Environment and Ecology Research 9(5): 235-241, 2021 http://www.hrpub.org
DOI: 10.13189/eer.2021.090504

The Level of Ecological and Hydrobiological Indicators in the Cheboksary Reservoir

Andrey Vladimirovich Kozlov[1,*], Nataliya Nikolaevna Koposova[1], Irina Pavlovna Uromova[1], Elena Aleksandrovna Krotova[1], Anna Vladimirovna Matveeva[1], Nadezhda Vasilevna Polyakova[2]

[1]Minin Nizhny Novgorod State Pedagogical University, 1 Ulyanova str., Nizhny Novgorod, 603950, Russia
[2]Nizhny Novgorod State Agricultural Academy, 97 Gagarina ave., Nizhny Novgorod, 603107, Russia

Received July 23, 2021; Revised September 2, 2021; Accepted September 26, 2021

Cite This Paper in the following Citation Styles

(a): *[1] Andrey Vladimirovich Kozlov, Nataliya Nikolaevna Koposova, Irina Pavlovna Uromova, Elena Aleksandrovna Krotova, Anna Vladimirovna Matveeva, Nadezhda Vasilevna Polyakova , "The Level of Ecological and Hydrobiological Indicators in the Cheboksary Reservoir," Environment and Ecology Research, Vol. 9, No. 5, pp. 235 - 241, 2021. DOI: 10.13189/eer.2021.090504.*

(b): *Andrey Vladimirovich Kozlov, Nataliya Nikolaevna Koposova, Irina Pavlovna Uromova, Elena Aleksandrovna Krotova, Anna Vladimirovna Matveeva, Nadezhda Vasilevna Polyakova (2021). The Level of Ecological and Hydrobiological Indicators in the Cheboksary Reservoir. Environment and Ecology Research, 9(5), 235 - 241. DOI: 10.13189/eer.2021.090504.*

Abstract The paper assesses the ecological state of the Cheboksary reservoir based on the criteria of the total abundance, biomass, and species diversity of phytoplankton, zooplankton, and benthos. During the study period, no significant changes in the indicators of the development of algocenoses, their distribution over the water area of the reservoir were noted. The average phytoplankton biomass for the reservoir turned out to be in the dynamic norm, the trophic status was assessed as eutrophic; The revealed ratios of the leading systematic groups of planktonic algae and the composition of cenosis-forming species had also been in the previous years of the study. According to the level of the saprobity index, all sampling stations belong to class III (moderately polluted waters). The benthos of the reservoir was also characterized by sufficient diversity with the dominance of mollusks and chironomid larvae in the taxonomic composition. Thus, despite the presence of a certain anthropogenic impact on the water area of the Cheboksary reservoir, its hydrobiological state remains satisfactory, which is determined by a wide buffer limit to the level of pollution of the water body.

Keywords Artificial Reservoir, Hydrobiological Properties, Ecological State of a Water Body

1. Introduction

Due to the uneven location of rivers, lakes, and other hydrological objects on the Earth's surface, artificial reservoirs have become a common planetary phenomenon. These include various ponds, canals, reservoirs, filtration reservoirs, and other objects that have any unique economic and/or biospheric importance. The main purpose of creating reservoirs is to accumulate water with its subsequent use. In addition, the reservoir, as an artificially created water body, has a strategically significant function in the national economic sectors and the ecological biosphere plan [1].

The construction of regulating reservoirs provides an opportunity to partially or completely eliminate the conditions for the occurrence of such adverse events as floods and high water. At the same time, in addition to reducing direct damage from them, the costs of construction and reconstruction of capital objects in various sectors of the economy are also reduced due to the reduction of flood control costs. The creation of reservoirs solves the problem of water shortage in certain regions and also solves the reclamation problem of water supply following the most optimal timing of irrigation for crops. Reservoirs are ubiquitous sites for organizing fisheries. Commercial fish species (bream, pike perch, etc.) are often grown in artificial reservoirs. Besides, initiatives are taken to acclimatize such valuable fish species as silver carp, grass carp, rainbow trout, and others in this kind of water body.

In addition to their economic importance, the reservoirs are also important for the biosphere. For example, in their water area, favorable conditions are created for nesting, breeding, and wintering of waterfowl. The same applies to mammals, whose life is directly related to water. Reservoirs affect the level and balance of groundwaters in the territory. In addition to the animal world, both the reservoir itself and the territories immediately adjacent to it contribute to the development of aquatic vegetation, as well as various mollusks and insects [2,3].

Since the reservoirs mainly receive water from river networks, which, passing through large industrial and urbanized centers, carry a significant amount of pollutants [4-8], the assessment of the ecological state of artificial reservoirs is an urgent issue of modern hydroecology. In this case, more informative criteria for such an assessment are often not only the properties of the hydrochemical regime [9-12] but also hydrobiological indicators [13,14]. In particular, the dynamics of phytoplankton, zooplankton, and benthos is traditionally considered the criterion that can serve as an indicator of the ecological state of a water body [15,16].

In this work, we studied the hydrobiological characteristics of the water area of the Cheboksary reservoir as criteria for assessing its ecological state.

2. Materials and Methods

In the Big Volga project (1931) supervised by Professor A.V. Chaplygin, the idea of building a cascade of hydroelectric power plants and reservoirs on the Kama and Volga rivers was put forward. According to the data of the project, it was planned to lay a waterway suitable for the movement of large-sized vessels, which was supposed to connect the Caspian, Black, Baltic and White seas. Along its entire length, waterworks were supposed to be constructed [3].

The Cheboksary reservoir is one of the links of the Volga/Kama cascade of artificial reservoirs and is located on the territory of three constituent entities of the Russian Federation: the Nizhny Novgorod region, the Chuvash Republic, and the Republic of Mari El (Fig. 1). The territory of 14 administrative districts, including 6 cities and 119 other settlements (including 3 cities, 14 rural settlements, and 7 lowlands for agricultural purposes in the Nizhny Novgorod region), falls into the zone of its influence.

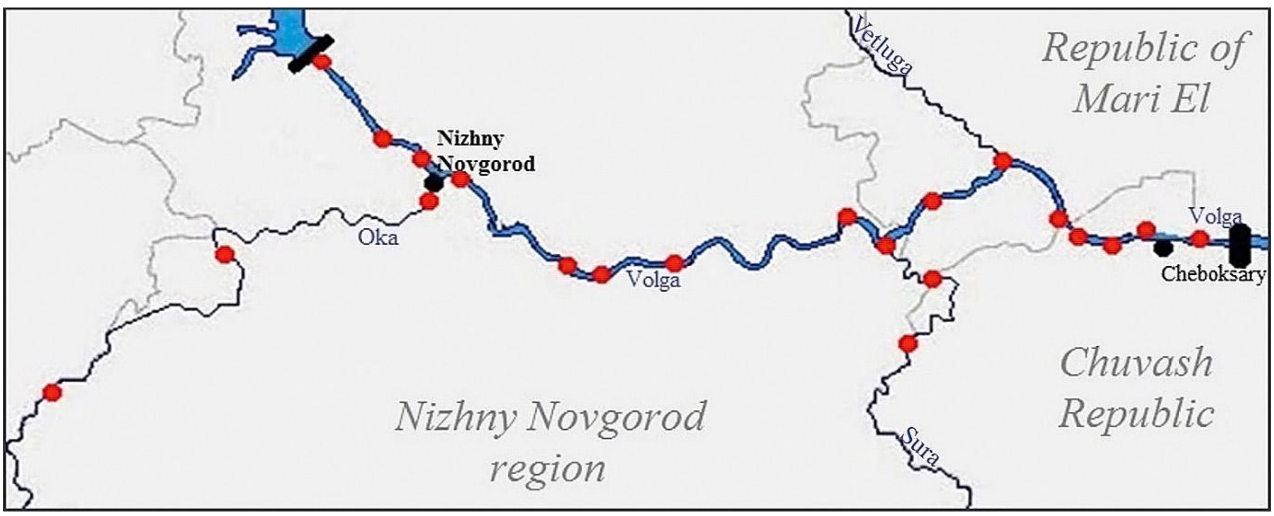

Figure 1. Part of the Volga river, included in the Cheboksary reservoir, with the designation of permanent water sampling points

The Cheboksary reservoir is a reservoir of complex significance, which has been used for a very long time in many sectors of the national economy. As a result of these circumstances, to one degree or another, the entire territory of the reservoir experiences anthropogenic pressure of varying intensity and frequency. In particular, these phenomena are concentrated on the right-bank area located below the confluence of the Oka River, which, in turn, carries a significant amount of ecotoxicants into the reservoir basin [9,15]. In particular, oil products, organic compounds of the aromatic series, heavy metals, arsenic, manganese, aluminum, iron, and many others are recognized as the main pollutants here [3,17,18].

Hydrobiological research is aimed at understanding the various ecological processes of the aquatic environment associated with the vital activity of microscopic organisms. The ecological assessment of the waters of the Cheboksary reservoir was carried out in 2015-2016 based on generally accepted hydrobiological indicators analyzed by students of the Nizhny Novgorod State Pedagogical University (NGPU) named after K. Minin during their industrial practice. Water samples were taken using a BG-1.0 hydrological bottle and fixed with Lugol's solution. Further, the microbiota was isolated by centrifugation in a laboratory PE-6910 centrifuge, and the resulting sediments were analyzed. During laboratory analyzes, microscopic algae was identified and its number was determined using a Bogorov counting chamber and a Bio-Tech-330-LED2-Tr LED luminescent microscope at low and medium magnifications. The biomass of algae was estimated based on the determination of the concentration of carbon biomass using the chromium sulfate method with a photocolorimetric end on a PE-5400VI spectrophotometer. The saprobity index of the watercourse was calculated according to Nikolayev's method [19-21].

3. Results

The abundance, biomass, and proportion of algae of various divisions in the total abundance and biomass of phytoplankton in various parts of the Cheboksary Reservoir in 2015-2016 are presented in Table 1. In the river parts of the reservoir in 2015, the complex of phytoplankton species prevailing in biomass, as in previous years of research, was determined by centric diatomic algae that served as indicators of increased organic and biogenic pollution, namely, species of the genera *Stephanodiscus*, *Cyclotella*, *Aulacosira, Melosira* with the presence of components of the Caspian plankton complex (*Actyncyclus normanii*), which have been actively spreading throughout the Volga in recent years.

Table 1. Average abundance (mln cells/l, numerator), biomass (g/m^3, denominator), and proportion of algae of different parts in total population (numerator) and biomass (denominator) of phytoplankton in different parts of the Cheboksary reservoir in 2015-2016

Parts of the water reservoir	Percentage of occurrence					Abundance Biomass
	Diatomic algae	*Green algae*	*Blue-green algae*	*Cryptophytes*	*Dinophytes*	
2015						
The upper river part	5.00 32.10	0.34 2.12	94.50 64.89	0.11 0.19	0.01 0.45	49.5±8.01 4.27±0.47
The Oka spur	48.46 85.72	36.77 11.43	14.50 2.75	0 0	0 0	11.13±1.07 6.02±0.80
The middle river part	29.09 78.59	17.78 6.87	51.09 10.79	1.08 1.35	0.08 0.99	22.91±3.9 7.13±1.15
The lacustrine part	26.91 62.17	13.07 7.29	56.69 19.12	2.03 6.66	0.13 2.67	15.36±5.15 4.79±1.69
The dam part	17.59 61.82	2.34 1.72	75.63 22.89	3.06 6.83	0.08 1.89	33.97±14.9 4.13±1.75
2016						
The upper river part	46.21 79.13	12.52 8.81	35.91 8.64	0.12 0.42	0.10 0.60	9.53±2.30 3.44±0.72
The Oka spur	36.60 82.80	52.50 12.16	7.01 0.24	0.74 0.24	0.37 2.78	5.41 3.31
The middle river part	29.33 82.15	29.31 7.75	38.55 3.53	1.66 1.65	0.43 4.13	18.84±4.70 8.54±2.9
The lacustrine part	20.99 64.16	25.34 7.49	47.73 5.19	2.43 3.30	2.15 17.33	13.19±4.20 5.19±2.70
The dam part	11.36 41.59	9.90 4.68	75.99 48.50	1.16 0.32	0.54 4.47	75.39±47.8 4.49±2.10

In the lacustrine and dam areas, the role of cyanobacteria and various groups of phytoflagellates increased. In general, there were no significant changes in the indicators of the development of algocenoses or their distribution over the water area of the reservoir. The average phytoplankton biomass for the reservoir in 2015 was 5.61±0.35 g/m^3, the trophic status was assessed as eutrophic; the ratio of the leading systematic groups of planktonic algae and the composition of cenosis-forming species had also been in the previous years of the study.

In 2016, the complex of phytoplankton species prevailing in biomass, as in previous years of the study, was determined by centric diatoms that served as indicators of increased organic and biogenic pollution, namely, species of the genera *Stephanodiscus*, *Cyclotella*, *Aulacoseira*, *Melosira* with the presence of components of the Caspian planktonic complex (*Actynocyclus normanii*). In the lacustrine part, the role of phytoflagellates increased, and in the dam section, cyanobacteria (*Microcystis aeruginosa*, *Aphanizomenon flos-aquae*).

In general, there were no significant changes in the indicators of the development of algocenoses or their distribution over the water area of the reservoir. The average phytoplankton biomass for the reservoir in 2016 was 5.71±1.3 g/m^3, the trophic status was assessed as eutrophic; The revealed ratio of the leading systematic groups of planktonic algae and the composition of cenosis-forming species had also been noted in the previous years of the study.

The zooplankton of the Cheboksary reservoir in 2015 included 51 species; among them,17 species of rotifers, 24 species of cladocerans, and 10 species of copepods. The abundance, biomass, and share of the three groups in the total abundance and biomass of zooplankton in various parts of the Cheboksary reservoir in 2015 are presented in Table 2.

The average biomass of zooplankton for the reservoir in 2015 was 0.87±0.59 g/m^3, which is slightly higher than the average long-term indicators (0.75 g/m^3). The trophic status was assessed as mesotrophic (average feeding); the revealed ratio of the leading systematic groups of zooplankton and the composition of cenosis-forming species had also been noted in the previous years of the study.

According to the level of the saprobity index, all sampling stations belong to class III (moderately polluted waters). Species of the genera *Bosmina* and *Daphnia* prevailed throughout almost the entire reservoir, only in some areas *Cyclopoida* prevailed.

The species composition of the reservoir zooplankton in 2016 was 49 species. The composition of zooplankton was dominated by euplankton forms. In general, for the entire reservoir, the average abundance was 50.500 ind./m^3, the average biomass was 1.3 g/m^3, which is slightly more than the average long-term indicators (0.75). This characterizes the Cheboksary reservoir as an α-mesotrophic reservoir with moderate feeding capacity for zooplanktivorous forms of fish and their larvae. In general, there were no significant changes in the indicators of the development of cenoses or their distribution over the water area of the reservoir.

Table 2. The average abundance (thousand ind./m^3, numerator), biomass (g/m^3, denominator), and proportion of three groups in the total abundance (numerator) and biomass (denominator) of zooplankton in various parts of the Cheboksary Reservoir in the 2015-2016 summer season

Parts of the water reservoir	Percentage of occurrence			Abundance / Biomass
	Rotatoria	*Cladocera*	*Copepoda*	
2015				
The upper river part	0.4 / 0.01	69.6 / 82.1	30.0 / 17.9	51.8±22.01 / 0.46±0.23
The Oka spur	35.5 / 3.4	52.0 / 60.6	12.5 / 26.0	30.0±11.2 / 0.5±0.26
The middle river part	6.7 / 1.0	49.9 / 54.5	44.4 / 44.5	40.0±34.1 / 0.8±0.6
The lacustrine part	3.1 / 0.8	68.9 / 85.3	22.0 / 14.9	46.6±34.4 / 0.7±0.6
The dam part	1.4 / 0.1	70.6 / 87.9	22.0 / 12.0	69.5±47.2 / 1.9±1.4
2016				
The upper river part	33 / 1	30 / 95	37 / 4	52.4±39.2 / 2.4±0.6
The Oka spur	62 / 55	5 / 38	33 / 57	16.2±14.8 / 0.7±0.1
The middle river part	23 / 2	18 / 59	59 / 39	33.4±34.4 / 1.1±1.4
The lacustrine part	15 / 0	40 / 83	45 / 17	18.9±18.1 / 0.7±0.6
The dam part	14 / 0.4	20 / 73.3	66 / 26.3	116.1±79.7 / 1.7±0.6

According to the level of the saprobity index, all sampling stations belong to class III (moderately polluted waters, only near the settlement of Barmino the water was the border of saprobity classes III and IV due to *Moina brachiata).* Species of the genera Daphnia and stages of *Cyclopoida* of different ages prevailed throughout almost the entire reservoir.

The benthos of the Cheboksary reservoir in 2015 was characterized by a high level of development. It included 108 species and forms, including chironomid larvae (35 species and forms), mollusks (31), oligochaetes (16), crustaceans (9), leeches (7). Other groups (larvae of mayflies, beetles, caddisflies, butterflies, biting midges, polychaetes) were represented by one to three species. The abundance of zoobenthos averaged 1702 ind./m^2, the biomass equaled 43.88 ind./m^2. The number of organisms at different points ranged from 40 to 9500 ind./m^2, their biomass equals from 0.04 to 550.6 g/m^2. The dominant position in the forage biomass is occupied by mollusks (91%), the bulk of which is accounted for by *Lithoglyphus naticoides* and young specimens of *Dreissena polymorpha*.

As before, the benthos of the reservoir in 2016 was diverse (65 species and forms), with a dominance of mollusks (22 species) and chironomid larvae (16 forms) in the taxonomic composition; oligochaetes and crustaceans had 7 species each, leeches had 6 species, and polychaetes, bugs, larvae of caddisflies and some dipterans included one or two species. The average number of benthic organisms in the reservoir is 2361 ind./m^2, the biomass is 52.36 g/m^2, which characterizes the reservoir as polytrophic for benthophagous fish. The abundance in the reservoir was mainly composed of crustaceans (58%) (mainly in the middle river region) and mollusks (19%). 85% of the biomass is made up of mollusks.

4. Discussion

Phytoplankton in 2015 was characterized by the highest values of quantitative development (typical for water bodies of the eutrophic type) in the middle river part. In other parts of the reservoir, the trophy level corresponded to the average productive status. The phytoplankton of the reservoir in 2016 was also characterized by the highest values of quantitative development (typical for water bodies of the eutrophic type) in the middle river part. In other parts of the reservoir, the degree of trophy corresponded to mesotrophy.

The zooplankton of the reservoir in the summer of 2015, on average, was characterized by the values of quantitative development typical of mesotrophic water bodies. According to the structural indicators of zooplankton, the reservoir in 2015 had the status of a mesotrophic reservoir, with an average food supply for fish. According to the structural indicators of zooplankton, the Cheboksary reservoir in 2016 also had the status of a mesotrophic reservoir, with an average food supply.

According to the level of benthos biomass, only the upper river part was characterized as α-mesotrophic (moderate feeding); in that area of the reservoir, soft benthos had a slight advantage in the total biomass of benthic communities (57%) comparing with mollusks (47%). The level of biomass of benthic communities in the areas located below is characteristic of β-eutrophic and α-polytrophic water bodies (high-feeding and very high-feeding). The basis of the biomass in them is formed by mollusks (88-97%).

As studies of different years show [22, 23], for long periods, the Cheboksary Reservoir has been characterized by a high eutrophic ecological status, typical for areas with a strong and chronic anthropogenic load on the ecosystem of the watercourse despite its natural intensive flow. In such cases, typical hydrobiological characteristics include not only the actual abundance and biomass of the microbiota but also some biochemical indicators, in particular, the concentration of various types of chlorophyll. These substances are typical for organelles of cells of green algae, cyania, and many other representatives of plankton and benthos. Their content is one of the indicator criteria for the ecological state of water bodies and streams [1,19,20].

For example, despite the relatively young age of the reservoir (active filling of the basin began in 1981), according to the studies mentioned above, already in 1985, it was characterized by an outbreak of trophy up to 198 μg/L of chlorophyll "a", the relative stabilization of the content of which was recorded only in 2005 (45.1 μg/l). However, this level of the indicator also characterizes the high intensity of the development of hydrobiological processes in terms of the decomposition of various organic substances due to the biochemical work of actively developing plankton and benthos.

5. Conclusions

During the study period, no significant changes in the indicators of the development of algocenoses, their distribution over the water area of the reservoir was noted. The average phytoplankton biomass for the reservoir turned out to be in the dynamic norm, the trophic status was assessed as eutrophic; The revealed ratios of the leading systematic groups of planktonic algae and the composition of cenosis-forming species had also been in the previous years of the study. The benthos of the reservoir was also characterized by sufficient diversity with the dominance of mollusks and chironomid larvae in the taxonomic composition.

Thus, despite the presence of a certain anthropogenic impact on the water area of the Cheboksary reservoir, its hydrobiological state remains satisfactory, which is determined, on the one hand, by a wide buffer limit to the level of pollution of the water body and, on the other hand, chronic anthropogenic load on the chemical composition of all watercourses of the reservoir.

REFERENCES

[1] G. S. Rozenberg. Volzhskii bassein: na puti k ustoichivomu razvitiyu [The Volga basin: towards sustainable development], Kassandra, Tolyatti, 2009, 478 p.

[2] D. B. Gelashvili, E. V. Koposov, L. A. Laptev. Ekologiya Nizhnego Novgoroda: monografiya [The ecology of Nizhny Novgorod: a monograph], NNGASU, N.Novgorod, 2008, 530 p.

[3] G. S. Rozenberg. Volzhskii bassein. Ustoichivoe razvitie: opyt, problemy, perspektivy [The Volga basin. Sustainable development: experience, problems, prospects], Institut ustoichivogo razvitiya Obshchestvennoi palaty RF, Moscow, 2011, 104 p.

[4] D. Yu. Garashchuk, Zh. A Dimidenok. Monitoring ekologicheskogo sostoyaniya vody reki Ivanovka Amurskoi oblasti, Problemy regionalnoi ekologii, No.5, 1, 2017.

[5] O. A. Kozyreva. Pedagogicheskoe modelirovanie v professionalnoi deyatelnosti uchitelya i nauchno-pedagogicheskogo rabotnika [Pedagogical modeling in the professional activities of a teacher and a researcher/lecturer], Vestnik of Minin University, Vol.8, No.2(31), 1, 2020.

[6] Yu. A. Mazhaiskii, T. M. Guseva. Monitoring tyazhelykh metallov v ekosisteme maloi reki Okskogo basseina [Monitoring of heavy metals in the ecosystem of a small river at the Oka basin], Teoreticheskaya i prikladnaya ekologiya, No.2, 54-59, 2017.

[7] N. V. Zhukova, E. V. Berest, O. V. Nacharkina. Otsenka ekologicheskogo sostoyaniya poverkhnostnykh vod gorodskogo okruga Saransk [An assessment of the ecological state of surface waters of the urban district of Saransk], Uspekhi sovremennogo estestvoznaniya, No.10, 7-11, 2018.

[8] A. V. Kozlov, N. N. Koposova, I. P. Uromova, A. V. Volkova, I. R. Novik, L. D. Kovler, A. Yu. Zhadaev, Yu. M. Avdeev. General trends in the environmental state of the atmosphere of the industrial territory of the Nizhny Novgorod region and the sanitary protection zone of Nizhny Novgorod city-forming enterprise, Journal of Environmental Treatment Techniques, Vol.8, No.4, 1434-1438, 2020.

[9] E. S. Bikbulatov. Gidrologo-gidrokhimicheskie usloviya v Gorkovskom i Cheboksarskom vodokhranilishchakh v letnyuyu mezhen 2001 g. [Hydrological and hydrochemical conditions in the Gorky and Cheboksary reservoirs in the summer low-water period in 2001], Ekologicheskaya khimiya, Vol.15, No.2, 82-94, 2006.

[10] A. V. Kozlov, D. S. Markova, S. A. Sokolyuk, V. I. Toguzov. Ekspertiza ekologo-gidrokhimicheskogo sostoyaniya pamyatnika prirody – ozera Svetloyar Nizhegorodskoi oblasti [Expertise of the ecological and hydrochemical state of a natural monument, lake Svetloyar of the Nizhny Novgorod region], Uspekhi sovremennogo estestvoznaniya, No.6, 74-81, 2019.

[11] O. A. Kozyreva. Teoretizatsiya i modelirovanie pedagogicheskikh uslovii v professionalnoi deyatelnosti nauchno-pedagogicheskogo rabotnika [Theorization and modeling of pedagogical conditions in the professional activities of a researcher/lecturer], Vestnik of Minin University, Vol.9, No.1(34), 3, 2021.

[12] A. V. Kozlov, N. N. Koposova, I. P. Uromova, A. V. Volkova, I. V. Vershinina, Yu. M. Avdeev, A. Yu. Veselova. Environmental assessment of minor rivers flowing within the boundaries of Nizhny Novgorod, International Journal of Advanced Research in Engineering and Technology, Vol.11, No.4, 100-107, 2020.

[13] M. A. Baturina, O. A. Makarevich, I. A. Kaigorodova, T. V. Zhukova, B. V. Adamovich. Rol annelid (*Annelida*) v ozerakh Narochanskoi sistemy (Belarus) [The role of Annelida in the lakes of the Naroch system (Belarus)], Mezhdunarodnyi zhurnal prikladnykh i fundamentalnykh issledovanii, No.12-1, 56-59, 2018.

[14] E. N. Imant, A. P. Novoselov. Kachestvennye i kolichestvennye pokazateli zooplanktona ozer Lacha (Arkhangelskaya oblast) i Golodnaya Guba (Nenetskii avtonomnyi okrug) [Qualitative and quantitative indicators of zooplankton in Lacha (Arkhangelsk region) and Golodnaya Guba (Nenets autonomous region) lakes], Mezhdunarodnyi zhurnal prikladnykh i fundamentalnykh issledovanii, No.12-2, 266-271, 2018.

[15] V. A. Gabyshev, O. I. Gabysheva. K izucheniyu vliyaniya kontsentratsii organicheskikh i biogennykh veshchestv na tsenoticheskuyu i floristicheskuyu strukturu soobshchestv miksotrofnykh fitoflagellyat krupnykh subarkticheskikh rek Vostochnoi Sibiri [Towards the study of the influence of the concentration of organic and biogenic substances on the cenotic and floristic structure of the communities of mixotrophic phytoflagellates of large subarctic rivers of Eastern Siberia], Mezhdunarodnyi zhurnal prikladnykh i fundamentalnykh issledovanii, No.6, 93-97, 2018.

[16] P. V. Matafonov. Prostranstvennoe raspredelenie litoralnogo zoobentosa v ozere Arakhlei v malovodnyi period [The spatial distribution of littoral zoobenthos in Lake Arakhley during dry periods], Mezhdunarodnyi zhurnal prikladnykh i fundamentalnykh issledovanii, No.5-1, 180-184, 2018.

[17] G. V. Shurganova. Gidrokhimicheskii rezhim i sovremennoe sostoyanie soobshchestv zooplanktona Gorkovskogo i Cheboksarskogo vodokhranilishch [The hydrochemical regime and current state of zooplankton communities in the Gorky and Cheboksary reservoirs], Vestnik Nizhegorodskogo universiteta im. N. I. Lobachevskogo, Vol.1, No.11, 63-68, 2006.

[18] Yu. Yu. Levin. Dinamika sovremennogo sostoyaniya vody Cheboksarskogo vodokhranilishcha na territorii Nizhegorodskoi oblasti [Dynamics of the current state of water in the Cheboksary reservoir in the territory of the Nizhny Novgorod region], Uspekhi sovremennogo estestvoznaniya, No.2, 94-100, 2014.

[19] S. P. Kitaev. Ekologicheskiye osnovy bioproduktivnosti ozer raznykh prirodnykh zon [Ecological bases of bioproductivity of lakes of different natural zones], Nauka, Moscow, 1984, 208 p.

[20] A. M. Lyakh, A. M. Suvorov, Yu. V. Bryantseva. Obzor metodov kolichestvennogo ucheta fitoplanktona [Review of methods for quantitative accounting of phytoplankton], Sbornik nauchnykh trudov NAN Ukrainy "Sistemy kontrolya okruzhayushchey sredy" [Collection of scientific papers of the National Academy of Sciences of Ukraine "Environmental control systems"], MGI, Sevastopol, 425-430, 2002.

[21] Rukovodstvo po metodam gidrobiologicheskogo analiza poverkhnostnykh vod i donnykh otlozheniy [Guidelines for methods of hydrobiological analysis of surface waters and bottom sediments], Gidrometeoizdat, St. Petersburg, 1983. 240 p.

[22] N. M. Mineeva, N. N. Abramova. Pigmenty fitoplanktona kak pokazateli ekologicheskogo sostoyaniya Cheboksarskogo vodokhranilishcha [Phytoplankton pigments as indicators of the ecological state of the Cheboksary reservoir]. Vodnyye resursy, Vol. 36, No. 5, 588-596, 2009.

[23] A. G. Okhapkin, S. I. Genkal. Tsentricheskiye diatomovyye vodorosli v planktone Cheboksarskogo vodokhranilishcha [Centric diatoms in the plankton of the Cheboksary reservoir], Biologiya vnutrennikh vod: informatsionnyy byulleten, No. 83, 12-16, 1989.