Chapter 16

FORECAST OF CHANGES IN ALGOCENOSES RICHNESS OF THE DNIEPER FLOODPLAIN AFTER THE KAKHOVKA HEPS DAM DESTRUCTION IN THE CONTEXT OF FOOD SECURITY IN SOUTHERN UKRAINE

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DOI https://doi.org/10.30525/978-9934-26-480-1-16

INTRODUCTION

The destruction of the Kakhovka HEPS dam, which occurred in June 2023, led to a complete change in the conditions of existence of all without exception the hydrobionts of the Dnieper-Buh mouth region, which is a unique and the largest freshwater ecosystem in the South of Ukraine. After this technogenic disaster, the hydrological, hydrochemical and hydrobiological modes of water ecosystems functioning in the region completely changed. The negative consequences of such changes threatened the existence of the most productive agro-industrial region of Ukraine[1, 2, 3]. The existing fish breeding and breeding plants, which are located in the territory of the Kherson region, do not work after the destruction of the Kakhovka HEPS dam, which also creates a significant resource deficit in the country's fishing industry. Considering this, we believe that the only way to preserve the resource potential of the largest freshwater ecosystem in the South of Ukraine is to reproduce the potential of natural water areas and their high biological diversity.

[1] Korzhov Ye. I. Changes in the key hydrological factors of the lower reaches of the dnieper water ecosystems functioning after the Kakhovka hydroelectric power station dam was destroyed / G. Datsenko, E. Golovnina, E. Jorovlea at al. / *Erbe der europäischen Wissenschaft: Wirtschaft, Management und Marketing, Tourismus, Medizin, Biologie und Ökologie, Landwirtschaft*. Monografische Reihe «Europäische Wissenschaft». Buch 27. Teil 4. 2024. Pp. 102–113.

[2] Korzhov Ye. I. Changes in the main hydrophysical properties of the lower Dnieper section water masses due to the destruction of the Kakhovka HEPS. The 7th International scientific and practical conference «*Science and society: modern trends in a changing world*» (June 10–12, 2024) MDPC Publishing, Vienna, Austria. 2024. Pp. 251–257.

[3] Korzhov Ye. I. Aspects of disruption of the lower Dnieper section floodplain network external water exchange after Kakhovka dam destruction. The 10th International scientific and practical conference «*Topical aspects of modern scientific research*» (June 13–15, 2024) CPN Publishing Group, Tokyo, Japan. 2024. Pp. 243–249.

The purpose of our work was to determine the main patterns of algocenoses formation in the Dnieper floodplain, as the primary trophic link of its water ecosystem, and to determine their possible changes caused by the destruction of the Kakhovka HEPS dam.

For the study, we selected one typical waters of the Dnieper floodplain from three main classes of lakes ranked by the intensity of external water exchange, which is a characteristic of the rate of all water change in the lake to new water and is measured in days (Table 1).

Table 1

Classification of typical floodplain waters of the Lower Dnieper according to the intensity of external water exchange

The intensity of external water exchange	Typical waters of the class	Period of external water exchange, days	Average current speed, m/s
I. Fast	Sabetskiy Liman, Frolovo, Kaznachyivskiy Liman,	> 3	< 0,30
II. Moderate	Krugle, Glukhiy Liman, Bile, Golubov Liman, Steblyivskiy Liman, Kardashynskiy Liman, Krasniukove, Zolote, Didove	3–15	0,30–0,01
III. Slow	Zakytne, Nazarovo-Pohorile, Oleksiyvskiy Liman	< 15	> 0,01

Among the lakes with fast external water exchange, the Sabetskiy Liman was chosen for research with an average long-term value of the water exchange period of 2.5 days. Among the water bodies with a moderate water exchange, the research was carried out on the Krugle lake with a rate of water masses change of 7.9 days. From the lakes with slow water exchange, we chose a typical water of the floodplain type – Zakytne lake with an external water exchange period of 23.1 days[4].

Algological samples with a volume of 0.5 dm^3 were taken with a Rutner bathometer, fixed with 40% formaldehyde, settled, thickened by the sedimentation method (up to 20 ml) and processed using methods generally accepted in hydrobiology and algology[5, 6]. Water samples were taken once a season during the warm period of 2015–2021; the total number is 63 natural samples.

[4] Коржов Є. І. Зовнішній водообмін руслової та озерної систем пониззя Дніпра в сучасний період. *Гідрологія, гідрохімія і гідроекологія*. К. : Обрії, 2013. Том 2(29). С. 37–45.

[5] Методи гідроекологічних досліджень поверхневих вод / О. М. Арсан, О. А. Давидов, Т. М. Дьяченко та ін. ; за ред. Романенко В. Д. К. : ЛОГОС, 2006. 108 с.

[6] Wasser S.P., Tsarenko P.M. Diversity of algae of Ukraine. *Algologiya* 10 (4), 2000. Pp. 3–309.

1. Analysis of species diversity of the Lower Dnieper floodplain algal flora and factors of its formation

The resource value of algal flora of surface waters lies in the fact that it is one of the main natural primary producers of organic nutrients, which serves as food for organisms at higher levels of the trophic chain, such as zooplankton, ichthyofauna, and others. It is also a biological indicator of pollution and disruption of internal ecological processes in water bodies. The essential role of algal flora in the trophic relationships of plankton, photosynthetic aeration of the water column, water quality formation, etc.

During the period of research on the flora of algae in the lakes of the Dnieper floodplain[7] , there were 207 species represented by 242 intra-species taxa (further – ist) from 9 divisions, which belonged to 13 classes, 22 orders and 87 genera. The basis of phytoplankton species richness was formed by algae of three divisions: Bacillariophyta (35%), Chlorophyta (27%), Cyanoprokaryota (19%), they account for 81% of the total list of lowest-ranking taxa. The taxonomic diversity of Euglenophyta is much less (8%), and the minimum share in the list of algae belonged to Cryptophyta, Chrysophyta, Xanthophyta and Streptophyta (from 1 to 4%, a total – 11%).

The leading role in the formation of algocenoses belonged to the Fragilariophyceae – 74 ist (30% of the total number of species), Chlorophyceae – 42 ist (17%) and Hormogoniophyceae – 27 ist (11%). At the level of orders, Sphaeropleales (30 ist), Fragilariales (28 ist), Euglenales (18 species), Chroococcales, Oscillatoriales (17 ist each), Chlorellales (16 ist) were distinguished by species richness, which made up 52% of the species diversity of phytoplankton. When ranking the genus composition of algae in three lakes, 13 leading genera in terms of taxonomic significance were identified: *Oscillatoria* Vauch. (12 species), *Synedra* Ehr. (8 ist), *Microcystis* (Kütz.) Elenkin, *Cyclotella* Kütz., *Cymbella* Ag., *Fragilaria* Lingb. (по 7 ist), *Gloeocapsa* Kütz., *Navicula* Bory, (6 ist), *Euglena* Ehr., *Amphora* Ehr., *Nitzschia* Hass., *Desmodesmus* (Chodat) An et al., *Closterium* Nitzsch. (по 5 ist), a total of 14% of the species richness of phytoplankton.

The species composition of algae is an indicator of the conditions of existence of algocenoses, which reflects the peculiarities of genesis, structure, anthropogenic influence and the level of water bodies productivity. The distribution of algae according to the taxonomic categories of the highest rank reflects the conditions in which algocenoses were formed in various types of Lower Dnieper lakes (Fig. 1).

[7] Коржов Є. І., Пуленко Ю. В. Термінологічні особливості географічних назв елементів гідрографічної мережі нижньої течії річок. *Topical issues of modern science, society and education.* Proceedings of the 1st International scientific and practical conference (August 8-10, 2021). Kharkiv, Ukraine: SPC–Sci-conf.com.ua, 2021. P. 325–331.

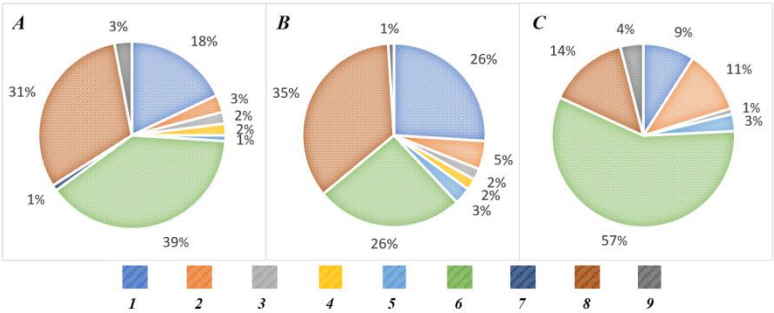

Fig. 1. Floristic spectrum of plankton algae in typical lakes of the Lower Dnieper:

A – Sabetskiy Liman, *B* – Krugle, *C* – Zakytne.
Algae divisions: *1* – Cyanoprokaryota, *2* – Euglenophyta, *3* – Dinophyta, *4* – Cryptophyta, *5* – Chrysophyta, *6* – Bacillariophyta, *7* – Xanthophyta, *8* – Chlorophyta, *9* – Streptophyta

The species richness of plant plankton in the studied typical lakes consisted of algae of 7–9 divisions. The most common among them were representatives of the Bacillariophyta department – in different lakes from 26 to 57% of the taxonomic composition of algae, Chlorophyta – from 14 to 35%, Cyanoprokaryota – from 9 to 26%, Euglenophyta – from 3 to 11%, Streptophyta – 1–4%, Chrysophyta – 1–3%, Dinophyta – 1–2%; representatives of the Cryptophyta division were found in Krugle and the Sabetskiy Liman lakes, in which they formed 2% of the species richness of algae, the Xanthophyta division – 1% in the Sabetskiy Liman.

The most diverse flora of algae was in Krugle Lake, which was formed under conditions of moderate water exchange and good flow. In waters of this type, a balance of organic substances that are produced in the reservoir and come from the outside, which creates conditions for the active development of microflora, is created that is favorable for aquatic ecosystems[8, 9]. Here we discovered 113 species of algae (124 varieties and forms, including those containing the nomenclature type of the species, ist) from 8 divisions. The basis of the species richness were representatives of the Chlorophyta division, which made up 35% of the floristic spectrum, Cyanoprokaryota and Bacillariophyta – 26% each. Algae of other departments formed only 13% of the species richness (see Fig. 1 *B*).

[8] Korzhov Ye. I., Kucheriava A. M. Peculiarities of External Water Exchange Impact on Hydrochemical Regime of the Floodland Water Bodies of the Lower Dnieper Section. *Hydrobiological Journal* – Begell House (United States). Vol. 54, Issue 6, 2018. P. 104–113.

[9] Коржов Є. І., Мінаєва Г. М. Вплив режиму течій на кількісні показники фітопланктону мілководних водойм пониззя Дніпра. *Гідрологія, гідрохімія і гідроекологія*. К. : Обрії, 2014. Том 2(33). С. 61–65.

The second rank in terms of species richness of algae was occupied by the Sabetskiy Liman Lake, in which 93 species (101 ist) from 9 divisions were found in the plankton. The most widespread are Bacillariophyta (39% of the total number of species found in the lake), Chlorophyta (31%) and Cyanoprokaryota (18%), the remaining divisions in the formation of the species richness of phytoplankton accounted for 1–3% (see Fig. 1 *A*). Fluctuations in the water level and intensive water exchange in the lake contributed to the development of diatom flora adapted to the turbulent conditions of the water flow and to some extent inhibited the development of limnophilic flora, primarily cyanide.

The poorest in terms of taxonomic diversity among the studied lakes was Zakytne Lake, in which 89 species (97 ist) from 7 divisions were identified. The number of species was dominated by Bacillariophyta (57%); Chlorophyta (14%), Euglenophyta (12%), Cyanoprokaryota (9%) are represented by a much smaller number. The rest of the departments accounted for 8% of the species composition (see Fig. 1 *C*). The dominance of diatom flora in a lake with a slow water exchange is due to the ingress of epiphytic algae into the water column, which developed massively in the growth of higher aquatic vegetation, which covered almost the entire area of the water mirror from April to October, significantly slowed down the flow and contributed to the formation of large stagnant zones with a deficit oxygen and accumulation of organic substances[10, 11, 12, 13]. In the structure of phytoplankton, the share of euglena algae compared to other water bodies was the largest (11%), among them aquatic vegetation with floating leaves significantly reduced the pervasion of light into the water column and negatively affected the development of green and blue-green algae.

A different combination of morphometric, hydrological and hydrochemical characteristics of the studied water bodies largely determined the specifics of the composition and structure of the dominant complex in different types of lakes. According to the gradient of the frequency of occurrence in Krugle Lake, the complex included 23 dominant species, diatoms and green algae are

[10] Коржов Є. І., Кучерява А. М. Особливості впливу зовнішнього водообміну на гідрохімічний режим заплавних водойм пониззя Дніпра. *Гідробіол. журн*. 54, № 4. 2018. С. 112–120.

[11] Науково-практичні рекомендації щодо покращення екологічного стану слабопроточних водойм пониззя Дніпра / С. В. Овечко, Є. І. Коржов, В. Л. Гільман. Херсон, 2015. 28 с.

[12] Кучерява А. М., Коржов Є. І. Формування кількісних показників бактеріопланктону заплавних водойм пониззя Дніпра з різною інтенсивністю зовнішнього водообміну. *Наукові читання, присвячені Дню науки. Екологічні дослідження Дніпровсько-Бузького регіону*. Вип. 12. Збірник наукових праць. Херсон, 2019. С. 33–40.

[13] Мінаєва Г. М., Коржов Є. І. Формування кількісних показників фітопланктону заплавних водойм гирлової ділянки Дніпра з різною інтенсивністю зовнішнього водообміну. *Наукові читання, присвячені Дню науки. Екологічні дослідження Дніпровсько-Бузького регіону*. Вип. 12. Збірник наукових праць. Херсон, 2019. С. 13–27.

represented almost equally (39% and 35%, respectively), blue-green algae co-dominated with them (26%). In the Sabetskiy Liman Lake, 20 dominant species of algae were identified, diatoms predominated (48%), green and blue-green algae were less abundant (28% and 19%, respectively). In the Zakytne Lake complex of dominant species is represented by the smallest number of taxa of the rank below the genus compared to other studied waters: only 11 dominant species were found, which belonged to three divisions, 82% of them were diatoms, the rest – green and blue-green algae.

According to the floristic diversity and composition of the dominant complex, the phytoplankton of the water body is characterized as green-diatom-blue-green in Krugle Lake, diatom-green with a noticeable share of blue-green algae in the Sabetskiy Liman Lake, and diatom in Zakytne Lake; the uniformity of the organization of the algal community in the lake is due to extreme conditions associated with slow water exchange as a result of the survival of a relatively small number of tolerant forms and is a sign of a depressed state of algocenosis.

In the studied lakes, 17 species of algae, the most significant in the formation of plant communities, were identified, the frequency of which exceeded 40%: *Desmodesmus communis* (Hegew.) Hegew. (83%), *Hyaloraphidium contortum* (Thur.) Komark.-Legn. (71%), *Stephanodiscus hantzschii* (Hust.) et Stoermes (67%), *Oscillatoria amphibia* Ag., *Cocconeis placentula* Ehrb., *Chlamydomonas monadina* Stein (53%), *Cyclotella meneghiniana* Kütz., *Stephanodiscus binderanus* (Kütz.) Krieg, *Synedra acus* Kütz., F*ragilariforma. virescens* (Ralfs) Will. et Round, *Cymbella tumidula* Grun. in A. Schmidt, *Amphora ovalis* (Kütz.) (47%), *Microcystis pulverea* (Wood.) Forti emend. Elenk., *Oscillatoria limnetica* Lemm., *O. planctonica* Wołosz., *Anabaena flos-aquae* Breb, *Anabaenopsis raciborskii* Wołosz (41%).

A comparison of the flora of algae found in the investigated lakes of the Dnieper floodplain showed a low level of commonality between them. The coefficient of floristic community was in the range of 0.27–0.38 and indicated a significant difference in the conditions in which algocenoses were formed. The taxonomic structure of algae at the species level in Zakytne Lake was equally strongly different from that in the other two lakes (coefficients of floristic commonality – 0.27 and 0.28, respectively). Common to all investigated water areas were 18 species, varieties and forms, most of which were diatoms – 16 ist (68%); green and blue-green, respectively, 3 (16%) and 2 species (6%).

It can be seen from the species richness assessment data of typical floodplains of the Lower Dnieper that the intensity of external water exchange directly affects the ratio of algae of different biotope affiliations. Thus, in the Sabetskiy Liman Lake, due to intensive mixing of water masses and intensive water exchange processes, planktonic (28 ist, 36%), planktonic-benthic and

benthic organisms (25 ist, 32% each) in the water column were present in almost equal quantities. Krugle Lake was dominated by planktonic-benthic species (44 ist, 47%) and planktonic algae (35 ist, 38%), benthic species – 14 ist, (15%). In Zakytne Lake, planktonic-benthic organisms (32 ist, 42%) and benthic organisms (29 ist, 38%) predominated, while plankton inhabitants are represented by a small group – 15 ist (20%).

In the samples taken from the lakes during the research period, from 11 to 53 species, varieties and forms of algae were counted. A low level of saturation of samples with species, respectively 24 and 28 ist, was noted in the Sabetskiy Liman and Zakytne lakes; minimum in spring and autumn (11–21 ist), maximum – in summer (39–42 ist). The specific species richness in Krugle Lake averaged 35 ist (in different seasons of the year 14–53 ist). In the lakes of the Lower Dnieper, which are characterized by «water bloom» in the summer-autumn period, in recent years there has been a tendency to increase the number of species in samples from spring (21 ist on average) to summer (39 ist) and autumn (45 ist). In autumn, 1.5–2 times more algae were identified than in summer, which we attribute to the increase in the duration of the autumn growing season as a regional effect of global warming[14, 15, 16].

In addition, under the maximum values of solar radiation, the maximum of which in the research region falls in August, the species richness of phytoplankton decreases, which is mainly associated with the photoinhibition of most species of algae of the Bacillariophyta and Chlorophyta divisions and the ability of Cyanoprokaryota to actively develop under high light intensity. In October, after the death of the main mass of causative agents of water "bloom", blue-green algae continued to grow and diatoms actively developed. The number of algae found in the samples increased due to the representatives of the *Aulacoseira*, *Cyclotella*, *Synedra* genera and green algae, among which the *Desmodesmus* genera stood out due to its diversity of species, varieties and forms.

[14] Rudik V. A., Korzhov Ye. I. Dynamics of climatic predictors of a possible invasion of epidemiologically dangerous blood-sucking mosquitoes (Diptera: Culicidae) into North-Western Black Sea Coast areas. *Biological sciences and education in the context of European integration*: Scientific monograph. Riga, Latvia : «Baltija Publishing», 2024. Pp. 63–80. DOI: https://doi.org/10.30525/978-9934-26-443-6-4.

[15] Білик Г. В., Коржов Є. І. Огляд основних аспектів впливу кліматичних змін на сучасний стан іхтіофауни Дніпровсько-Бузької гирлової області. *Наукові читання, присвячені Дню науки. Екологічні дослідження Дніпровсько-Бузького регіону*. Вип. 12. Збірник наукових праць. Херсон, 2019. С. 3–10.

[16] Kutishchev P. S., Korzhov Ye. I., Honcharova O. V. Retrospective analysis and forecast of the main abiotic factors of the environmental conditions of ichtyofauna of the Dnipro-Buh estuary ecosystem. *Topical issues of the development of veterinary medicine and breeding technologies*: Scientific monograph. Riga, Latvia: «Baltija Publishing», 2022. Pp. 476–497. DOI: https://doi.org/10.30525/978-9934-26-258-6-14.

2. Distribution of quantitative indicators of algal flora in the Dnieper floodplain lakes with different intensity of water exchange

Indicators of the quantitative development of algal flora in the Lower Dnieper floodplain lakes during the observation period fluctuated in a wide range: number – from 0.2 to 99.6 million cells/dm^3 (on average during the research 9.6 million cells/dm^3), biomass – from 0.107 to 17.213 mg/dm^3 (2.317 mg/dm^3). In the seasonal aspect, there was an increase in the number and biomass of algae in the floodplain lakes from spring to summer and a decrease in autumn: number – from 2.1 to 21.0 and up to 5.5 million cells/dm^3, biomass - from 0.419 to 4.394 and up to 2.138 mg/dm^3.

Among the studied water bodies, lakes with a low and high level of microflora development stood out. The Sabetskiy Liman and Zakytne lakes were distinguished by low indicators: the number of phytoplankton in them was on average 2.9 and 0.8 million cells/dm^3, biomass – 0.759 and 0.684 mg/dm^3, respectively. The change in the interseasonal quantitative indicators of phytoplankton occurred in a narrow range: numbers – 0.5–5.6 million cells/dm^3, biomass – 0.176–1.437 mg/dm^3. It was established that in lakes with an external water exchange of less than 3 and more than 15 days, which include the above-mentioned waters, there were unfavorable conditions for the development of algal flora, including due to the low content of biogenic elements (Table 2).

Table 2

Dynamics of the number and biomass of phytoplankton in the Lower Dnieper typical lakes during the warm period of the year

Typical lakes	Number, million cells/dm^3 / Biomass, mg/dm^3			
	spring	summer	autumn	average for the season
Sabetskiy Liman	5.6 / 0.858	2.5 / 1.061	0.6 / 0.360	2.9 / 0.759
Krugle	0.2 / 0.223	58.9 / 10.684	15.5 / 5.616	24.9 / 5.508
Zakytne	0.5 / 0.176	1.7 / 1.437	0.5 / 0.439	0.9 / 0.684

The maximally high quantitative indicators of phytoplankton are typical for bodies of water with a moderate water exchange, a typical example of which is Krugle Lake: the number of algae was 24.9 million cells/dm^3 (fluctuations of interseasonal values 0.2–58.9 million cells/dm^3), biomass – 5.508 mg/dm^3 (0.224–10.684 mg/dm^3). In Krugle Lake, in comparison with other types of water bodies, a sharp increase in plant plankton development indicators was observed from spring to summer (the number is almost 300, the biomass is 48 times) due to the intensive vegetation of blue-green algae.

In the Sabetskiy Liman and Krugle lakes during the entire warm period, Cyanoprokaryota formed the population – respectively 75 and 92% of the total abundance of phytoplankton (in absolute values 2.3 and 22.9 million cells/dm^3).

In different seasons of the year, the percentage of cyanide in the total number of algae in the lakes was at least 45%. The spring plankton of both lakes was dominated by blue-green algae of the genus Gloeocapsa (G. *minor f. dispersa* (Keissl.) Hollerb., *G. crepidium* Thur.), also *Microcystis aeruginosa f. flos-aquae* (Wittr.) Elenk. emend. Kom., *M. Pulverea*, *O. amphibia*. In the summer, the high abundance of phytoplankton was due to the vegetation, primarily of the algae genus: *Oscillatoria (O. amphibia*, *O. limnetica*, *O. planctonica)*. A significant contribution to the formation of the number of phytoplankton in Krugle Lake also belonged to genera *Anabaenopsis* – 16%, *Aphanizomenon* – 15%, *Anabaena* – 11%, among which stood out *A. raciborskii* (14%, 8.5 million cells/dm^3) and *Aph. flos-aquae* (L.) Ralfs. (11%, 5.4 million cells/dm^3*)*. In the autumn plankton of the lake, cyanides continued vegetation, but they were gradually replaced by diatoms: *C. meneghiniana*, *Aulacoseira italica* (Ehrb.) Simons., *S. acus*, *S. hantzschii*, *Aulacoseira granulata* (Ehrb.) Simons.

In Zakytne Lake, the number of phytoplankton was made up of diatoms – 64% (0.5 million cells/dm^3), mostly in the Fragilariales order – *P. brevistriata* (Grun. in Van Heurck) Williams et Round, *F. virescens*, *Staurosira construens* Ehrb. and cyanides – 23% (0.2 million cells/dm^3), more often *Anabaena oscillarioides* Bory, *Merismopedia major* (G.M. Smith) Geitl., *G. crepidium*. Green algae, mostly *D. communis and Ch. monadina*, the dominant ones included autumns.

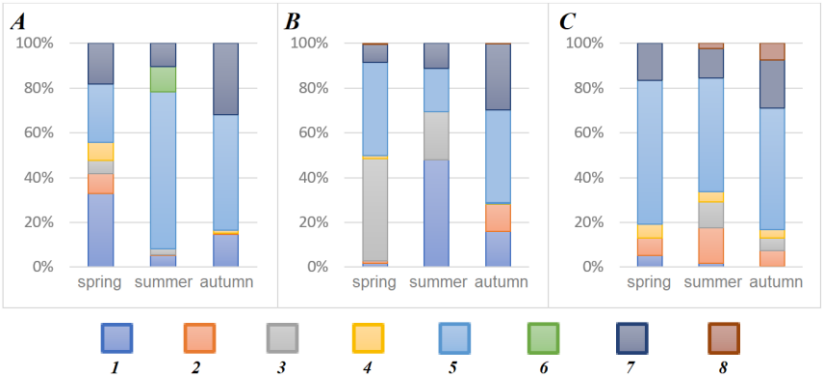

Fig. 2. Formation of algae flora biomass by algae of different divisions in the Lower Dnieper lakes:

A – Sabetskiy Liman, *B* – Krugle, *C* – Zakytne.
Algae divisions: *1* – Cyanoprokaryota, *2* – Euglenophyta, *3* – Dinophyta, *4* – Chrysophyta, *5* – Bacillariophyta, *6* – Xanthophyta, *7* – Chlorophyta, *8* – Streptophyta

The main role in the formation of phytoplankton biomass in the Lower Dnieper lakes belonged to the division Bacillariophyta – 45%, the share of Cyanoprokaryota and Chlorophyta in the total biomass was 18 and 17%, respectively, Dinophyta and Euglenophyta – 8 and 7%. Streptophyte, cryptophyte, and yellow-green algae detected in the plankton of water bodies formed no more than 2% and actually did not affect the total biomass of algal communities. In lakes of different types, the ratio of algae of different taxonomic affiliations in the formation of biomass differed (Fig. 2).

The hydrological features of different types of lakes were reflected in the biomass structure of algocenoses. The original data obtained by us during the period of research showed that in lakes with intensive and slow water exchange there were conditions under which mainly diatom algae grew.

In the Sabetskiy Liman, the hydrological regime of which was characterized by significant flow and rapid intensity of external water exchange, the share of diatoms in the total biomass was 55%, with them co-dominant with a much smaller percentage of green and blue-green algae – 17% and 16%, respectively. In April-May, when the external water exchange slowed down to 23-28 days, which is related to the mode of operation of the Kakhovka HEPS during the spawning spring period, contributed to a sharp increase of blue-green, diatom and green algae and their dominance in the formation of phytoplankton biomass. It was compiled *A. flos-aquae* (13% total algae biomass), *G. minor f. dispersa* (11%), *C. pediculus* Ehr. (10%). The restoration of the peak operating mode of the Kakhovka HEPS in the summer contributed to the vegetation of diatoms tolerant to the turbulent conditions of the water flow, their share in the biomass structure increased to 76% and remained high in autumn – 51%. The basis of the biomass was made in the summer *S. hantzschii* і *A. italica* (відповідно 32 and 18%), in autumn – *Epithemia turgida* (Ehr.) Kütz. (19%) and *Pinnularia lata* (Brèb.) W. Sm. (13%), and green (32%), among which significantly influenced the amount of biomass of *D. communis* (up to 20%). (see Fig. 2 *A*).

In Zakytne Lake, a low-flow, shallow water body with a small area, which has been abundantly overgrown with higher aquatic vegetation since April, the biomass of algae was formed by planktonic-benthic diatoms, which formed 53% (0.362 mg/dm^3) of the total biomass. It consisted mainly of representatives of the order Fragilariales, a much smaller share was represented by greens – 16% (0.109 mg/dm^3) and euglenophytes – 14% (0.096 mg/dm^3). In the spring, a significant proportion of algae biomass in the lake was formed by small-celled algae *P. brevistriata* (19%) and *F. virescens* (13%). The summer transitional period was characterized by a decrease in the share of diatoms in the formation of biomass (from 64 to 51%) and an increase in euglena (from 8 to 16%); the amount of biomass was influenced *Staurosira construens v. binodis* (Ehr.) Bukht. (17%), *Sphaerodinium cinctum* (Ehr.) Wołosz. (11%) and *Phacus orbicularis* Hübn. (10%). In October, representatives of diatoms and green algae

formed 82% of the biomass: *F. virescens* (17%), *Melosira varians* Ag. and *Synedra ulna* (Nitzsch) Ehr. (10%), *Ch. monadina* (19%).

The main role in the formation of phytoplankton biomass in Lake Krugle was taken by Cyanoprokaryota – 36% (1.994 mg/dm^3) and Bacillariophyta – 27% (1.484 mg/dm^3). To a lesser extent, they influenced its value Chlorophyta – 17% (0.956 mg/dm^3) and Dinophyta – 14% (0.759 mg/dm^3). Dinophytes (*Peridinium cinctum* (O.Mull.) Ehr., 46%) and diatoms (42%, *S. hantzschii*, *Cocconeis pediculus*, *Cymatopleura solea* (Bréb) W.Sm.) accounted for 88% of algae flora biomass in the spring period. Krugle Lake is the only water body among those studied by us, in which the development of microflora in summer reached the level of intensive «blooming»; in the structure of biomass in this season, 48% belonged to cyanides, basically *A. raciborskii* (14%), *Aph. flos-aquae* і *A. flos-aquae* (together 18%), a noticeable share in the biomass belonged *A. granulata* (10%). In October, a diatom-green dominant complex (by biomass) was formed *S. hantzschii* (15%), *Oonephris obesa* (W. West) Fott (14%), *Ch. monadina* (10%), *Phacus longicauda* (Ehr.) Duj. (9%).

According to the average biomass of phytoplankton (5.508 mg/dm^3), the trophic status of Krugle Lake is defined as eupolytrophic, which during the warm period of the year changed from oligotrophic in spring to polytrophic in summer and eupolytrophic in autumn. The level of trophicity of the Sabetskiy Liman and Zakytne Lake during the research period (0.759 and 0.684 mg/dm^3, respectively) was mesotrophic. In different seasons, the status of water bodies changed from oligotrophic to mesotrophic.

Therefore, from the point of view of the stock of natural resources of Ukraine, the most productive in terms of algae flora indicators are the water bodies of the II group of the Dnieper floodplain with a moderate intensity of external water exchange (change of water masses in 3–15 days; see Table 1). The lakes of this type contain the largest reserves of the natural feed base of aboriginal and valuable industrial species of ichthyofauna, which is one of the strategic resources of Ukraine's food security.

It should be noted that with an increase, and especially with a weakening of water exchange processes, the resource value of the Dnieper floodplains decreases significantly. For waters in the research region with a period of external water exchange faster than 3 days and slower than 15 days, the depleted species diversity of algal flora and the general biological diversity of hydrobionts, much lower reserves of the feed base, ichthyofauna and other valuable freshwater natural resources are characteristic. In view of this, the intensity of external water exchange can be considered one of the most important factors in the formation of the Dnieper floodplain algocenoses, and its changes can be used to predict future changes in the general feed base of waters in the region.

3. Assessment of possible changes in the algocenoses of the Lower Dnieper floodplains due to the destruction of the Kakhovka HEPS dam

The destruction of the Kakhovka HEPS dam and, as a result, the violation of the regulated flow of fresh water to the lower reaches of the Dnieper, caused a significant negative impact on the ecological state of the hydroecosystems of the Dnieper-Buh mouth region. We have repeatedly noted the extremely negative impact of the cessation of regulated water flow through the Kakhovka HEPS, which is reflected in the change in the elements of the hydrological regime[17, 18], hydrochemical balance [19, 20] and reductions in total biological diversity [21, 22] of all water bodies that have reached the affected area.

The general ecological condition of the floodplain of the Lower Dnieper, as an integral element of the hydrographic network of the Dnieper-Buh mouth region, also, through water exchange with the channel network of the river, is completely dependent on the regulated (peak) water flow through the Kakhovka HEPS dam. It was the peak mode of hydroelectric power station operation unit for almost 70 years in a row before its destruction that ensured

[17] Buriachok B. T., Korzhov Ye. I. Results of mathematical modeling of water flow velocity in the lower Dnieper section floodplain lakes after the destruction of the Kakhovska HEPS. *Current state of aquatic bioresources and aquaculture in Ukraine and the World* : Proc. of Scien. and Pract. Conf. of Young Scientists with International Participation; coll. of science works edited by Ph. D. of Geogr. Scien. Ye. I. Korzhov (Kherson, October 31, 2023). Kherson: KSAEU, 2023. Pp. 94–98. DOI: https://doi.org/10.13140/RG.2.2.10083.94245.

[18] Korzhov Ye. I., Honcharova O. V. Environmental aspects of the Kakhovska hydroelectrical power station reconstruction in the post-war period. Proceedings of the 7th International scientific and practical conference «*Science and technology: problems, prospects and innovations*» (April 13-15, 2023) CPN Publishing Group, Osaka, Japan, 2023. Pp. 17–23.

[19] Korzhov Ye. I., Honcharova O. V. Assessment of the key factors of the expected deterioration of the ecological condition of the Lower Dnieper in the modern period due to the violation of the regulated river waters flow regime. *SWorldJournal* – SWorld & D.A. Tsenov Academy of Economics (Svishtov, Bulgaria). Issue 18, Part 2, 2023. Pp. 45–52. DOI: https://doi.org/10.30888/2663-5712.2023-18-02-021.

[20] Korzhov Ye. I. Key factors of the expected deterioration of the ecological condition of the Lower Dnieper in the modern period due to the technogenic violation of the regulated river waters flow regime. Proceedings of the International scientific conference «*Organization of scientific research in modern conditions*» (March, 2023). *Series «SW-US Conference proceedings»,* USA, Seattle, 2023. Pp. 44–47.

[21] Коржов Є. І. Оцінка можливих екологічних наслідків порушення режиму регульованого надходження води до пониззя Дніпра. *Міжнародна науково-практична конференція Таврійського національного університету до 160-ї річниці від дня народження В. І. Вернадського* : матеріали Міжнародної науково-практичної конференції, 16–17 березня 2023 р., м. Київ. Частина 2. Львів – Торунь : Liha-Pres, 2023. С. 172–176. DOI: https://doi.org/10.36059/978-966-397-303-6-43.

[22] Кутіщев П. С., Коржов Є. І. Оцінка збитків заподіяних рибному господарству внаслідок зниження рівня води у Каховському водосховищі в лютому 2023 року. The 10th International scientific and practical conference «*Science and technology: problems, prospects and innovations*» (July 6–8, 2023) CPN Publishing Group, Osaka, Japan, 2023. Pp. 27–35.

the normal functioning of floodplain lakes and watercourses in the study region. According to experts, this mode of Kakhovka HEPS operation was favorable for the Lower Dnieper floodplain and ensured fairly high production capabilities of various types of water bodies, a high species diversity and their good ecological condition[23, 24, 25, 26].

The destruction of the Kakhovka hydroelectric plant in June 2023 made it practically impossible to regulated water flow to the lower reaches of the Dnieper and its floodplain in peak mode. Under such conditions, external water exchange between the channel and floodplain network is practically absent (Table 3).

Our calculated values of the external water exchange of typical lakes of the Dnieper floodplain, which are noted here after the explosion of the Kakhovka HEPS dam, showed that the water exchange processes have weakened significantly at the present time. If before the destruction of the dam, most of the floodplain lakes belonged to bodies of water with fast and moderate water exchange, now, even in the most flowing water bodies of the region, the water exchange is slowed down, exceeding 20 days. In fact, the most flowing floodplain lakes, located in the before-delta section of the Dnieper, lost this status after the destruction of the dam and moved to the category of low-flowing lakes with signs of dystrophy of aquatic ecosystems. The periods of external water exchange in them increased by 520–820% from those before the destruction of the dam. Water bodies located in the immediate vicinity of the HEPS dam, such as Sabetskiy Liman, Kaznachyivskiy Liman, Frolovo lakes, and others, were especially affected. The intensity of water exchange processes in them decreased by 7–8 times (see Table 3).

We note that we can observe the least weakening of water exchange processes in lakes located in the sea edge of the Dnieper delta (Krasniukove, Zolote, Didove, etc.). This is due to the spread in this part of significant natural fluctuations of the water level, which are formed under the action of water surges and ebbs from the wind, weak tidal fluctuations and natural water level fluctuations in the Dnieper-Buh estuary. Thanks to such water level fluctuations, which remained unchanged after the destruction of the Kakhovka

[23] Класифікація плавневих водойм пониззя Дніпра за біологічними показниками / Т.Л. Алексенко, С.В. Овечко, Г.М. Мінаєва та ін. *Наукові записки Тернопільського національного педагогічного університету ім. В. Гнатюка. Серія: Біологія. Спеціальний випуск: Гідроекологія*. 2010. №2(43). С. 3–6.

[24] Кучерява А.М. Якість води водотоків нижнього Дніпра за мікробіологічними показниками. *Гідрологія, гідрохімія, гідроекологія.* Матеріали четвертої всеукраїнської наукової конференції. Луганськ, 2009. С 111–112.

[25] Мінаєва Г.М. Екологічний стан і якість води водотоків нижнього Дніпра за показниками фітопланктону. *Наукові читання присвячені Дню науки.* Збірник наукових праць. Херсон, 2009. С. 8–13.

[26] Самойленко Л.М., Ломоносова Т.Г. Оцінка якості води водотоків пониззя Дніпра за показниками зоопланктону. *Наукові читання присвячені Дню науки.* Збірник наукових праць. – Херсон, 2009. С. 41–46.

HEPS dam, the water ecosystems of the lowest part of the Dnieper delta did not undergo a significant weakening of water exchange processes. The periods of water exchange here after the destruction of the Kakhovka HEPS dam on some lakes increased by only 35–39%.

Table 3

Periods of external water exchange of Lower Dnieper typical floodplain lakes before and after the destruction of the Kakhovka HEPS dam

The name of the lakes		Distance from Kakhovka HEPS dam, km	Period of external water exchange, days	
			before the dam was destroyed*	after the dam was destroyed
Before-delta section	Sabetskiy Liman	11	2.5	20.4
	Kaznachyivskiy Liman	17	2.8	27.0
	Frolovo	19	2.9	27.4
	Glukhiy Liman	35	9.0	47.8
	Oleksiyvskiy Liman	54	17.8	51.6
	Golubov Liman	55	9.3	31.1
Delta of the Dnieper	Kardashynskiy Liman	65	9.3	43.2
	Krugle	67	7.9	41.4
	Zakytne	69	23.1	51.8
	Steblyivskiy Liman	71	11.4	49.8
	Nazarovo-Pohorile	73	21.8	53.9
	Bile	75	10.2	21.5
	Krasniukove	87	8.4	11.6
	Zolote	89	8.1	11.0
	Didove	90	8.6	11.6

Note: * – normalized data for 2000–2020.

As noted above, the intensity of water exchange processes in the floodplains of the Dnieper directly affects the species diversity, quantitative characteristics, and richness of their algae flora. At the same time, the greatest species diversity, reserves and productivity are formed in waters with moderate water exchange with the rate of change of water masses to new ones within 3–15 days. An increase in this indicator leads to the degradation of the state of the water ecosystem of the lakes and a significant reduction in the species diversity of algal flora. Given the dynamics of technogenic changes

that have taken place at the present time, almost all lakes have moved to the class of waters with slow external water exchange. The periods of their external water exchange are currently 40–50 days, which did not exceed 15 days before the Kakhovka HEPS dam was destroyed.

Given the changes that have taken place within the Lower Dnieper, a significant reduction in the richness of algocenoses in the studied region can be predicted in the coming decades. If the biomass of phytoplankton in the warm period of the year exceeded 5.5 mg/dm^3 in lakes with a moderate water exchange, which included the majority of waters in the region, then at the present time it should be expected that this indicator will decrease to the values of 0.5–0.7 mg/dm^3 typical for lakes with a slow change in water masses.

From the point of view of the natural resources of Ukraine stock, the reduction of algae flora stocks on the indicated scales, and, as a result, the destruction of unique hydrophytocenotic complexes, the reduction of the floristic diversity of the region and the reduction of the fodder base of industrially important hydrobionts within the Dnieper-Buh mouth region, the area of which is 1440 km^2, is significant ecological and economic resource losses. According to the estimates of the relevant UN experts, the Kakhovka disaster led to the greatest losses precisely in the environmental sector, and currently they are estimated at more than 6.4 billion dollars of USA[27]. The country should prepare for the fact that the further inevitable degradation of the region's water ecosystems will cause even greater losses of natural resources in the near future compared to what we have at the present time. In view of this, in order to preserve the rich natural resource and potential of the Lower Dnieper, the most urgent issue now is the development and implementation of practical methods for improving the ecological condition and preserving the biodiversity of the unique water ecosystems of the Dnieper-Buh mouth region.

CONCLUSIONS

The floodplain part of the Lower Dnieper, before the destruction of the Kakhovka HEPS in 2023, was the richest part of the river in terms of biological diversity and reserves of freshwater bioresources. The catastrophic consequences caused by the undermining of the Kakhovka dam affected not only the main industrial species of hydrobionts, changed the quality indicators of surface natural waters, but also changed the conditions for the formation of ecocenoses in the research area, in particular the algae flora of the Lower Dnieper.

[27] Звіт «Оцінка потреб після катастрофи на греблі Каховської ГЕС» (PDNA) / Уряд України, Організація Об'єднаних Націй. Жовтень 2023 р. 10 с. URL: https://ukraine.un.org/uk/248860-звіт-оцінка-потреб-після-катастрофи-на-греблі-каховської-гес-pdna. (дата звернення 02.08.2024).

According to our research, before the destruction of the Kakhovka HEPS, 207 species of algae, represented by 242 intraspecific taxa (including those containing the nomenclatural type species) from 9 divisions, were recorded in the Dnieper floodplain. The structure of algal communities was mainly formed by representatives of Bacillariophyta, Chlorophyta, Cyanoprokaryota (81% of the total list of algae). The species composition of individual waters was formed mainly under the influence of external water exchange and was quite closely dependent on its intensity. The depleted composition of algocenoses was formed in the Dnieper floodplain lakes with fast and, especially, with slow water exchange – 93 species (101 ist) and 89 species (97 ist), respectively. The greatest diversity was found in lakes with an external water exchange period of 3–15 days – 113 species (124 ist).

According to the indicators of specific species richness, number and biomass of algae, a similar dependence can also be traced. Waters with intensive and slow water exchange are characterized by low average vegetation indicators of the quantitative development of phytoplankton: specific species richness – 24–28 ist, abundance – 0.8-2.9 million cells/dm^3, biomass – 0.684–0.759 mg/dm^3 and the dominance of diatoms flora in the floristic spectrum and algae biomass formation. In lakes with moderate water exchange, on the contrary, high indicators of developed phytoplankton were noted: specific species richness was 35 ist, abundance – 24.9 million cells/dm^3, biomass – 5.508 mg/dm^3 and predominance of blue-green-green-diatom flora in the formation of taxonomic structure and algae biomass.

Since the main factor shaping the diversity of algocenoids in typical floodplain lakes of the Lower Dnieper is the intensity of external water exchange, we made predictive calculations of changes in algae flora reserves based on its changes in the modern period.

We established that after the destruction of the Kakhovka hydroelectric power station, the water exchange processes in the floodplain waters of the region weakened significantly. The most flowing lakes with a period of external water exchange of 2–3 days have passed into the group of lakes with a slow water exchange and at the present time the water in them changes to new in more than 20 days. The richest in terms of algae flora reserves, the lakes with moderate water exchange also moved to the group with significantly slowed external water exchange. If before the destruction of the Kakhovka dam, the water in them changed to new within 7–12 days, now it changes in 40-50 days or longer.

Of course, such changes will have an extremely negative impact on the algocenoses of the floodplain part of the Lower Dnieper. The lakes, which were once rich in fodder, have now acquired the status of slow flow with slowed external water exchange. In the coming decades, we can expect a sharp impoverishment of the species diversity of the algae flora of the region

and the general biological diversity, especially of freshwater species of hydrobionts. Also, the reserves of the natural feed base, stocks of ichthyofauna and other valuable natural resources will decrease significantly.

To prevent the general degradation of water ecosystems of the Dnieper floodplain and their transformation into a wetland in conditions of the impossibility of restoring regulated water flow through the Kakhovka HEPS dam, only the development and implementation of local methods of strengthening the water exchange of the floodplain with a channel network and improving the intra-basin dynamics of water masses to the necessary ecologically favorable level can equal.

Only active science-based management of water ecosystems state can restore valuable natural reserves of their biological resources as one of the components of Ukraine's food security.

References

1. Korzhov Ye. I. Changes in the key hydrological factors of the lower reaches of the Dnieper water ecosystems functioning after the Kakhovka hydroelectric power station dam was destroyed / G. Datsenko, E. Golovnina, E. Jorovlea at al. / *Erbe der europäischen Wissenschaft: Wirtschaft, Management und Marketing, Tourismus, Medizin, Biologie und Ökologie, Landwirtschaft*. Monografische Reihe «Europäische Wissenschaft». Buch 27. Teil 4. 2024. Pp. 102–113.

2. Korzhov Ye. I. Changes in the main hydrophysical properties of the lower Dnieper section water masses due to the destruction of the Kakhovka HEPS. The 7th International scientific and practical conference «*Science and society: modern trends in a changing world*» (June 10–12, 2024) MDPC Publishing, Vienna, Austria. 2024. Pp. 251–257.

3. Korzhov Ye. I. Aspects of disruption of the lower Dnieper section floodplain network external water exchange after Kakhovka dam destruction. The 10th International scientific and practical conference «*Topical aspects of modern scientific research*» (June 13–15, 2024) CPN Publishing Group, Tokyo, Japan. 2024. Pp. 243–249.

4. Коржов Є. І. Зовнішній водообмін руслової та озерної систем пониззя Дніпра в сучасний період. *Гідрологія, гідрохімія і гідроекологія*. К. : Обрії. 2013. Том 2(29). С. 37–45.

5. Методи гідроекологічних досліджень поверхневих вод / О. М. Арсан, О. А. Давидов, Т. М. Дьяченко та ін. ; за ред. Романенко В. Д. К. : ЛОГОС, 2006. 108 с.

6. S.P. Wasser, P.M. Tsarenko Diversity of algae of Ukraine. *Algologiya* 10 (4), 2000. Pp. 3–309.

7. Коржов Є. І., Пуленко Ю. В. Термінологічні особливості географічних назв елементів гідрографічної мережі нижньої течії річок. *Topical*

issues of modern science, society and education. Proceedings of the 1st International scientific and practical conference (August 8–10, 2021). Kharkiv, Ukraine: SPC–Sci-conf.com.ua, 2021. P. 325–331.

8. Korzhov Ye. I., Kucheriava A. M. Peculiarities of External Water Exchange Impact on Hydrochemical Regime of the Floodland Water Bodies of the Lower Dnieper Section. *Hydrobiological Journal* – Begell House (United States). Vol. 54, Issue 6, 2018. P. 104–113.

9. Коржов Є. І., Мінаєва Г. М. Вплив режиму течій на кількісні показники фітопланктону мілководних водойм пониззя Дніпра. *Гідрологія, гідрохімія і гідроекологія*. К. : Обрії, 2014. Том 2(33). С. 61–65.

10. Коржов Є. І., Кучерява А. М. Особливості впливу зовнішнього водообміну на гідрохімічний режим заплавних водойм пониззя Дніпра. *Гідробіол. журн.* 54, № 4. 2018. С. 112–120.

11. Науково-практичні рекомендації щодо покращення екологічного стану слабопроточних водойм пониззя Дніпра / С. В. Овечко, Є. І. Коржов, В. Л. Гільман. Херсон, 2015. 28 с.

12. Кучерява А. М., Коржов Є. І. Формування кількісних показників бактеріопланктону заплавних водойм пониззя Дніпра з різною інтенсивністю зовнішнього водообміну. *Наукові читання, присвячені Дню науки. Екологічні дослідження Дніпровсько-Бузького регіону*. Вип. 12. Збірник наукових праць. Херсон, 2019. С. 33–40.

13. Мінаєва Г. М., Коржов Є. І. Формування кількісних показників фітопланктону заплавних водойм гирлової ділянки Дніпра з різною інтенсивністю зовнішнього водообміну. *Наукові читання, присвячені Дню науки. Екологічні дослідження Дніпровсько-Бузького регіону*. Вип. 12. Збірник наукових праць. Херсон, 2019. С. 13–27.

14. Rudik V. A., Korzhov Ye. I. Dynamics of climatic predictors of a possible invasion of epidemiologically dangerous blood-sucking mosquitoes (Diptera: Culicidae) into North-Western Black Sea Coast areas. *Biological sciences and education in the context of European integration*: Scientific monograph. Riga, Latvia : «Baltija Publishing», 2024. Pp. 63–80. DOI: https://doi.org/10.30525/978-9934-26-443-6-4.

15. Білик Г. В., Коржов Є. І. Огляд основних аспектів впливу кліматичних змін на сучасний стан іхтіофауни Дніпровсько-Бузької гирлової області. *Наукові читання, присвячені Дню науки. Екологічні дослідження Дніпровсько-Бузького регіону.* Вип. 12. Збірник наукових праць. Херсон, 2019. С. 3–10.

16. Kutishchev P. S., Korzhov Ye. I., Honcharova O. V. Retrospective analysis and forecast of the main abiotic factors of the environmental conditions of ichtyofauna of the Dnipro-Buh estuary ecosystem. *Topical issues of the development of veterinary medicine and breeding technologies*:

Scientific monograph. Riga, Latvia: «Baltija Publishing», 2022. Pp. 476–497. DOI: https://doi.org/10.30525/978-9934-26-258-6-14.

17. Buriachok B. T., Korzhov Ye. I. Results of mathematical modeling of water flow velocity in the lower Dnieper section floodplain lakes after the destruction of the Kakhovska HEPS. *Current state of aquatic bioresources and aquaculture in Ukraine and the World* : Proc. of Scien. and Pract. Conf. of Young Scientists with International Participation; coll. of science works edited by Ph. D. of Geogr. Scien. Ye. I. Korzhov (Kherson, October 31, 2023). Kherson : KSAEU, 2023. Pp. 94–98. DOI: https://doi.org/10.13140/RG.2.2.10083.94245.

18. Korzhov Ye. I., Honcharova O. V. Environmental aspects of the Kakhovska hydroelectrical power station reconstruction in the post-war period. Proceedings of the 7th International scientific and practical conference «*Science and technology: problems, prospects and innovations*» (April 13–15, 2023) CPN Publishing Group, Osaka, Japan, 2023. Pp. 17–23.

19. Korzhov Ye. I., Honcharova O. V. Assessment of the key factors of the expected deterioration of the ecological condition of the Lower Dnieper in the modern period due to the violation of the regulated river waters flow regime. *SWorldJournal* - SWorld & D.A. Tsenov Academy of Economics (Svishtov, Bulgaria). Issue 18, Part 2, 2023. Pp. 45–52. DOI: https://doi.org/10.30888/2663-5712.2023-18-02-021.

20. Korzhov Ye. I. Key factors of the expected deterioration of the ecological condition of the Lower Dnieper in the modern period due to the technogenic violation of the regulated river waters flow regime. Proceedings of the International scientific conference «*Organization of scientific research in modern conditions*» (March, 2023). Series «SW-US Conference proceedings», USA, Seattle, 2023. Pp. 44–47.

21. Коржов Є. І. Оцінка можливих екологічних наслідків порушення режиму регульованого надходження води до пониззя Дніпра. *Міжнародна науково-практична конференція Таврійського національного університету до 160-ї річниці від дня народження В. І. Вернадського* : матеріали Міжнародної науково-практичної конференції, 16–17 березня 2023 р., м. Київ. Частина 2. Львів – Торунь : Liha-Pres, 2023. С. 172–176. DOI: https://doi.org/10.36059/978-966-397-303-6-43.

22. Кутіщев П. С., Коржов Є. І. Оцінка збитків заподіяних рибному господарству внаслідок зниження рівня води у Каховському водосховищі в лютому 2023 року. The 10th International scientific and practical conference «*Science and technology: problems, prospects and innovations*» (July 6–8, 2023) CPN Publishing Group, Osaka, Japan, 2023. Pp. 27-35.

23. Класифікація плавневих водойм пониззя Дніпра за біологічними показниками / Т. Л. Алексенко, С. В. Овечко, Г. М. Мінаєва та ін. *Наукові записки Тернопільського національного педагогічного університету*

ім. В. Гнатюка. Серія : Біологія. Спеціальний випуск : Гідроекологія. 2010. № 2(43). С. 3–6.

24. Кучерява А. М. Якість води водотоків нижнього Дніпра за мікробіологічними показниками. *Гідрологія, гідрохімія, гідроекологія.* Матеріали четвертої всеукраїнської наукової конференції. Луганськ, 2009. С. 111–112.

25. Мінаєва Г.М. Екологічний стан і якість води водотоків нижнього Дніпра за показниками фітопланктону. *Наукові читання присвячені Дню науки* : збірник наукових праць. Херсон, 2009. С. 8–13.

26. Самойленко Л. М., Ломоносова Т. Г. Оцінка якості води водотоків пониззя Дніпра за показниками зоопланктону. *Наукові читання присвячені Дню науки* : збірник наукових праць. Херсон, 2009. С. 41–46.

27. Звіт «Оцінка потреб після катастрофи на греблі Каховської ГЕС» (PDNA) / Уряд України, Організація Об'єднаних Націй. Жовтень 2023 р. 10 с. URL: https://ukraine.un.org/uk/248860-звіт-оцінка-потреб-після-катастрофи-на-греблі-каховської-гес-pdna. (дата звернення 02.08.2024).

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