ЕКОЛОГІЧНА БЕЗПЕКА НАВКОЛИШНЬОГО СЕРЕДОВИЩА

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O. M. KRAINIUKOV[1], DSc (Geography), Associate Professor, **V. D. TIMCHENKO[2]**
[1]*V. N. Karazin, Kharkiv National University*
6 Svobody Sq., Kharkiv, 61022, Ukraine
e-mail: alkraynukov@gmail.com, https://orcid.org/0000-0002-5264-311
[2]*Research Institution «Ukrainian Scientific Research Institute of Ecological Problems»*
6 Bakulina st., Kharkiv, 61166, Ukraine

ECONOMIC CONSEQUENCES OF ANTHROPOGENIC WATER POLLUTION (BY USING PECHENIZKY RESERVOIR AS AN EXAMPLE)

Purpose. The purpose is to study and analyse up-to-date publications related to the study of pollution of water bodies by organic and inorganic substances, which deals with the correlation of fish productivity reduction due to the fodder organisms death. Based on the experimental studies results on the anthropogenic pollution impact on the livelihoods of fodder organisms, we have calculated the losses caused by water body pollution by using the indicator of bioproductivity decrease (using the Pechenizky reservoir as an example). **Methods**. To obtain data for calculating the damage caused to the Pechenizky reservoir by using the commercial fish catches indicator that use zooplankton and zoobenthos as natural feeds, we have performed toxicological study of water samples that were selected on four different hydrographic and morphological features of the Pechenizky reservoir. Biotesting of water samples was carried out by using zooplankton (*Daphnia Magna Straus*) and zoobenthos - insect larvae (*Chironomus dorsalis Meig*.) as a test-organisms for fodder organisms for fish**. Results**. The potential causes and consequences of the reduction of the natural forage base for the ichthyofauna are identified by ecological and toxicological assessment of the level of danger of the habitat of the main species of fodder organisms - zooplankton and zoobenthos representatives. The damages caused to Pechenizky reservoir by the indicator of reduction of catches of three species of fish (carp, bream, crucian carp) as a result of the fodder organisms death and the size of the damage to the Pechenizky reservoir by the indicator of reduction of catches of commodity fish (in value form) were calculated**. Conclusions.** It is shown that as a result of pollution of the reservoir, heavy metals accumulation in fodder organisms is observed and there is a chronic cumulative toxicosis, which leads to their death. In this connection, one of the main factors of reducing the catch of such species of fish as crucian carp, carp, bream and others, is the reduction of fodder organisms biomass, in particular, zooplankton and zoobenthos representatives.

Key words: water body, ecological state, water quality, biotesting, economic losses

Крайнюков О. М.[1], Тімченко В. Д.[2]
[1]*Харківський національний університет імені В.Н. Каразіна*
[2]*Науково-дослідна установа «Український науково-дослідний інститут екологічних проблем», м. Харків*

ЕКОНОМІЧНІ НАСЛІДКИ АНТРОПОГЕННОГО ЗАБРУДНЕННЯ ВОДНИХ ОБ'ЄКТІВ (НА ПРИКЛАДІ ПЕЧЕНІЗЬКОГО ВОДОСХОВИЩА)

Мета. Опрацювання сучасних праць, пов'язаних із дослідженням забруднення водних об'єктів органічними та неорганічними речовинами, в яких розглядаються питання взаємозв'язку зниження рибопродуктивності внаслідок загибелі кормових організмів. На основі результатів експериментальних досліджень впливу антропогенного забруднення на життєдіяльність кормових організмів здійснити розрахунок збитків, заподіяних водним об'єктам за показником зниження біопродуктивності на прикладі Печенізького водосховища. **Методи.** З метою отримання даних для розрахунків збитків, заподіяних Печенізькому водосховищу за показником вилову товарної риби, які використовують в якості природних кормів організми зоопланктону і зообентосу, були виконані токсикологічні дослідження проб води, що відбиралась на чотирьох різних за гідрологічними і морфологічними ознаками ділянках Печенізького водосховища. Біотестування проб води проводили з використанням в якості тест – об'єктів кормових організмів для риб – представники зоопланктону (*Daphnia Magna Straus*) та зообентосу − личинки комах (*Chironomus dorsalis Meig*.). **Результати.** Розраховано збитки, що заподіяні Печенізькому водосховищу за показником зменшення обсягів вилову трьох видів риб (короп, лящ, карась) внаслідок загибелі кормових організмів та розмір заподіяної шкоди Печенізькому водосховищу за показником зменшення обсягу вилову товарної риби (у вартісному вигляді). **Висновки.** Показано, що внаслідок забруднення водосховища спостерігається накопичення важких металів в кормових організмах та від-

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бувається хронічний кумулятивний токсикоз, що призводить до їх загибелі. У зв'язку з цим, одним із головних чинників зниження вилову таких видів риб як карась, короп, лящ та інших, є зменшення біомаси кормових організмів, зокрема, представників зоопланктону і зообентосу.

Ключові слова: водний об'єкт, екологічний стан, якість води, біотестування, економічний збиток

Крайнюков А. Н.[1], Тимченко В. Д.[2]

[1]*Харьковский национальный университет имени В.Н. Каразина,*

[2]*Научно-исследовательское учреждение «Украинский научно-исследовательский институт экологических проблем»*

ЭКОНОМИЧЕСКИЕ ПОСЛЕДСТВИЯ АНТРОПОГЕННОГО ЗАГРЯЗНЕНИЯ ВОДНЫХ ОБЪЕКТОВ (НА ПРИМЕРЕ ПЕЧЕНЕЖСКОГО ВОДОХРАНИЛИЩА)

Цель. Изучение современных работ, связанных с исследованием загрязнения водных объектов органическими и неорганическими веществами, в которых рассматриваются вопросы взаимосвязи снижение рыбопродуктивности в результате гибели кормовых организмов. На основе результатов экспериментальных исследований влияния антропогенного загрязнения на жизнедеятельность кормовых организмов осуществить расчет ущерба, причиненного водным объектам по показателю снижения биопродуктивности на примере Печенежского водохранилища. **Методы.** С целью получения данных для расчетов убытков, причиненных Печенежскому водохранилищу по показателю вылова товарной рыбы, которые используют в качестве естественных кормов организмы зоопланктона и зообентоса, были выполнены токсикологические исследования проб воды, которые отбирались на четырех разных по гидрологическим и морфологическим признакам участках Печенежского водохранилища. Биотестирование проб воды проводили с использованием в качестве тест - объектов кормовых организмов для рыб - представители зоопланктона *(Daphnia Magna Straus)* и зообентоса - личинки насекомых *(Chironomus dorsalis Meig.).* **Результаты.** Рассчитано убытки, причиненные Печенежском водохранилище по показателю уменьшения объемов вылова трех видов рыб (карп, лещ, карась) в результате гибели кормовых организмов и размер причиненного вреда Печенежскому водохранилищу по показателю уменьшения объема вылова товарной рыбы (в стоимостном выражении). **Выводы.** Показано, что в результате загрязнения водохранилища наблюдается накопление тяжелых металлов в кормовых организмах и происходит хронический кумулятивный токсикоз, что приводит к их гибели. В связи с этим, одним из главных факторов снижения вылова таких видов рыб как карась, карп, лещ и других, является уменьшение биомассы кормовых организмов, в частности, представителей зоопланктона и зообентоса.

Ключевые слова: водный объект, экологическое состояние, качество воды, биотестирования, экономический ущерб

Introduction

The reproduction of natural resources, its protection require substantial material costs, the economic and social efficiency of which must be high enough for the society to afford them. In this connection, there is the problem of the economic assessment of human impact on nature. The problem is rather multifaceted, since it includes the area of mutual penetration and the interaction of nature and society, and the methodology for evaluating the results of this interaction is not yet sufficiently developed.

Any kind of economic activity involves some harmful influence, the result of which may be changes in the adaptive-compensatory possibilities of the organism, the emergence of adverse effects on the environment. In general terms, the term "economic loss" refers to actual or potential economic and social losses, expressed in value form, arising as a result of any events or phenomena, including pollution of the environment. Ecological and economic damage is to reduce the volume of products received or profits as a result of adverse environmental impacts.

Issues of water resources is one of the urgent problems of development of the entire economy of Ukraine in the coming years. The intensification of economic activity, one of the mandatory conditions for the further development of human society, is accompanied by an unconditional increase in the anthropogenic impact on the environment. The most vulnerable part of it is the water of local runoff of small rivers, streams and reservoirs. The consequence of the high anthropogenic impact is on the one hand in the eutrophication of water bodies. It is a complex process in fresh and marine waters, where the rapid development of certain types of microalgae disrupts aquatic ecosystems and poses a threat to animals and human health. The greatest attention is paid to the study of the inflow and distribution of nutrients in the waters of local runoff, especially nitrogen and phosphorus compounds. After all, they are chemical catalysts for the process of anthropogenic eutrophication of surface waters. It is characterized by a sharp increase in the biomass of algae, higher aquatic vegetation, phytoplankton due to the receipt of nutrients of anthropogenic Genesis. As a result of biochemical decomposition of biomass in the water of rivers and reservoirs may occur from the second half of the summer, the deficiency of oxygen, accompanied by saturnine phenomena and poses a significant threat to the livelihoods of many aquatic organisms. In addition, as a result of the decomposition of plant organisms, toxic substances dangerous for aquatic organisms and for humans enter the water [1-2].

On the other hand, there is a problem of pollution of water bodies with heavy metals, which are toxic chemicals [3]. In aqueous media, metals can be present in three forms: suspended solids, colloids, and dissolved compounds. The latter are represented by free ions and soluble complex compounds with organic and inorganic ligands. Hydrolysis has a great influence on the content of these elements in water, which determines the form of the element in aqueous media. A significant part of heavy metals is transported by surface waters in suspended state. Many metals form quite strong complexes with organic matter, these complexes are one of the most important forms of migration of elements in natural waters. The majority of organic complexes are formed by the chemical principle and are quite stable. The complexes formed by soil acids with salts of iron, aluminum, titanium, uranium, vanadium, copper, molybdenum and other heavy metals are relatively well soluble in neutral, weakly acidic and weakly alkaline media. Therefore, organometallic complexes are able to migrate in natural waters over very long distances.

Thus, chelated forms of Cu, Cd, Hg are less toxic than free ions. To understand the factors that regulate the concentration of metal in wastewater and surface waters, their chemical reactivity, bioavailability and toxicity, it is necessary to know not only the content, but also the proportion of bound and free forms of metals [4].

Accumulation of organic matter is one of the biggest problems of artificial reservoirs. In balanced ecosystems, organic residues decompose to simple inorganic compounds that serve as fertilizer for aquatic higher plants. If oxygen is not enough, the decomposition of organic matter is accompanied by the release of toxic compounds, in particular, hydrogen sulfide and ammonia. Due to the slowdown in the flow of water, an excessive amount of organic matter and nutrients, there is an increased development of blue-green algae, which lead to the flowering of water and siltation of certain areas of the reservoir. The annual flowering of water causes a steady increase in eutrophication of water bodies. Blue-green algae impede water supply, clogging filters and actually stopping water treatment and industrial water intakes. The decrease in the flow rate causes an increase in the scale of the phenomenon of water flowering [5]. In fish farms, especially the industrial type, with a high density of fish landing eutrophication can be caused by the accumulation of phosphorous and nitrogen compounds, excretory fish. In addition, in pond farms eutrophication is created purposefully by applying mineral fertilizers to increase the amount of phytoplankton, which is a significant part of the fish feed base. The quantitative relationship between nutrient loads and trophic status of fishery water bodies is as follows: nitrogen compounds are supplied mainly by feed and fertilizers – 76%, while feed accounts for 44%. Phosphorus with feed and fertilizers in the pond gets 81%, and with river runoff in the period of water filling – only 5%. In bottom sediments of fish farming ponds accumulated annually to 4 – 7 tonnes of total nitrogen and 3 to 5 tons of total phosphorus. Nutrient load varies depending on the category of ponds to nitrogen in the range of 21 – 30 of 87 g/m^2 , to phosphorus of 7 – 9 g/m^2 . For reservoirs, the biogenic load is much lower-12 g / m^2 for nitrogen and 1 g/m^2 for phosphorus. In the process of growing commercial fish, water receives 0.25 tons of nitrogen, 0.07 tons of phosphorus and 0.35 tons of organic carbon from each ton of fish [6].

In reservoirs of drinking water supply for the purpose of realization of their potential often apply a biological method of cleaning. The scheme of biological reclamation of water bodies includes actions aimed at minimizing the impact of pollutants, improving sanitary conditions, preventing the "flowering" of water, the removal of biomass of higher aquatic vegetation and, finally, catching fish and other aquatic organisms. In this case, fish is considered not only as an object of commercial or Amateur fishing, but as a component of the ecosystem, which contributes to the removal of primary products from the reservoir, which is transformed into ixtiomas, now biomeliorative work makes it possible to obtain valuable fish products, which is environmentally and economically feasible [5,7].

With regard to the influence of heavy metals on the water ecosystem, this problem is devoted to numerous scientific works [8-12]. In particular, in [13], concentration of As, Cd, Cr, Co, Cu, Ni, Pb and Zn in samples of water and bottom sediments from the Trepa and Sitnitsa rivers was determined in order to determine the level of pollution of water bodies. In water of water objects, the exceedance of regulatory requirements was recorded for the following chemical elements - As, Cd, Pb and Zn, which is primarily due to the discharge of sewage from the mining industry. The assessment of sediment contamination was carried out using pollution indicators, such as the pollution factor, the degree of pollution, the degree of pollution, the load index. The results of experiments showed that the level of concentration of heavy metals in all investigated areas exceeded the background values and recommendations for the quality of bottom sediments. Average concentrations of heavy metals in the bottom sediments of the Trepa and Sitnica rivers showed the following tendency to accumulate Cd> As> Pb> Zn> Cu> Co> Cr> Ni.

The authors of the study [14] determined the concentration of heavy metals (Cd, Cr, Cu, Pb and Zn) in water, bottom sediments and tissues (muscle and grass) of Leuciscus cephalus from the Dipsis River (southwestern part of Turkey). The study did not find correlations between the concentrations of metals in water and bottom sediments and between the concentrations of metals in water, muscles and grasses L. cephalous, but a positive correlation was found between concentrations of Cu and Zn in the bottom sediments and fish tissue.

The paper [15] presented the results of research on the water of the water body and bottom sediments from the 20 streams of the Burigang River (Bangladesh) in the summer and winter of 2009. It was found that the concentration of total Cr, Pb, Cd, Zn, Cu, Ni, Co and As in water samples significantly exceeded the toxicity benchmarks in both seasons. The concentrations of Cr, Pb, Cu and Ni in bottom sediment samples were generally higher than the normalized value at which bottom sediments are considered to be heavily contaminated.

The study of the influence of heavy metal pollution (Cr, Cu, Pb, Cd) in the Salado river basin (Argentina) on the zooplankton community was carried out in [16]. Total density, density by groups *(Copepoda, Cladocera and Rotifera)*, density of micro - and meso-plankton, biomass, number of species and species diversity were studied. The results showed that the total density of zooplankton was significantly higher along the river than in the channels and ducts, where there was a higher concentration of heavy metals (2-3 times) compared to the city of Salado. The results of this study show that zooplankton reacts to changes in water quality, which is an effective tool for assessing heavy metal contamination of water bodies.

The formation of technogenic deposits is caused by changes in the conditions of formation of solid runoff. It is technogenic bottom sediments that are the concentrators of the bulk of pollutants of water systems, which not only dissolve in water, but also partially inactivated, interacting with each other (neutralization, complexation and other reactions), or form new compounds, more toxic than the original ones. The accumulation of trace elements in the bottom sediments is an indicator of the ecological status of the water system. The problem of accumulation of heavy metals is directly proportional to the problem of surface water pollution by heavy metals [17].

The toxicity of Hg, Cd and Cu ions for both marine and freshwater species is significantly higher than that of Pb and Zn ions. Sharp fluctuations of abiotic factors of the aquatic environment (temperature, pH, salinity, etc.) affect the functional status of the representatives of aquatic ecosystems and the concentration of water-soluble forms of metals, change, and toxicitytesting crustaceans. With an increase in the temperature of solutions for every 5 °C, the LC50 value of Cd, Cu, Pb and Zn ions usually increase from 2 to 100 times, and the maximum for Cd in the elevated temperature range.

Comparison of the calculated values of lethal concentrations of heavy metal ions with the content of their dissolved forms in the waters of contaminated waters suggests that certain concentrations of many metals can cause depletion of the species composition of crustaceans, cause death of young people in the early stages of development, especially with sharp fluctuations in the values of abiotic factors [18,19].

Resistance of animals to heavy metals depends on their ecological niche and size or body weight. For 90% of the considered species of marine zooplankton and benthos, the value of cadmium LC50 in acute experiments was 15.0 and 23.0 μg/l, respectively [20]. However, it should be taken into account that the minimum values of LC50 of this metal are determined for small larvae of natural shrimp *Palaemonetes pugio*. Consequently, the resistance of animals to the action of heavy metals is determined primarily by environmental, morphological and physiological characteristics, rather than the systematic position of the species. Features of biochemical and physiological processes, small size of larvae and, consequently, a large specific surface area of the body, a significant number of critical periods of development increase their vulnerability to toxicants [19].

Thus, it is possible to assume that the excess content of heavy metals and other inorganic and organic compounds leads to deterioration of water quality of water bodies and, as a consequence, to a decrease in fish productivity, as a result of the death of forage organisms (zooplankton and zoobenthos).

The purpose of this work is based on the results of experimental studies of the influence of anthropogenic pollution on the livelihoods of food organisms to carry out the calculation of losses caused to water bodies by the reduction of bio-productivity on the example of the Pechenezhsky reservoir.

Research methods

Integrated water reservoirs, in particular, water reservoirs, are among the water objects of fishery management, along with other ones, which have their own specifics, concerning the need to preserve the quality of water within the requirements of water users and the functioning of biocenoses with a relatively limited species composition.

In this regard, within the framework of the study, the economic consequences of anthropogenic pollution of water bodies were assessed by calculating the damage caused to water bodies by the indicator of reduction of fish productivity due to the death of fodder organisms − representatives of zooplankton (crustacean daphnia) and zoobenthos (insect larvae) .

According to the «Methodology for estimating the damage from the consequences of natural and man-made emergencies» (closed by the Ministry of Ecology and Natural Resources of Ukraine No. 196 dated June 9, 2011) [21] the calculation of losses incurred to the fish industry is carried out in kind (the weight of lost fish resources), as well as in terms of value, which is calculated taking into account the prices for certain types of commodity fish for a given region.

In order to solve the problem of estimating the economic consequences of anthropogenic pollution of water bodies, the most appropriate methodological approach is used to calculate the losses caused to the fish industry due to the reduction of the natural forage base for the ihtiofauna, the criterion for reducing fish productivity.

In order to obtain the data necessary for calculating the amount of damages caused to the fish industry due to the death of fodder organisms in aquatic ecosystems, experimental studies were carried out to determine the acute lethal toxicity of water and bottom sediments samples taken in control structures of water objects. Biotesting of water samples was carried out using zooplankton (*Daphnia Magna Straus*) and zoobenthos (insect larvae (*Chironomus dorsalis Meig*.) According to the techniques [22, 23] as test objects of fish forage).

Results and discussion

Pechenizky reservoir is located on the river Siversky Donets for 880 km. from its mouth between Pechenigy and the city of Vovchansk in the Kharkiv region. The type of reservoir - the channel, the area of the water mirror - is 86.0 km^2, the volume of water mass reaches 383 million m^3. Length of reservoir 65 km; the maximum width is 4 km, the maximum depth is 20 m in the gravel section. It is used for industrial, municipal agricultural water supply, fish farming and recreation. According to the main indicators of the state of the natural forage base, the reservoir refers to the average productive reservoirs. The annual catch of commodity fish in Pechenizky reservoir is 380-560 tons. The species composition of the industrial ichthyofauna includes aboriginal species (pike, pike perch, perch, carp, crucian carp, etc.) and the species «allies» − papilla and white amur.

The main source of contamination to the reservoir is the flat flush from the territory of the catchment area. As a result of pollution of the reservoir, there is an excess of fishmeal MPC of heavy metals (iron, zinc, lead, cadmium, copper), which are toxic chemicals [24]. In the process of accumulation of heavy metals in fodder organisms there is a chronic cumulative toxicosis, which leads to their death. In this connection, one of the main factors of reducing the catch of such species of fish as crucian carp, carp, bream and others, is the reduction of biomass of fodder organisms, in particular, representatives of zooplankton and zoobenthos.

In order to obtain data for calculating the damage caused to the Pechenizky reservoir by the indicator of commercial fish catch, which uses natural zoo organisms as zooplankton and zoobenthos, toxicological studies were carried out on water samples that were selected on four different hydrographic and morphological features of the Pechenizky reservoir.

In fig. the locations of the sampling points of water within the four sections of the Pechenizky reservoir, which were selected in the summer of 2018, are shown.

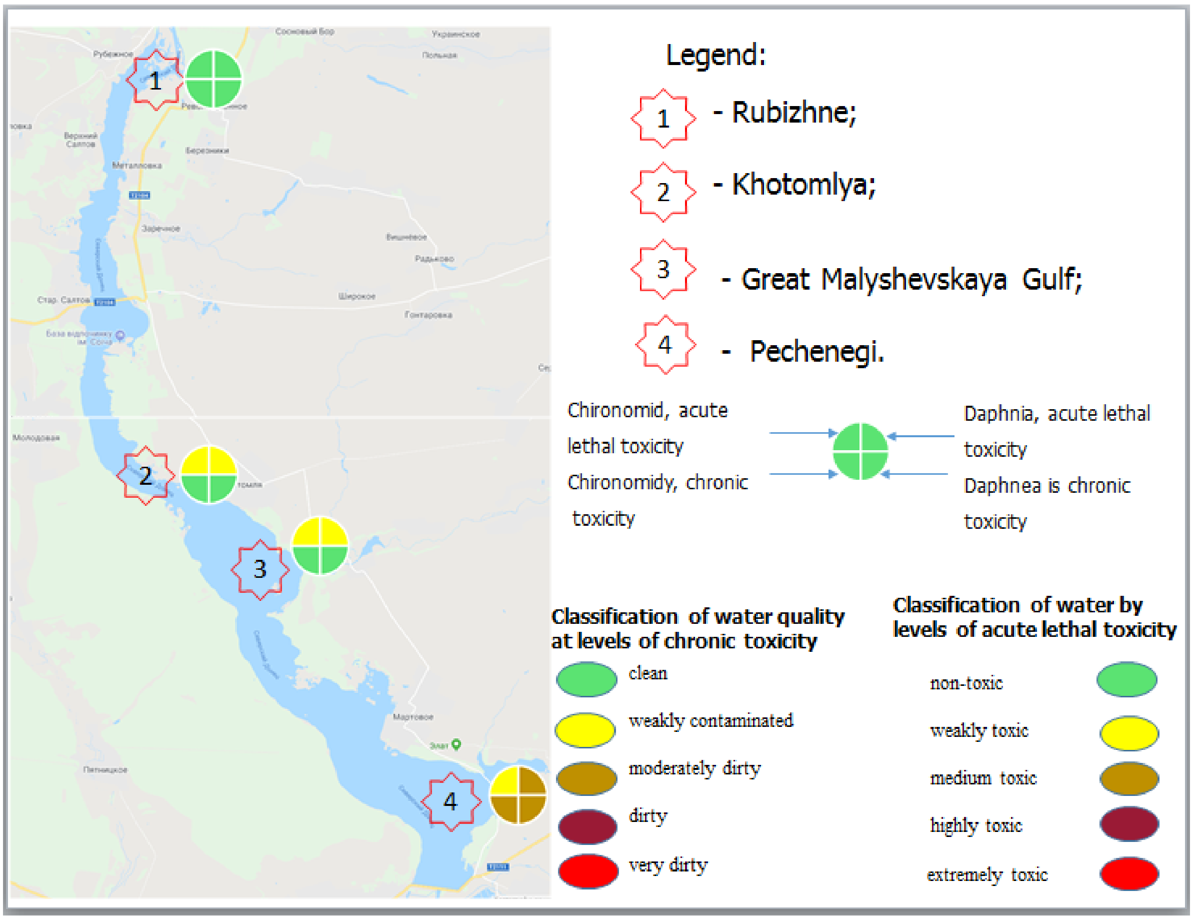

Fig. − Placements of surface water sampling sites and the results of the determination of their acute lethal and chronic toxicity

Water samples were taken by a rod batometer at various depths, taking into account the characteristics of the test habitat environment: in order to determine the toxicity of water using planktonic organisms (daphnia), the water samples were averaged after the selection of three samples (50 cm from the surface, at the depths of several meters and in the bottom layer of water); To determine the toxicity of water on insect larvae, biotesting was subjected to sampling, selected from the bottom of the water layer.

In water samples, acute lethal and chronic toxicity was determined using testosterone daphnia and insect larvae of the hironomid as test objects.

The results of biotesting of water samples using test daphnia and insect larvae, selected within the four sections of the reservoir as a test, showed the following.

Water samples taken within the first section (1), which is a slightly enlarged riverbed of the Siv. Donets with a prominent flow turned out to be non-toxic for the used test objects.

Water samples, which were selected within the middle shallow water section of the reservoir (2.3), had a severe lethal toxic effect on the test objects and belonged to grade II - water is weakly toxic (for daphnia and insect larvae).

The lower part of the catchment area of the reservoir is considerably expanded by flooding the wide floodplain of the river Siv. Donets with almost complete absence of the current. It is the lower part of the reservoir subject to significant anthropogenic stress. Confirmation of this can be the results of biotesting of water samples, which belonged to the third class of toxicity (water average toxic) for both representatives of fodder organisms.

In order to calculate the damage caused to Pechenizky reservoir as a result of its man-made pollution and the death of fodder organisms for fish, data (tabl.) For 2016 were used in connection with the fact that the fish was fished in 2016 was larger (15.63 tons) compared from 2017 year (12,312).

Table

Data from the Pechenizky Fish Market regarding fish catch in 2016 and 2017

Year	Name of the water object	Area	Breeding facilities					Invisible species of fish						Total	
			Carp	Vegetable	Mussels	Pilengas	Other types	Crucian	Lazy	Tile / roach	Redhead	Spit	Other types	Plan	Fact
2016	Pechenizky reservoir		0,7	11,7	0	0	0	1,56	1,67	0	0	0	-	348,7	15,63
2017		8620	0	7,194	0	0	0	1,219	1,304	0	0	0	2,595	422,7	12,312

In 2016, the catches of the main species of fish (carp, straw, crucian carp), which are used as natural feed by zooplankton and zoobenthos organisms, amounted to 3930 kg, including carp − 700 kg, bream − 1670 kg, carp - 1560 kg. The total monetary value of the specified types of fish at current retail prices is UAH 104 290.

The calculation of losses caused to Pechenizky reservoir by the indicator of reduction of catches of three species of fish (carp, bream, crucian carp) as a result of the death of fodder organisms was carried out for the lower most contaminated section of the reservoir (Martovo − Pechenegi), the area of which is 25,000 m^2 (using the formulas used for calculation of damages caused by river systems):

$$N_1 = [S * H * П * P/B * K_1 * 10^{-6}/[100 * K_2], \quad (1)$$

$$N_2 = [S * П * P/B * K_1 * 10^{-6})]/[100 * K_2], \quad (2)$$

where: N_1,N_2 − losses in natural terms, tons; S − area of damage, sq. meters; H − depth of the reservoir, m; P − average concentration of fodder organisms, g / cu. meter (for plankton) and grams / sq. meter (for benthos); R / B − coefficient of transfer of biomass of fodder organisms into products; K_1 − indicator of the maximum possible use of fish feed, percent; K_2 − feed rate for the transfer of fodder products to fish products; 10^{-6} – conversion factor of grams per ton.

Thus, the damage caused to Pechenizky reservoir by the indicator of the reduction of catches of fish with a shortage of natural forages − zooplankton (N_1) is 63300 kg, zoobenthos (N_2) − 6300 kg.

The size of the damage caused to the Pechenizky reservoir by the indicator of reduction of the catch of commercial fish (in value form) was calculated by the formula:

$$N_{uan} = N \times G, \quad (3)$$

where: N_{uan} – monetary amount of losses (UAH); N − volume of fishing of fish products (kg); G − cost of production (for 1 kg) at current retail market prices at the time of calculating the amount of damage caused (UAH)

According to the preliminary calculation N_1 = 63300 кг, N_2 = 6300 кг.

Distribution by species of the volume of losses in kind and in value:

N_{1uan} = 1 687 747 UAH N_{2uan} = 167 182 UAH.

Thus, the amount of monetary losses inflicted on Pechenizky reservoir by the indicator of the reduction of catches of three fish species (carp, bream, crucian carp) due to a shortage of natural forages is UAH 1,854,929.

Conclusions

As a result of the study, probable causes and consequences of the actual reduction of the natural forage base for the ichthyofauna were determined by ecological and toxicological assessment of the level of danger of the habitat of the main species of forage organisms − representatives of zooplankton and zoobenthos. The economic damage caused to Pechenizky reservoir by the indicator of the reduction of catches of fish with a deficit of natural forage - zooplankton (N1) is 63300 kg, zoobenthos (N2) − 6300 kg, and the amount of monetary losses inflicted on Pechenizky reservoir on the indicator of the reduction of catches of three species of fish (carp, bream , crucian carp) due to a shortage of natural forages is UAH 1 854 929. The proposed method for determining the actual reduction of the natural forage base for the ichthyofauna by means of ecotoxicological assessment of the level of danger of the habitat of the main species of fodder organisms of the representatives of zooplankton and zoobenthos is the latest and generally used in environmental protection practice for the first time.

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