka VK № 66, p. Gamaliyivka, Shostkinsky district, KP Housing and communal services "Lipovodolinskoe".

4. By processing the received information on indicators of ecological status of reservoirs of Sumy region, average indicators of their pollution were obtained. This information was used as input for further statistical analysis.

5. The numerical characteristics of the time trends of the pollution indicators of the studied water bodies of the specified region over the past 10 years, as well as the indicators of the significance of the obtained trends, by the method of Holt-Winters were obtained. Indicators of significance of the obtained numerical characteristics of time trends indicate the accuracy of the forecasting results. As a result of such analysis, an indirect assessment of the time trends of the industrial potential of the region is made. The analysis of the obtained data showed that the industrial potential of Sumy region during the indicated period tends to decrease, however, there was a slight increase in the pollution of some rivers by some types of pollutants, which may be explained by the re-profiling of the polluting enterprises.

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Conflicts of Interest.

None of the authors have any potential conflicts of interest associated with this present study.

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ВДОСКОНАЛЕННЯ ПІДХОДУ ДО ЕКОЛОГІЧНОГО МОНІТОРИНГУ ОБЄКТІВ ГІДРОСФЕРИ ПРОМИСЛОВО РОЗВИНЕНОГО РЕГІОНУ ШЛЯХОМ АНАЛІЗУ ЧАСОВИХ ТЕНДЕНЦІЙ ПОКАЗНИКІВ ТЕХНОГЕННОЇ ЗАБРУДНЕННОСТІ ПОВЕРХНЕВИХ ВОД НА ПРИКЛАДІ СУМСЬКОЇ ОБЛАСТІ

Метою дослідження, результати якого описані у даній статті, є отримання чисельних характеристик часових тенденцій показників забрудненості основних об'єктів водного фонду Сумської області промисловими підприємствами, об'єктами житлово-комунального господарства, а також об'єктами агропромислового комплексу, для здійснення екологічного моніторингу як основи непрямого оцінювання промислового потенціалу регіону. Об'єктом дослідження є екологічний стан поверхневих вод Сумської області як показника її промислового потенціалу. Предметом дослідження є часові тенденції кількісних характеристик об'єкту дослідження. У дослідженні здійснено аналіз науково-технічної та довідникової літератури щодо методів здійснення екологічного моніторингу урбанізованих регіонів зі значним промисловим, агротехнічним потенціалом розвинутих країн світу. За допомогою ГІС-технологій проаналізовано розподіл основних об'єктів гідросфери, їх забруднювачів, потенційних місць їх моніторингу Сумської області та побудовано відповідні мапи. На основі даних хімічного аналізу проб води отримано усереднені показники забрудненості цих водних об'єктів. Здійснено статистичний аналіз часових тенденцій цих показників за останні 10 років методом Хольта-Винтерса. Показники значимості отриманих числових характеристик часових тенденцій свідчать про достовірність результатів прогнозування. За результатами такого аналізу здійснено непряме оцінювання часових тенденцій промислового потенціалу вказаного регіону. Таким чином, набув подальшого розвитку підхід до прогнозування довготривалих тенденцій екологічного стану поверхневих вод як частина екологічного моніторингу регіону з високим ступенем промислово-аграрного розвитку на основі ГІС-технологій та методу Хольта-Винтерса. Отримані кількісні та якісні характеристики часових тенденцій екологічного стану поверхневих вод придатні для непрямого оцінювання тенденцій стану промислового розвитку інших адміністративно-територіальної одиниці держави. Аналіз отриманих даних показав, що промисловий потенціал Сумської області за вказаний період має тенденцію до зниження, проте зафіксовано незначне підвищення забрудненості деяких річок за окремими видами забруднювачів, що може бути пояснене перепрофілюванням підприємств-забруднювачів.

Ключові слова: поверхневі води, метод Хольта-Винтерса, екологічний моніторинг, значимість, часова тенденція, забруднюючі речовини, промисловий потенціал.

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СОВЕРШЕНСТВОВАНИЕ ПОДХОДА К ЭКОЛОГИЧЕСКОМУ МОНИТОРИНГУ ОБЪЕКТОВ ГИДРОСФЕРЫ ПРОМЫШЛЕННО РАЗВИТЫХ РЕГИОНОВ ПУТЕМ АНАЛИЗА ВРЕМЕННЫХ ТЕНДЕНЦИЙ ПОКАЗАТЕЛЕЙ ТЕХНОГЕННОЙ ЗАГРЯЗНЕННОСТИ ПОВЕРХНОСТНЫХ ВОД НА ПРИМЕРЕ СУМСКОЙ ОБЛАСТИ

Целью исследования, результаты которого описаны в данной статье, является получение численных характеристик временных тенденций показателей загрязненности основных объектов водного фонда Сумской области промышленными предприятиями, объектами жилищно-коммунального хозяйства, а также объектами агропромышленного комплекса, для осуществления экологического мониторинга как основы косвенного оценивания промышленного потенциала региона. Объектом исследования является экологическое состояние поверхностных вод Сумской области как показателя ее промышленного потенциала. Предметом исследования является временные тенденции количественных характеристик объекта исследования. В исследовании проведен анализ научно-технической и справочной литературы по методам осуществления экологического мониторинга урбанизированных регионов со значительным промышленным и агротехническим потенциалом развитых стран мира. С помощью ГИС-технологий проанализированы распределение основных объектов гидросферы, их загрязнителей и потенциальных мест их мониторинга Сумской области и построены соответствующие карты. На основе данных химического анализа проб воды получены усредненные показатели загрязненности этих водных объектов. Осуществлен статистический анализ временных тенденций этих показателей за последние 10 лет методом Хольта-Винтерса. Показатели значимости полученных числовых характеристик временных тенденций свидетельствуют о достоверности результатов прогнозирования. По результатам такого анализа осуществлено косвенное оценивание временных тенденций промышленного потенциала указанного региона. Таким образом, получил дальнейшее развитие подход к прогнозированию долгосрочных тенденций экологического состояния поверхностных вод как часть экологического мониторинга региона с высокой степенью промышленно-аграрного развития на основе ГИС-технологий и метода Хольта-Винтерса. Полученные количественные и качественные характеристики временных тенденций экологического состояния поверхностных вод пригодны для косвенного оценивания тенденций состояния промышленного развития других административно-территориальной единицы государства. Анализ полученных данных показал, что промышленный потенциал Сумской области за указанный период имеет тенденцию к снижению, однако зафиксировано незначительное повышение загрязненности некоторых рек по отдельным видам загрязнителей, что может быть объяснено перепрофилированием предприятий-загрязнителей.

Ключевые слова: поверхностные воды, метод Хольта-Винтерса, экологический мониторинг, значимость, временная тенденция, загрязняющие вещества, промышленный потенциал.