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ESTIMATION OF ECOLOGICAL STATE OF SURFACE WATER BODIES IN COAL MINING REGION AS BASED ON THE COMPLEX OF HYDROCHEMICAL INDICATORS

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ОЦІНКА ЕКОЛОГІЧНОГО СТАНУ ПОВЕРХНЕВИХ ВОДОЙМ ВУГЛЕДОБУВНОГО РЕГІОНУ ЗА КОМПЛЕКСОМ ГІДРОХІМІЧНИХ ПОКАЗНИКІВ

Purpose. The study of mining water discharge into surface water bodies and determination of correspondence of measured values of hydrochemical and hydrophysical indicators of water quality with environmental safety standards.

Methodology. The estimation of surface water bodies state under the conditions of mining water discharge was carried out as based on the average annual values of hydrochemical and hydrophysical indicators of water quality according to the requirements of Methodology of Ecological Estimation of Surface Water in Accordance with the Categories. The average values of the following three complex indices of water quality: pollution by saline components, ecological and sanitary indicators, and special indicators of toxic effect, were determined for every plot of surface water quality monitoring.

Findings. The ecological state of water bodies affected by mining water of coal mining enterprises with respect to the system of ecological indicators was studied. It was determined that as for three complex indices of surface water quality in the plots of monitoring, the major pollutant was represented by the saline components, the minor one, by special indicators of toxic effect. It was stated that the quality of surface water in all plots does not meet the standards of ecological safety because of crude wastewater discharge by coal mining enterprises.

Originality. The estimation of water quality of water bodies affected by mining water discharge was carried out for the first time as based on the analytical study for enterprises of coal mining industry in Western Donets Basin. The estimation was based on the following complexes of indicators: saline components of water, ecological and sanitary criteria and special substances of toxic effect.

Practical value. The results of the study can be used for the determining of the main vectors of water protection activity for the improvement of ecological state of water bodies or their sections, as well as for the estimation of nature conservation measures efficiency.

Keywords: *coal mining enterprises, mining water, surface water bodies, hydrochemical indicators, water quality, environmental safety*

The problem substantiation. The coal mining industry is an important component of industrial potential of Ukraine. Its efficiency and stable functioning is the base of future sustainable development and energy security of a state [1, 2].

As a result of continuous mining of coal deposits, the objects of environment became transformed and polluted. The load on the environment, caused by different stages of mines operation, is one of the most important factors to be considered while determining the prospective of coal mining industry development [1–3].

Despite the significant role of surface water bodies in most environmental processes, their state is considered to be critical. None of the water bodies in this country can be described as "very pure" or even "pure" according to their level of water pollution or ecological state.

The worsening of the state of water resources in coal mining regions of Ukraine is one of the most urgent ecological problems of the recent decades. The main cause of water ecosystems pollution is mining water discharge by coal mining enterprises, which is the base for the increase of ecological danger level of natural territorial complex. As a result of long-term discharge of mining water, the surface water bodies loose their natural capacity of self-purification [4, 5].

The Samara river basin is one of the most ecologically stressed regions of Ukraine. The current state of the Samara river ecosystem is reasoned by the intensive long-term anthropogenic influence on its biotic and abiotic components, which has lasted for more than 80 years. The initial negative changes of biotic and abiotic components of the river were caused by the construction of DniproGES and the creation of Dniprovs'ke storage facility. The further anthropogenic influence on the components of the Samara river ecosystem was caused by the intensive development of industry and agriculture. As a result, the processes of river eutrophication, shoaling, the decrease of the level of biodiversity of the most ecosystem components, especially in the location of agricultural runoff, wastewater and industrial wastewater discharge have started. The next factor affecting the existence of all ecosystem components of the Samara river was coal mining process. There are significant deposits of black coal on the territory; the fact substantiated the development of new industrial area in Dnipropetrovs›k region called Western Donets basin with the territory of approximately of 10 thousand km^2. There are coal reserves of approximately 25 mlrd tons; 40 % of them occur under the high-water bed of the Samara and its feeders. Mining water discharge caused by coal mining intensified in early 1970-s. From mid 1950-s the Samara also started to take mining water from the Central Donets Basin via its feeders.

Nowadays the process of pumping in Western Donets Basin is as follows: mining water is accumulated in the settling ponds in Kos'minna, Taranova, Svydovok gullies, and then, after water precipitation, it is discharged into the Samara river. The water is directly discharged into the river basin from Kos'minna and Svydovok gullies. Mining water from the Taranova gully is pumped over the Svydovok gully. The process of pollutants infiltration via bed and body of the dams in settling ponds causes the additional pollution of the river basin by 5 to 15 % of mine drainage.

The aggravation of problem of natural water bodies pollution calls for the permanent monitoring of ecological state of water resources. That is the reason for the demand in methodological approaches to estimation of environmental consequences of mining water discharge into surface water bodies in order to develop and implement timely the proper nature conservation measures.

Review of the related researches. The increase of technological level of water consumption, implementation of less water intensive technologies, the development of more reasoned standards of water consumption, building, reengineering and modernization of water-supply and canalization systems are the base of one of the main principles of the State Goal-oriented program of water industry development and ecological rehabilitation of the Dnipro river basin by 2021.

There are many criteria for complex estimation of quality of surface fresh water bodies in Ukraine and other world countries. Some classifications are based on the estimation of bacteriological and physical and chemical indicators; the others, on hydrobiological estimation of water pollution. Every criterion describes the important information on water contamination by the definite substance in definite period of time; the system of criteria enables the estimation of the aquatic environment from the ecological point of view [5–8].

The studies of the influence of mining water discharge by coal mining enterprises on the state of the Samara river basin were carried out since the point of mining water pumping intensification (late 1970-s). The estimation of rivers pollution in the Samara river basin is shown by B.O. Baranovs'kyi, A.I. Horova, H.P. Yevhrashkina, N.I. Zahubizhenko, V.M. Kotchet, H.A. Kroik, A.F. Kulik, V.I. Onyschenko, O.O. Hrystov. The authors have carried out complex bioindication studies of the Samara and its feeders' ecological state. As a result, the changes of phytodiversity of macrovegetation, state of fish communities and macrozoobenthos were investigated, as well as the qualitative and quantitative peculiarities of the development of ground fauna were determined in accordance with the conditions of mining water discharge into the Samara river.

We should consider the fact that most aquatic organisms can adapt or demonstrate constancy to external influence and load. The fact is reasoned by the ability of water ecosystems to resist the external influence for a long period of time, which becomes apparent in the change of parameters of hydrochemical regime of water body. But it is worth mentioning that the hydrobiological methods of surface water quality estimation are very difficult to be used in practice. They complicate significantly the estimation process of water bodies state, as well as they do not allow consideration of the hydrological peculiarities of water object. They are also related to the hydrochemical indicators in different ways. Along with, they are changed under the conditions of influence of agriculture and industry in the first place.

The allocation of unsolved issues. The study of the qualitative state of natural water bodies, as based on the definite criteria, causes the need in the development of classifications of the level of surface water bodies pollution. The most popular approach is to compare the obtained values of pollutants concentration and the proper standards or interval-valued values of the studied indicators for every water quality class in order to determine the quality state of water objects. The other cases enable classification of surface water bodies according to the pollution level with respect to the values of index of pollution calculated on the base of the system of indicators or criteria [5–8].

Ecological classification of surface water in Ukraine considers the ecosystem principle. The comprehensiveness and objectivity of surface water quality estimation is achieved by means of set of indicators, which show the peculiarities of change of abiotic and biotic components of water ecosystems. The criterion estimation of water bodies state is a component of regulatory and methodological base for complex estimation of environment, planning and implementation of water-protective measures and their efficiency estimation. The results of the study are a base for estimation of the change trends for land surface water quality in the time and space [9].

The estimation of influence of anthropogenic load on water ecosystems enables determination of the specifics of changes of water resources. Nevertheless, the estimation of water quality in accordance with the hydrochemical indicators is a labour intensive process, as it is based on the comparison of average concentrations in the plots of water quality monitoring and standards of maximum permissible concentrations (MPC) for each ingredient considering the category of water object function. Most used indicators were distinguished as a result of integration and generalization of partial qualitative criteria into the integrating one, which enables description of different states of water objects.

The central failure of most classifications is that the quantitative values of criteria for the same classes of pollution are not coordinated with each other, so it is difficult to use them for practical purposes. This means that quantitative values of the criteria are either determined up to the authors or are integrated into the other classifications. The set of criteria from different classifications does not show the reliable results because of the difference of classification principles.

A number of other methods of complex estimation of water quality were developed recently, but most of them are too tedious; require the data of the content of the components, which are not monitored by control authorities; they are often based on the complex calculations.

As based on the analysis of different approaches to the methods of surface water quality assessment, we used the method of determination of the integral ecological index of water quality as most effective method one in our research. The method is the most perfect one, it enables the determination of changes of chemical content of surface water, as well as more accurate estimation of water quality from the ecological point of view. It also usable for the obtaining information about water objects state or their parts.

The purpose formulation. The aim of the paper is the study surface water quality in the Samara river basin, which is affected by mining water discharge from coal mining industry enterprises, according to the complex of ecological indices and determination of correspondence of measured values of pollutants concentration with environmental safety standards.

The main part. The ecological estimation of surface water quality in the Samara river basin, which is affected by mining water discharge from coal mining industry enterprises in Western Donets basin, was carried out as based on the average annual values of hydrochemical and hydrophysical indicators of water quality according to the requirements of *Methodology of Ecological Estimation of Surface Water in Accordance with the Categories* [9].

The procedure of ecological estimation of qualitative state of surface water includes three stages (Figure):

I stage – is the determination of the class and category of water quality according to separate hydrophysical and hydrochemical indicators ($I_{A1}...I_{Ai}$, $I_{B1}...I_{Bi}$, $I_{C1}...I_{Ci}$);

II stage – is the generalization of assessment of water quality according to the class and category indices into the complexes with the determination of complex values of classes and categories of water quality (I_A, I_B, I_C);

III stage – is the determination of integral (complex) ecological estimation of water quality state with the determination of class and category for the particular water object or its part in the definite period of monitoring (I_E).

The ecological state of surface water was estimated with respect to the complex of physicochemical and chemical indicators of water quality, including the general indicators of chemical content and properties of surface water, describing the normal ingredients peculiar to water ecosystems, which can be changed as influenced by anthropogenic factors. The indicators of pollutants of toxic action, which are widespread in surface water in Ukraine, and affect the biocoenosis functioning were also considered.

The integral quantitative characters, based on the integration of elementary indicators of water quality, are the characters of generalizing type. The classes, categories and indices of water quality, zones of saprobity, and degrees of trophicity are determined with considering of elementary indicators and generalizing characters. The classes and categories of water quality,

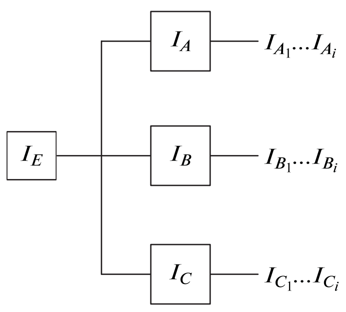

Fig. The framework for the complex estimation of ecological state of surface water which are distinguished according to the characters, describe the natural state and the degree of anthropogenic pollution of surface water [9]. The classification of surface water state according to the hydrochemical and hydrophysical indicators is shown in the Table 1.

The ecological estimation of qualitative state of surface water in the Samara river basin was carried out according to the short list of indicators, which implies the consideration of the minimum information based on the indicators sampled permanently by the State framework of surface water monitoring in Ukraine.

The analysis of qualitative state of surface water in the Samara river basin, affected by mining water discharge of enterprises of coal mining industry in Western Donets Basin, was carried out as based on the systematic monitoring data of the laboratory of analytic control and monitoring of surface water from the State Department of Natural Environment Protection in Dnipropetrovs'k Region [10], collected in 2013–2014 [10].

As the plots of monitoring of surface water quality in the Samara river basin in the industrial area of Western Donets Basin region, the following plots were chosen: I is the Samara river (entry of the industrial area of Western Donets Basin region); II is the Samara river after the discharge point of settling pond in Kos'minna gulley; III is the Samara river before the discharge point of settling pond in Svydovok gulley; IV is the Samara river after the discharge point of settling pond in Svydovok gulley; V is the Samara river (leaving the industrial area of Western Donets Basin region).

The average values of three complex indices of water quality (I_E), i.e. index of pollution by saline components (I_A), index of ecological and sanitary indicators (I_B), index of special indicators of toxic effect (I_C), were determined for every plot of surface water quality monitoring. The indices show a wide range of hydrophysical, hydrochemical, hydrobiological and other indicators of water ecosystems.

The values of indices of separate hydrophysical or hydrochemical indicators (I stage) were determined by means of comparison of average annual values with the correspondent criteria of water quality, which are tabulated in the tables of the system of ecological classification in the Б.1–Б.5 [9].

The average values of indices of separate hydrophysical or hydrochemical indicators may be both even and fractional figures. This enables the differentiation of estimation of water quality state and increases its flexibility and faithfulness. In this case the specified value of water quality category is calculated from the formula

$$K_y = K + \frac{\left(C_i - K_{\min}\right)}{\left(K_{\max} - K_{\min}\right)}, \qquad (1)$$

where K_y is the specified value of water quality category, which corresponds to the value of on index according to separate hydrophysical or hydrochemical indicator (I_{Ai}, I_{Bi}, I_{Ci}); K is the even for the category of water quality, which corresponds to the number of the category including the average annual value of concentration of hydrophysical or hydrochemical indicator of water quality; C_i is the average annual value of concentration of i-hydrophysical or hydrochemical indicator of water quality in the plot of monitoring, mg/dm^3; $K_{\min}$ and $K_{\max}$ are the minimum and maximum values of a range of water quality category values, which includes the average annual value of concentration of i-indicator, mg/dm^3.

As based on the comparison of average annual values, the categories and water quality class, were determined for each indicator separately. The comparison of average values and classes and categories of water qual-

Table 1

The scale of estimation of qualitative state of surface water according to the ecological classification

Water quality class	I	II		III		IV	V
Water quality category (K)	1	2	3	4	5	6	7
Specified range of water quality category	<1	1.01–2	2.01–3	3.01–4	4.01–5	5.01–6	>6
State of water quality	perfect	good		satisfactory		bad	very bad
		very good	good	satisfactory	fair		
Degree of purity (pollution) of water	perfectly pure	pure		polluted		polluted	very polluted
	perfectly pure	pure	quite pure	slightly polluted	moderately polluted		
Saprobity	oligosaprobic		β-mesosaprobic		α-mesosaprobic		polysaprobic
	β- oligosaprobic	α-oligosaprobic	β′-mesosaprobic	β″-mesosaprobic	α′-mesosaprobic	α″-mesosaprobic	
Trophicity (dominant type)	oligotrophic	mesotrophic		eutrophic		polytrophic	hypertrophic
	oligotrophic-oligomesotrophic	mesotrophic	mesoeutrophic	eutrophic	eupolytrophic		

ity for the separate indicators was carried out in accordance with the correspondent units of the ecological classification. The belonging to the definite class or category was determined on the basis of complex indices.

It is noticeable and significant that the values of complex index of pollution by saline components are prevalent among the other complex indices for water quality state in the Samara river on the industrial territories of Western Donets basin region, as it was observed on all plots of monitoring. The complex of saline components includes the following hydrochemical indicators: the content of chlorides, sulphates and salinity criterion. The results of average values calculations for index of surface pollution by saline components are tabulated in the Table 2.

According to the indicators of saline components the Samara river water river on the industrial territories of Western Donets Basin belongs to the IV quality class of the ecological classification. This is valid for all plots of monitoring. The quality of water according to its state is described as "bad", and according to the degree of purity, as "polluted". But the plot of the Samara river after the discharge point of settling pond in Svydovok gulley is an exception. The surface water on the plot belong to the V quality class, and are estimated as "very bad" according to the state and "very polluted" according to the degree of purity.

The calculations showed that the major pollutant among the saline components was represented by high concentration of chloride components. As for all plots of monitoring, the water belongs to the V quality class according to the indicator and its proper description (Table 1).

According to the sulphates content, the quality of the Samara river water on the entrance of the industrial territories of Western Donets Basin and before the discharge point of settling pond in Svydovok gulley, is estimated as "fair" and "moderately polluted" according to its state and the degree of purity respectively. On leaving the industrial area of Western Donets Basin region the water quality is described as "satisfactory" and "slightly polluted" respectively. The Samara river water on the three plots of monitoring belongs to the III quality class. After mining water discharge from the settling ponds in Svydovok and Kos'minna gulleys, the quality of water is worsened according to the criteria of sulphates content. The water belongs to the IV quality class with the correspondent description (Table 1).

The complex index of ecological and sanitary indicators was determined to demonstrate in-between values. The calculation of complex index was carried out on the basis of seven indicators as follows: content of suspended matter, ammoniacal nitrogen, nitrite nitrogen, nitrate nitrogen, phosphates, indicators of dichromate oxidizability and BOD_5 (Table 3).

According to the average values of complex index of ecological and sanitary indicators in industrial area of Western Donets Basin region the Samara river water was qualified as belonging to the IV quality class of the ecological classification and estimated as "bad" and "polluted" considering the state and degree of purity respectively. This is valid for all plots of monitoring.

The calculations for the determination of the Samara river water quality class with respect to the complex index of ecological and sanitary indicators showed that major pollutants were represented by ammoniacal and nitrite nitrogen, phosphates and BOD_5 indicator. The high concentrations of ammonium ions and nitrites indicates the worsening of the sanitary state of water bodies caused by the contamination by organic nitrogen substance from grey water, agricultural waste waters and industrial wastewater of food industry and other industrial branches. The high concentrations of ammonium ions in the water bodies means "recent" pollution, and high concentrations of nitrates and nitrites is a sign of pollution in the past.

The surface waters are polluted by phosphorus as a result of extra phosphorus delivery by means of mineral fertilizers from agricultural runoff, low-purified effluent or crude wastewater or even some industrial wastewater. This causes dramatic uncontrolled increase of plant biomass in a water body. The estimation of phosphorus content in a river water is significant for the determination of potential productivity of water objects, as the increase of bioproductivity of water bodies, caused by phosphorus delivery, leads to the intensive eutrophication and dramatic worsening of water quality.

Table 2

Estimation of quality state of water in the Samara river according to the saline components criteria

Indicators	Qualitative and quantitative hydrochemical indicators of water quality in the Samara river on the plots of monitoring									
	I plot		II plot		III plot		IV plot		V plot	
	C_i, mg/dm^3	I_{Ai}, (quality class)	C_i, mg/dm^3	I_{Ai}, (quality class)	Ci, mg/dm^3	I_{Ai}, (quality class)	C_i, mg/dm^3	I_{Ai}, (quality class)	C_i, mg/dm^3	I_{Ai}, (quality class)
Salinity	2900	4.9 (III)	3300	5.3 (IV)	3140	5.14 (IV)	4120	6.12 (V)	2550	4.6 (III)
Chlorides	616	6.15 (V)	784	7 (V)	805	7 (V)	1347.5	7 (V)	770	7 (V)
Sulphates	1170	4.68 (III)	1285	5.15 (IV)	1200	4.8 (III)	1330	5.32 (IV)	770	3.54 (III)
Complex index value I_A	–	5.24 (IV)	–	5.81 (IV)	–	5.65 (IV)	–	6.15 (V)	–	5.05 (IV)

Table 3

Estimation of quality state of water in the Samara river according to the complex index of ecological and sanitary indicators

Indicators	Qualitative and quantitative hydrochemical indicators of water quality in the Samara river on the plots of monitoring									
	I plot		II plot		III plot		IV plot		V plot	
	C_i, mg/dm^3	I_{Bi}, (quality class)	C_i, mg/dm^3	I_{Bi}, (quality class)	C_i, mg/dm^3	I_{Bi}, (quality class)	C_i, mg/dm^3	I_{Bi}, (quality class)	C_i, mg/dm^3	I_{Bi}, (quality class)
Suspended matter	17.2	3.69 (III)	20.425	4.05 (III)	23.65	4.29 (III)	22.575	4.18 (III)	12.9	3.21 (III)
Ammoniacal nitrogen	0.37	4.32 (III)	0.36	4.26 (III)	0.35	4.21 (III)	0.22	3.11 (III)	0.33	4.11 (III)
Nitrite nitrogen	0.03	5.31 (IV)	0.03	5.31 (IV)	0.06	6.18 (V)	0.037	5.55 (IV)	0.084	6.67 (V)
Nitrate nitrogen	1.6	6.4 (V)	1.9	6.6 (V)	2.3	6.87 (V)	2.4	6.93 (V)	1.5	6.33 (V)
Phosphates	0.38	7 (V)	0.18	5.8 (IV)	0.26	6.6 (V)	0.32	7 (V)	0.56	7 (V)
Dichromate oxidizability	14.9	2.98 (II)	16.5	3.06 (III)	15.7	3.12 (III)	16.5	3.06 (III)	31	5.25 (IV)
BOD_5	11.16	6.83 (V)	12.6	7 (V)	11.28	6.85 (V)	12.33	7 (V)	10.74	6.74 (V)
Complex index value I_B	–	5.22 (IV)	–	5.15 (IV)	2	5.45 (IV)	–	5.26 (IV)	–	5.62 (IV)

The complex index of special indicators of toxic effect includes the indicators for the content of iron, copper, zinc, chromium, manganese, lead, nickel, cadmium and petrochemicals (Table 4).

According to the average values of complex index of special indicators of toxic effect in industrial area of Western Donets Basin region the Samara river water was qualified as belonging to the III quality class of the ecological classification and estimated as "fair" and "moderately polluted" considering the state and degree of purity respectively. This is valid for all plots of monitoring. The following indicators are of the most influence on the quality of Samara river water: copper, nickel, cadmium and petrochemicals. It was stated that the water in the Samara river belongs to the IV–V quality class for all plots of monitoring.

For the complex ecological estimation of quality state of surface water of the Samara river basin in in-

Table 4

Estimation of quality state of water in the Samara river according to the complex index of special indicators of toxic effect

Indicators	Qualitative and quantitative hydrochemical indicators of water quality in the Samara river on the plots of monitoring									
	I plot		II plot		III plot		IV plot		V plot	
	C_i, mg/dm^3	I_{Ci}, (quality class)	C_i, mg/dm^3	I_{Ci}, (quality class)	C_i, mg/dm^3	I_{Ci}, (quality class)	C_i, mg/dm^3	I_{Ci}, (quality class)	C_i, mg/dm^3	I_{Ci}, (quality class)
Iron	0.36	4.65 (III)	0.432	4.83 (III)	0.339	4.6 (III)	0.36	4.65 (III)	0.342	4.6 (III)
Copper	0.022	5.79 (IV)	0.024	5.93 (IV)	0.024	5.93 (IV)	0.023	5.86 (IV)	0.01	5 (III)
Zinc	0.008	1 (I)	0.01	1 (I)	0.008	1 (I)	0.009	1 (I)	0.012	2.4 (II)
Chromium	0.005	4 (III)	0.008	4.5 (III)	0.009	4.75 (III)	0.01	5 (III)	0.01	5 (III)
Manganese	0.022	2.8 (II)	0.024	2.93 (II)	0.026	3 (II)	0.027	3.04 (III)	0.043	3.71 (III)
Lead	0.005	3 (II)	0.007	3.25 (III)	0.008	3.5 (III)	0.009	3.75 (III)	0.008	3.5 (III)
Nickel	0.023	5.07 (IV)	0.026	5.17 (IV)	0.028	5.24 (IV)	0.026	5.17 (IV)	0.023	5.07 (IV)
Cadmium	0.0014	5.89 (IV)	0.0017	6.03 (V)	0.0024	6.24 (V)	0.0022	6.18 (V)	0.0022	6.18 (V)
Petrochemicals	0.459	7 (V)	0.45	7 (V)	0.399	7 (V)	0.444	7 (V)	0.51	7 (V)
Complex index value I_C	–	4.36 (III)	–	4.52 (III)	–	4.58 (III)	–	4.63 (III)	–	4.72 (III)

dustrial area of Western Donets Basin region the values of integral ecological index (I_E) were calculated from the formula

$$I_E = \frac{I_A + I_B + I_C}{3}. \qquad (2)$$

The results are given in the Table 5.

According to the obtained values of integral ecological index (I_E), in industrial area of Western Donets Basin region the Samara river water was qualified as belonging to the IV quality class of the ecological classification.

But the plot of the Samara river on the entrance to the industrial area of Western Donets Basin region is an exception. The water on the plot belongs to the III quality class, and is estimated as "fair" according to the state and "moderate polluted" according to the degree of purity. The worst indicators of integral ecological index were observed on the plots of monitoring of the Samara river after mining water discharge from the settling ponds in Svydovok and Kos'minna gulleys, which shows the significant influence of coal mining industry on the components of environment.

It should be noted that as for three complex indices of surface water quality in the Samara river plots of monitoring, the major pollutant was represented by the saline components index (I_A), the minor one, by special indicators of toxic effect (I_C). The index involving the ecological and sanitary indicators (I_B) has in-between position.

The conclusions and further development prospectives. Ecological estimation of water objects state is an inevitable condition for ecological standardization of surface water. As based on the studies, the following results were obtained:

- the value of integral ecological index was calculated, which allows considering the surface water of the Samara river, influenced by water discharge from coal mining industry enterprises of Western Donets Basin region, to the IV quality class and describe it as "bad" according to the state and "polluted" according to the degree of purity;
- it was stated that as for three complex indices of surface water quality in the plots of monitoring, the major pollutant was represented by the saline components, the minor one, by special indicators of toxic effect;
- it was proven that the worst indicators of ecological indices were observed on the plots of monitoring of the Samara river after mining water discharge from the settling ponds in Svydovok and Kos'minna gulleys;
- it was confirmed that the quality of surface water of the Samara river on the industrial area of Western Donets Basin region in all plots does not meet the standards of ecological safety because of mining wastewater discharge by coal mining enterprises.

The results of the study demonstrate that the Samara river basin is highly influenced by anthropogenic factors, which affects its ecological state and water quality. Moreover, mining wastewater discharge by coal mining enterprises has an influence on the worsening of hydrochemical regime of surface water in Western Donets Basin, and thus decreases the level of ecological safety in coal mining region. As usual the mining water is discharged as raw waste water into the surface water of the Samara river, so the self-purifying process does not take place. This means that the polluted water becomes not only unusable or almost unusable, but also it damages the whole natural territory complex.

To improve the ecological state of surface water bodies in the territory coal mining there is the need in: the development of new system and the change of existing systems of saline water refinement for coal mining enterprises; the increase of reusability of refined mining water for technological purposes; the development of the criteria for ecologically substantiated discharge of refined mining water with respect to the peculiarities of the Samara river

The estimation of surface water state is significant for the estimation of the ecological state of the Dnipro river basin, which is the major waterway of Ukraine. The results of the study can also be used for the determining of the main vectors of water protection activity for the improvement of ecological state of water bodies or their sections, as well as for the estimation of nature conservation measures efficiency. The results of the study can be used for the determining of the main vectors of water protection activity for the improvement of ecological state of water bodies or their sections, as well as for the estimation of nature conservation measures efficiency.

Table 5

Complex integral estimation of ecological state of water in the Samara river

Plot of monitoring, the Samara river	The values of ecological indices of water quality (category / class)				Water quality according to the integral ecological index I_E	Degree of purity of water according to the integral ecological index I_E
	I_A	I_B	I_C	I_E		
I	5.24/IV	5.22/IV	4.36/III	4.94/III	fair	moderate polluted
II	5.81/IV	5.15/IV	4.52/III	5.16/IV	bad	polluted
III	5.65/IV	5.45/IV	4.58/III	5.23/IV	bad	polluted
IV	6.15/V	5.26/IV	4.63/III	5.35/IV	bad	polluted
V	5.05/IV	5.62/IV	4.72/III	5.13/IV	bad	polluted

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Мета. Дослідження наслідків скиду шахтних вод у поверхневі водойми та визначення відповідності фактичних значень гідрохімічних і гідрофізичних показників якості води нормативам екологічної безпеки.

Методика. Оцінка стану поверхневих водних об'єктів, що перебувають під впливом скиду шахтних вод, виконана за середньорічними значеннями гідрофізичних і гідрохімічних показників якості води відповідно до вимог „Методики екологічної оцінки якості поверхневих вод за відповідними категоріями . Для кожної ділянки спостереження за якісним станом поверхневих вод визначалися середні значення для трьох блокових індексів якості води: забруднення компонентами сольового складу, еколого-санітарних показників та специфічних показників токсичної дії.

Результати. Досліджено екологічний стан водних об'єктів, що зазнають впливу шахтних вод вугледобувних підприємств, за сукупністю показників екологічних індексів. Встановлено, що з трьох блокових індексів, які характеризують якісний стан поверхневих вод на досліджуваних ділянках спостереження, найбільший внесок у сумарне забруднення вносять компоненти сольового складу, а найменший – показники специфічних речовин токсичної дії. Виявлено, що якість поверхневих вод, унаслідок скиду вугледобувними підприємствами недостатньо очищених шахтних вод, ні на жодній ділянці спостереження не відповідає нормативам екологічної безпеки.

Наукова новизна. Уперше на основі аналітичних досліджень проведена оцінка якісного стану водних об'єктів, що перебувають під впливом скиду шахтних вод, на прикладі підприємств вугільної промисловості Західного Донбасу, за трьома блоками показників: сольовим складом води, еколого-санітарними критеріями та специфічними речовинами токсичної дії.

Практична значимість. Результати дослідження можуть бути використані для визначення основних напрямів водоохоронної діяльності щодо оздоровлення екологічної стану кожного водного об'єкта або його окремої ділянки й оцінки ефективності проведених природоохоронних заходів.

Ключові слова: *вугледобувні підприємства, шахтні води, поверхневі водойми, гідрохімічні показники, якість води, екологічна безпека*

Цель. Изучение последствий сброса шахтных вод в поверхностные водоемы и определение соответствия фактических значений гидрохимических и гидрофизических показателей качества воды нормативам экологической безопасности.

Методика. Оценка состояния поверхностных водных объектов, находящихся под влиянием сброса шахтных вод, выполнена по среднегодовым значениям гидрофизических и гидрохимических показателей качества воды в соответствии с требованиями „Методики экологической оценки качества поверхностных вод по соответствующим категориям . Для каждого участка наблюдения за качественным состоянием поверхностных вод определялись средние значения для трех блоковых индексов качества воды: загрязнения компонентами солевого состава, эколого-санитарных показателей и специфических показателей токсического действия.

Результаты. Исследовано экологическое состояние водных объектов, подвергающихся воздействию шахтных вод угледобывающих предприятий, по совокупности показателей экологических индексов. Установлено, что из трех блоковых индексов, характеризующих качественное состояние поверхностных вод на исследуемых участках наблюдения, наибольший вклад в суммарное загрязнение вносят компоненты солевого состава, а наименьший – показатели специфических веществ токсического действия. Выявлено, что качество поверхностных вод, в результате сброса угледобывающими предприятиями недостаточно очищенных шахтных вод, ни на одном участке наблюдения не соответствует нормативам экологической безопасности.

Научная новизна. Впервые на основе аналитических исследований проведена оценка качественного состояния водных объектов, находящихся под влиянием сброса шахтных вод на примере угольной промышленности Западного Донбасса, по трем блокам показателей: солевому составу воды, эколого-санитарным критериям и специфическим веществам токсического действия.

Практическая значимость. Результаты исследования могут быть использованы для определения основных направлений водоохраной деятельности по улучшению экологического состояния каждого водного объекта или его отдельного участка, а также оценки эффективности проведенных природоохранных мероприятий.

Ключевые слова: *угледобывающие предприятия, шахтные воды, поверхностные водоемы, гидрохимические показатели, качество воды, экологическая безопасность*

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