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CONFERENCE PROCEEDINGS CONTENTS

ECOLOGY AND ENVIRONMENTAL PROTECTION

ASSESSMENT OF ECOLOGICAL STATE AND ECOLOGICAL RELIABILITY OF THE LOWER SECTION OF THE DNIEPER RIVER

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ABSTRACT

Ecological state of the Lower Section of the Dnieper River was estimated by method of calculation of integrated index on the basis of monitoring over the years 2013–2016. Self-purification potential and capability of restoration in time and space (along the river stream) of the aquatic ecosystem of the lower section of the Dnieper River was established.

The method for assessing the quality of surface water by hydrochemical parameters in accordance with the fishery standards as the most sensitive to changes of the ecological state of the river was used. The current calculation method takes into account the effect of the total action of substances and is approved practically for the analysis of the ecological state of other rivers.

It was discovered, that the state of surface water of region was characterized as unsteady with the low of ecological reliability. Consequently, the processes of self- purification potential and capability of restoration of the aquatic ecosystem are at the low level.

The ecological state of the river is characterized as an ecological regress.

Keywords: the quality of water, integrated index, assessment of ecological state, ecological reliability, fishery standards

INTRODUCTION

The intensive economic use of water resources enhances anthropogenic stress on water bodies, which leads to a change in the water balance, dynamic characteristics and hydrophysical properties of water masses and bottom sediments. These changes are often so powerful that influence on the regime of ecosystems biotic components.

There are frequent cases when the changes of even some elements of the natural water bodies hydrological regime cause a noticeable and sometimes radical transformation of individual sections or aquatic ecosystems in general [1]. An example is the cascade of the Dnieper reservoirs [2]. Theirs total reservoir capacity is greater in 14 times than the river bed volume of the Dnieper, and as a result the velocity of currents decreased in 30–40 times, water turbidity – in 7–9 times. The wind-wave processes, lowering-raising of the water level by the effect of wind processes and seiches were activated, the temperature regime was changed. All this created the conditions for changing the species composition and productivity of live organisms [2].

The listed effects reflect changes in the structure and functioning of aquatic ecosystems, demonstrating the dependence of biological processes of production-destruction of organic matters (self-purification potential and capability of restoration) by hydrochemical parameters [3, 4], and may lead to the aquatic ecosystems destruction [1, 4].

Modern scientists' experience allows on the basis of the analysis of the water exchange processes and formation of the water quality [1, 5, 6] to predict the consequences of the organic matter development [2] and the restoration capability of the aquatic ecosystem [4].

The hydroecologists' purpose suggests, by using models of water quality dependencies and bioproductivity from water exchange, to react promptly on changes of the water ecosystem state and manage of the water quality of the cascade of reservoirs for anthropogenic pollution reduction or elimination of water bodies [5, 6].

The modern calculation method [7] allows to determine quickly the ecological state of the aquatic ecosystem by the hydrochemical parameters. It also allows according to the ecological state integrated indices of the water body to assess its ability to self-purification potential and capability of restoration (ecological reliability), to analyze the ecological sustainability of the river and to take into account the effect of the total action of substances. Integrated index of the ecological state (IIES) is formed on the basis of existing standards and also includes maximum permissible concentrations (MPS).

Assessment of the ecological state of the Lower Section of the Dnieper River was performed on the Integrated index of the ecological state (IIES) [7] in accordance with the fishery standards, as the most sensitive to changes in the ecological state of the river. For water bodies which are used for the fishery use, the mean value of IIES is calculated by the formula:

$$IIES_{mean} = \frac{1}{m}\sum_{i=1}^{m} IIES_i \ , \qquad (1)$$

where m – number of water quality indices blocks (values $IIES_i$).

From the m blocks of water quality indices, the first includes indices that don't have the effect of total action (summation), the remaining blocks include indices that have this effect. According to the sanitary norms, the effect of total action is possessed by substances of the first and second classes of danger with the equal limiting indices of harmfulness (LIH). According to the fishery norms substances with the equal LIH without taking into account the classes of danger are analyzed.

The ecological state of a water body is classified as follows:

– if $IIES_{min} < 0$ and $IIES_{mean} < 0$ then the ecological state of the river area is estimated as unsteady;

– if $IIES_{min} < 0$ and $IIES_{mean} > 0$ then the ecological state of water is estimated on average as stable with sources of instability;

– if $IIES_{min} > 0$ and $IIES_{mean} > 0$ then the ecological state of water is estimated as stable.

In the qualification of the ecological state according by the first two points it is necessary to carry out environmental protection activities in the ecosystem. The obtained results allow carrying out an assessment of the ecological reliability of the ecosystem [7]. Ecological reliability (ER) is the ability of the ecosystem's state to perform relatively complete processes of self-purification potential and capability of restoration.

The probability of a stable state of the river is called ecological reliability (ER), which is determined by the formula:

$$ER = 1 - \chi^2 \big/ (2N - M + 0{,}5\chi^2)\,, \tag{2}$$

where χ^2 – the value of the function "chi-square" with the confidence probability assumed equal to 0,9 [8]; N – the total number of values $IIES_{mean}$; M – the number of values $IIES_{mean}$ which are less then the critical, zero value.

Distribution probability of "chi-squared" recognizing right in connection with the fact that usually the number of surveyed sections of the river is little. For a large value of N, the "chi-squared" distribution reduces to a normal distribution. Based on the fact that complex technical systems are considered reliable at a reliability level of 0,90–0,95, the following qualification of reliability levels is used with a confidence level of 0,9: a high level ($ER \geq 0{,}9$), an acceptable level ($0{,}9 > ER \geq 0{,}8$), a low level ($ER < 0{,}8$) [7].

The data of the analytical monitoring of surface waters of the Kherson Water Resources Board for the 2013–2016 was used to assess the ecological state of the Lower Section of the Dnieper River on points of supervisions of water: 1 – the Dnieper River – town Novovorontsovka-Ushkalka, Kakhovka Reservoir (195 km from the mouth), 2 – the Dnieper River – low tail-water of Kakhovka HPS (92 km from the mouth), 3 – the Dnieper River – city Kherson, 1 km upstream the city (40 km from the mouth), 4 – the Dnieper River – village Kizomys, arm of a river Rvach (0 km from the mouth) (fig. 1).

The Integrated indices of the ecological state calculation of the Lower Section of the Dnieper River according to the fishery norms over the period of 2013–2016 was made. An example of assessing the ecological state of a water body by using integrated index IIES on gauge station the Dnieper River – village Kizomys, arm of a river Rvach (0 km from the mouth) for observations in 2016 according to the fishery norms is presented in Table 1.

Summary results of the assessment of the ecological state in time and in space (along the river stream) are presented in Table 2.

During the observation period, the ecological state of the Lower Section of the Dnieper River in time and in space (along the river stream) is estimated as unsteady. Dynamics of quantitative parameters of mean and minimum coefficients demonstrates deterioration of river water quality in time.

For the observation period 2013–2016, the environmental reliability (ER) was assessed in time and in space (along the river stream). The values of environmental reliability were calculated (ER = 0,77), which corresponds to a low level of self-purification potential and capability of restoration.

Figure 1 – Scheme of the Lower Section of the Dnieper River

Table 1 – Assessment of water quality of the Dnieper River – village Kizomys, arm of a river Rvach (0 km from the mouth) according to the integrated index IIES following to the fishery norms for 2016

LIH	Parameter	C_i, mg/dm^3	MPS, mg/dm^3	MPS – C_i	IES	IIES
General health	Suspended solids	5,0	20,0	15,0	0,75	
	BOD_5	1,63	3,0	1,37	0,46	
	pH	7,91	6,5–8,5	0,59	0,07	
	Dissolved oxygen	10,0	6,0	–4,0	–0,67	
			Σ		0,61	0,15
Toxicological	Saline ammonia	0,12	0,50	–	0,24	
	Nitrites	0,03	0,08	–	0,38	
	ASAS	0,01	0,50	–	0,02	
	Iron	0,12	0,10	–	1,2	
	Copper	0,01	0,001	–	10,0	
	Manganese	0,05	0,01	–	5,0	
			Σ		16,84	–15,84
Sanitary-toxicological	Chlorides	82,0	300	–	0,27	
	Sulphates	68,4	100	–	0,68	
	Calcium	48,0	180	–	0,27	
	Nitrates	0,93	40,0	–	0,02	
	Chrome	0,001	0,001	–	1,00	
	Magnesium	18,3	40,0	–	0,46	
			Σ		2,70	–1,70
Fishery	Petroleum hydro-carbons	0,3	0,05	–	6,00	–5,00
$IIES_{mean}$ = (0,15–15,84–1,70–5,00)/4=–5,6, $IIES_{min}$ = –15,8 (the ecological state of the object is unsteady)						

Table 2 – Assessment of Ecological State of the Lower Section of the Dnieper River in space (along the river stream) and time over the years 2013–2016

Gauge station	Integrated index of the ecological state (IIES)							
	min	mean	min	mean	min	mean	min	mean
	ecological state of a water body							
	2013		2014		2015		2016	
1	–2,2	–0,6	–3,7	–1,0	–16,2	–5,7	–17,2	–5,9
	unsteady		unsteady		unsteady		unsteady	
2	–2,2	–0,5	–4,2	–1,1	–17,1	–5,1	–16,8	–5,8
	unsteady		unsteady		unsteady		unsteady	
3	–2,1	–0,5	–2,9	–0,8	–16,2	–5,6	–15,7	–5,5
	unsteady		unsteady		unsteady		unsteady	
4	–2,3	–0,7	–3,5	–1,3	–16,0	–4,8	–15,8	–5,6
	unsteady		unsteady		unsteady		unsteady	

The dynamics of the results of the studies in time (Table 2) demonstrates the increase of the negative consequences of anthropogenic load and the need for the implementation of environmental events aimed at renewing the ability of the aquatic ecosystem to self-purification and capability of restoration.

Recovery of the processes which activate an ability of the Lower Section of the Dnieper River to cleanse itself is possible due to the optimization of the regime of Kakhovka HPS-1 releases [3, 5, 6] and/or building Kakhovka HPS-2 [9].

According to the calculations of the Institute of Hydrobiology of the National Academy of Sciences of Ukraine approximately twice the size of the design (at a discharge of 5100 m^3/s) of the velocity of flow in the river bed and the arms of the Dnieper river. The external water exchange of the zone channel network will intensify – the period of its external water exchange will decrease from 11,4–17,2 to 5,8–8,8 days (values are given for 6 and 4-hour releases, respectively) [3, 9].

CONCLUSION

Ecological state of the Lower Section of the Dnieper River was estimated by method of calculation of integrated index on the basis of monitoring over the years 2013–2016.

Methodology for assessing the quality of surface water by hydrochemical parameters in accordance with the fishery standards as the most sensitive to changes of the ecological status of the river was used. The modern calculation method takes into account the effect of the total action of substances.

Self-purification potential and capability of restoration in time and space (along the river stream) of the aquatic ecosystem of the Lower Section of the Dnieper River was established. It was discovered, that the state of surface water of region was characterized as unsteady with the low of ecological reliability. Consequently, the processes of self-purification potential and capability of restoration of the aquatic ecosystem are at the low level. The ecological state of the Lower Section of the Dnieper River is characterized as an ecological regress.

Recovery of the processes which activate an ability of the Lower Section of the Dnieper River to cleanse itself is possible due to the optimization of the regime of Kakhovka HPS-1 releases and/or building Kakhovka HPS-2.

The activation of the external water exchange will unambiguously increase the intensity of the river ability to cleanse water masses, will improve the water quality in the system of the Lower Section of the Dnieper River and the ecological state of the hydroecosystem.

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