Article

Assessing the environmental status of the Zeya River by the state of aquatic communities at the construction site of the Amur Gas Chemical Complex

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Abstract. Environmental engineering survey performed at the construction site of the Amur Gas Chemical Complex in 2018 in order to assess the state of aquatic communities of the Zeya River revealed 37 taxa of planktonic algae (below genus rank), 32 species of zooplankton, and 37 species of benthic organisms. In May, phytoplankton was mainly represented by diatoms; in July, it was more diverse, when green algae, golden algae and cyanobacteria all played a significant role. In May, zooplankton included mainly rotifers; in July, crustaceans dominated by biomass at most stations. Zoobenthos was represented in May mainly by oligochaetes and bivalves, while insects dominated in July. The abundance and biomass of phytoplankton, zooplankton, and benthos were low. The Goodnight–Whitley, Parele, Woodiwiss, and Mayer indices testified to relatively favorable environmental conditions in the studied sections of the Zeya River. According to the indicators of phyto- and zooplankton, and zoobenthos, the waters of the river are classified as oligosaprobic.

Keywords: phytoplankton, zooplankton, zoobenthos, water quality assessment, Amur River basin

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Научная статья

Оценка экологического статуса р. Зеи по состоянию сообществ гидробионтов на участке строительства Амурского газохимического комплекса

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Аннотация. В ходе оценки состояния сообществ гидробионтов реки Зеи на участке строительства Амурского газохимического комплекса в 2018 г. выявлено 37 таксонов планктонных водорослей рангом ниже рода, 32 вида зоопланктона и 37 видов бентосных организмов. В мае фитопланктон представлен большей частью диатомовыми водорослями, в июле он был более разнообразен, существенную роль играли зеленые, золотистые водоросли и цианобактерии. Зоопланктон в мае включал в основном коловраток, в июле на ряде станций по биомассе доминировали ракообразные. Зообентос в мае представлен преимущественно олигохетами и двустворчатыми моллюсками, тогда как в июле доминировали насекомые. Показатели численности и биомассы фитопланктона, зоопланктона и бентоса невысоки. Индексы Гуднайта и Уитлея, Пареле, Вудивиса, Майера свидетельствуют об относительно благополучных экологических условиях на изученных участках реки. По показателям фито- и зоопланктона, зообентоса воды реки отнесены к олигосапробным.

Ключевые слова: фитопланктон, зоопланктон, зообентос, оценка качества вод, бассейн Амура

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Introduction

Environmental engineering survey (EES) is a necessary stage in the construction of any large industrial facility already at the stage of design documentation. This step allows assessing the current state and predicting possible changes in the natural environment under the influence of anthropogenic load in order to prevent, to minimize, or to eliminate harmful and undesirable environmental and related social, economic, and some other consequences and to maintain optimal living conditions for the population[1].

The Amur Gas Chemical Complex (AGCC) will be the largest enterprise for the production of polyethylene and polypropylene in the region; its production capacity will be 2.7 million tons of ethylene per year. The construction of the AGCC in the Amur Region is carried out by SIBUR, the largest petro-chemical company in Russia. AGCC will be technologically linked to the Amur Gas Processing Plant, owned by Gazprom, which will produce feedstock for AGCC.

A part of EES in 2018 was an assessment of the environmental status of the Zeya River, particularly, describing the state of aquatic organisms at the site of the planned location of the water intake of river water and at that of the outlet of treated wastewater of the AGCC.

The Zeya River is the largest tributary of the Amur River. Although it is superior at the confluence of the Amur River in depth, width, and drainage, it is historically considered its left tributary, flowing into it at a distance of 1936 km from the mouth. The Zeya River has a length of 1242 km; it flows in the Amur Oblast. The river is mostly fed by rain (50–70% of the total annual runoff), it is characterized by high water content: the average annual discharge at the mouth is 1910 m^3/s. The greatest depth of the river at low water is 60 m, the greatest width is 4 km. The Zeya River has 640 tributaries, mostly less than 10-km long, with a total length of 1672 km. There are 19841 lakes in the catchment area with the total lake area of 1021 km^2. The waters of the river are used for water supply and hydropower, and navigation, since there are about 650 km from the dam of the Zeya hydroelectric power station to the river mouth. Watercourses and reservoirs of the basin of the Zeya River is often exposed to extreme natural events, such as floods, including catastrophic ones (Bogatov, 2003; Ermolaeva, 2014).

There is a small number of scientific publications devoted to the study of aquatic communities in the surveyed area; they mainly describe aquatic organisms of the Zeya Reservoir and of the tributaries of the Zeya River (Bogatov, 2003; Ermolaeva, 2014; Medvedeva, 2010, 2021; Sheveleva, 2006a, b). In 2017, 4 species are indicated as a part of the zooplankton community of the Zeya River, in 2018, 5 species, in 2019, 8 species (Ezhegodnik..., 2018, 2020).

An even smaller number of references is devoted to assessing the ecological state of water bodies as part of EES in nearby areas (Garetova et al., 2011; Yavorskaya, 2020).

The study aims to assess the ecological status of the site of the Zeya River in the area of river water intake and treated wastewater outlet of the AGCC (under construction) according to the state of aquatic communities.

Materials and methods

The studies were carried out in the Amur Oblast, Svobodnensky District, 15–17 km north-northeast of the town of Svobodny, at the Zeya River in the area of river water intake and treated wastewater outlet of the AGCC (under construction). On this site the Zeya River has a width of 450 to 550 m, the river valley is asymmetric, with a steep right bank and gentle left bank, the channel forms free, less often forced bends; the floodplain width reaches here 13–15 km. The river bottom is represented mainly by sands and sandy-pebbly sediments, but there are also areas, where the bottom is covered by sandy-silty sediments.

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[1] SP 502.1325800.2021 Engineering and environmental surveys for construction. General rules for the production of works.

Hydrochemical sampling was carried out in June and July 2018 at four stations (Fig. 1) in accordance with the approved methodology[2] using the equipment according to GOST 17.1.5.04-81[3]. The hydrochemical and hydrophysical parameters were measured in an accredited testing laboratory of the Federal State Budgetary Institution State Agrochemical Service "Kostromskaya", Kostroma (accreditation certificate no. ROSS RU.0001.21PCH18).

According to the chemical composition, the river water belongs to the hydrocarbonate class, calcium group. In June 2018, At the study site, fluorides MPC for fishery reservoirs[4] exceeded by 5.8 times in the water intake area, 6.4 times in the water outlet area; manganese MPC, 3.8 and 2.5 times, iron MPC, 4.4 and 4.6 times, aluminum MPC, 5.8 and 5.5 times, respectively, which was largely due to the natural background[5],[6].

In the water intake area (Fig. 1), the water turbidity ranged from 2.0 to 2.9 mg/dm^3 in June and from ≤ 0.1 to 0.1 in July; the coloration exceeded 100 degrees, the water transparency was 22 cm in June and 14–15.8 cm in July. A pH was 6.8–7.0, which corresponded to a neutral reaction.

In the outlet area of treated wastewater, water turbidity varied from 1.4 to 1.7 mg/dm^3 in June and from 1.4 to 5.4 mg/dm ^{3} in July, the values of transparency, color and pH were similar to those for the water intake area.

In the study area, a coastal pebble strip with very sparse herbaceous vegetation adjoins the water's edge, which turns into thickets of willow, periodically flooded during high water. On the border of pebbles and willows there is a strip of driftwood (tree trunks, branches) brought by floods.

Aquatic organisms were sampled at four stations in May and July 2018: in the area of the planned water intake of the AGCC under construction at the Zeya River (station no. 3) and 500 m upstream (station no. 4), as well as in the water outlet area (station no. 1) and 500 m upstream (station no. 2). Integral samples of phytoplankton, zooplankton and zoobenthos were taken. In the area of the downstream sampling site, the Gashchina River (right tributary, 23-km long) flows into the Zeya River.

Phytoplankton was sampled by filtration of 50 L of water through the Juday plankton net (mesh size 67 μm) (Voodorosli, 1989). Phytoplankton samples were processed by accepted method (Fedorov, 1979) in a Nageotte counting chamber (0.05-mL volume, 1.0-cm^2 counting area) under a microscope Micromed 2 var. 3-20inf equipped ToupCam 3/1 MP digital camera. The species composition of phytoplankton, abundance and biomass were determined (Sukhanov, 1983). When identifying genera and species of phytoplankton organisms, list of taxonomic keys was used (Dedusenko-Shchegoleva and Gollerbakh, 1962; Gollerbakh et al., 1953; Kiselev, 1954; Kosinskaya, 1960; Krammer and Lange-Bertalot, 1986, 1988, 1991a, b; Matvienko, 1954; Moshkova and Gollerbakh, 1986; Vinogradova et al., 1980; Zabelina et al., 1951).

Zooplankton samples were taken using a Juday plankton net through the entire water column (from the bottom to the surface) from a motorboat Gladiator 330. In order to detect small forms of zooplankton, samples were taken using a Ruttner bathometer with further applying the settling method. The samples were fixed in 4% formaldehyde solution and processed according to the standard procedure (Salazkin et al., 1982). When identifying zooplankton species, taxonomic keys were used, (Opredelitel'..., 1995, 2010). Based on the phytoplankton abundance and zooplankton, the water saprobity was assessed according to Pantle–Buck saprobity index (Pantle and Buck, 1955). The Shannon–Weaver species diversity index (Shannon and Weaver, 1963), Mäemets (Mäemets, 1979) and Hakkari (Hakkari, 1972) trophic state indices were used to characterize water quality. Ecological and geographic groups of zooplankton and phytoplankton were identified in accordance with the literature data (Ermolaeva, 2014; Proshkina-Lavrenko, 1953; Sheveleva and Shaburova, 2011).

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[2] GOST R 51592-2000. Water. General requirements for sampling, using the equipment accredited in GOST 17.1.5.04-81

[3] GOST 17.1.5.04-81. Instruments and devices for sampling, primary processing and storage of samples of natural waters.

[4] Order of the Ministry of Agriculture of Russia dated December 13, 2016 No. 552 "On approval of water quality standards for fishery water bodies, including standards for maximum permissible concentrations of harmful substances in the waters of fishery water bodies".

[5] Environmental engineering surveys of water intake sites and external communications. Technical report AGKhK.0008-VK-IEI1.1-T. Moscow, 2018.

[6] State Report "On the state of sanitary and epidemiological well-being of the population in the Russian Federation in 2017 in the Amur Oblast".
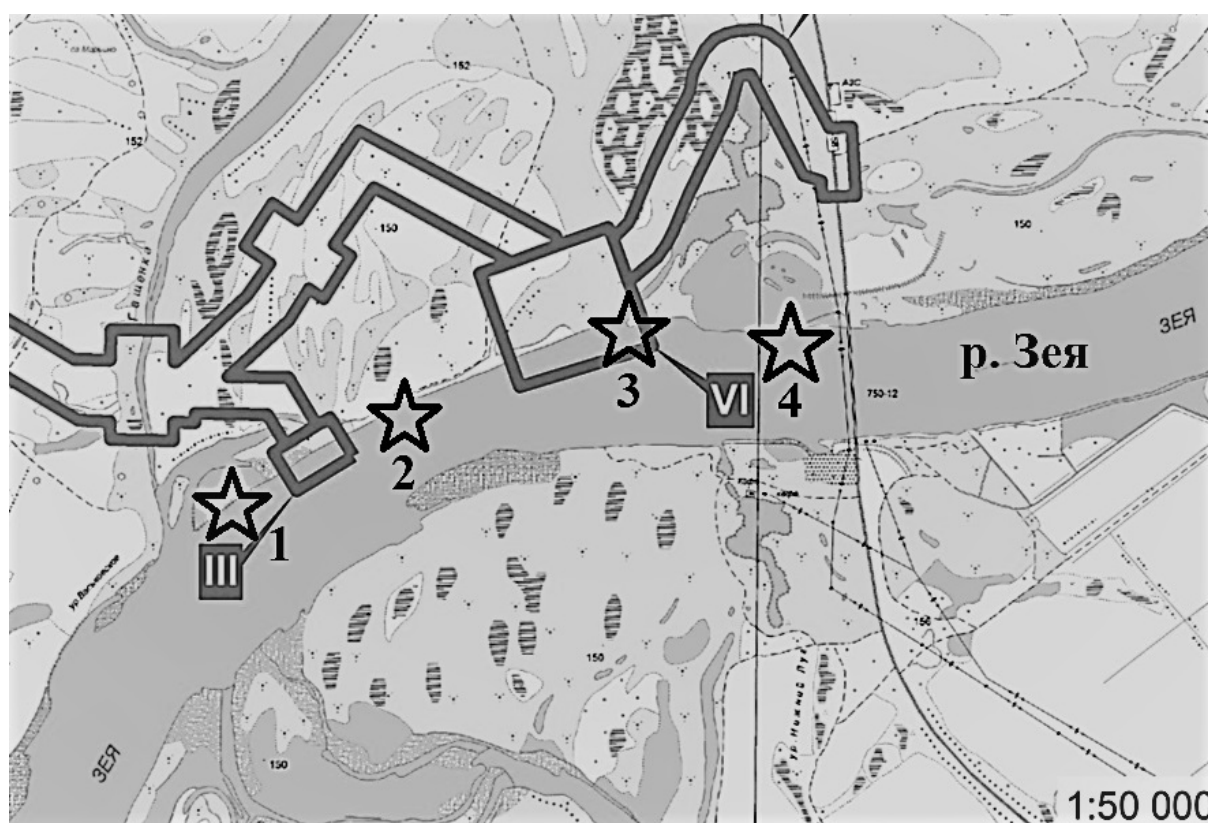
Fig. 1. Study site of the Zeya River. III – water outlet of treated wastewater; VI – river water intake at the Zeya River; 1–4 – sampling sites; gray lines indicate the boundaries of the EES.

Benthic samples were taken with an Ekman–Burge bottom grab and a benthic scraper in accordance with published recommendations (Tiunova, 2003). The organisms were fixed in flasks with 4% formaldehyde solution. Taxonomic keys were used to identify benthic species (Opredelitel'..., 1994, 1997, 2000, 2001, 2006, 2016). The abundance, biomass, Woodiwiss index (Woodiwiss, 1977), Mayer index (Surzhko et al., 2010), Goodnight–Whitley index (Goodnight and Whitley, 1961), Parele's oligochaete-based index (Shitikov et al., 2003), and Shannon–Weaver index (Shannon and Weaver, 1963) were used to assess the water quality of the studied areas of the Zeya River for benthos. The abundance of benthic organisms was determined by direct counting of the individuals in the sample, biomass, by direct weighing of the animals using an electronic scale Scoutspu (Ohaus, Switzerland).

Results

Phytoplankton

At the study sites, during the sampling period, the phytoplankton community was represented by 37 taxa with a rank below the genus: the species rank was determined for 16 taxa, genus rank, for 21 taxa. All algae taxa belonged to five divisions: Cyanobacteria, Bacillariophyta, Chlorophyta, Dinophyta, and Ochrophyta. At the same time, 45.5% of the total abundance were represented by Bacillariophyta, 33.3%, by Chlorophyta, all other divisions of algae were represented by a significantly lower relative abundance (Fig. 2).

According to ecological and geographical analysis of phytoplankton, cosmopolitan true planktonic forms prevailed in the microalgae communities of the studied section of the river, the share of planktonic benthic forms was 18.8%. Ubiquitous forms predominated in terms of halobity (93.7%).

In May 2018, phytoplankton community was represented by 24 genera and 9 species belonging to the divisions Cyanobacteria, Bacillariophyta, Chlorophyta, and Ochrophyta, in July, by 26 genera and 13 species from all the registered divisions (Fig. 3).

At all study sites, diatoms were present in phytoplankton, represented by the largest abundance of taxa with a rank below the genus, in May, phytoplankton community at station no. 3 was formed by diatoms only. Such diatoms as *Asterionella* Hassall, *Aulacoseira* Thwaites, and *Pinnularia* Ehrenberg were noted at all sampling sites. Also, Chlorophyta representatives made a significant contribution to the phytoplankton diversity; their share of the total abundance of taxa with a rank below the genus ranged from 18% to 37%. Representatives of golden algae (*Dinobryon divergens* O.E. Imhof.) were found in May at all sampling sites, except for the station no. 3. Cyanobacteria contributed significantly to the taxonomic structure of phytoplankton only at station no. 1 in July. The role of Dinophyta and Ochrophyta representatives was minor in the formation of the taxonomic structure of the studied section of the Zeya River during the study period.
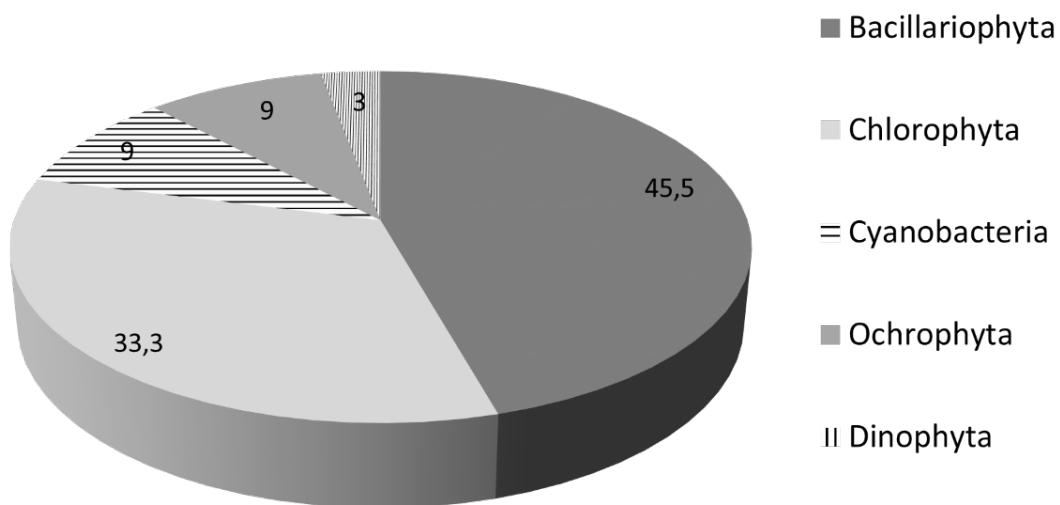

Fig. 2. The share (%) of different systematic groups of phytoplankton in the microalgal communities of the Zeya River.
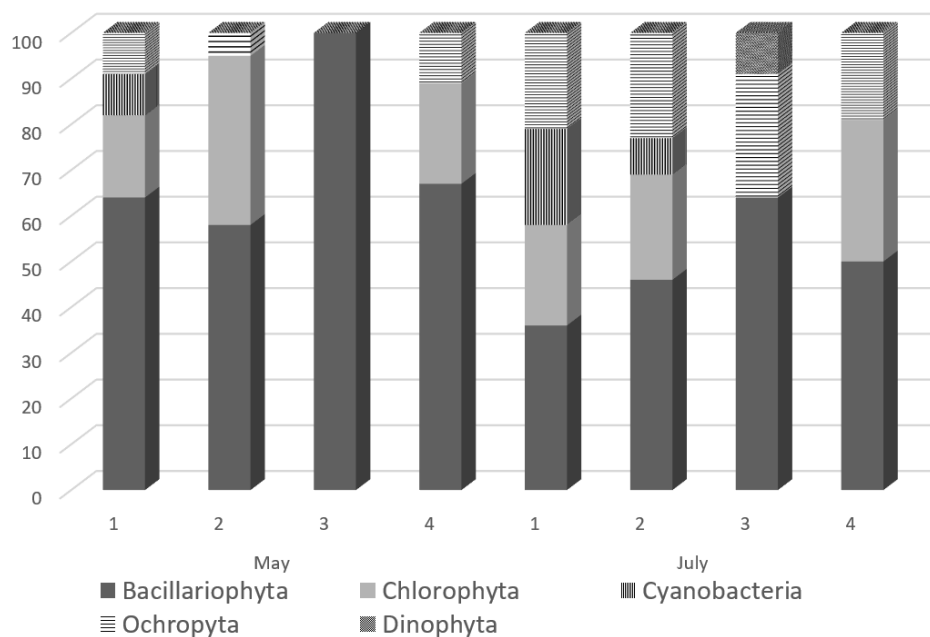

Fig. 3. The share (%) of representatives of different systematic groups of phytoplankton at the sampling sites in May and July 2018.

Indicators of the abundance and biomass of phytoplankton at the stations during the study period are presented in Table 1.

We noted the highest abundance and diversity of phytoplankton organisms in May at station no. 1, in the area of confluence of the Gashchina River. The largest contribution to the phytoplankton abundance here was made by Ochrophyta representatives (*D. divergens*). The impact of other divisions in the abundance was insignificant. The phytoplankton biomass at this station was low, since it was formed mainly by diatoms and green algae, which had a low abundance, and golden algae, due to their small size, did not make a significant contribution.

In May, at station no. 2, the phytoplankton abundance was 3.4 times lower than at station no. 1, but 4.1 and 2.0 times higher compared to stations nos. 3 and 4, respectively. At the same time, the abundance of diatoms and green algae at station no. 2 was more than two times higher than at station no. 1, and the abundance of golden algae compared with station no. 1 decreased by almost 9 times. No cyanobacteria were registered at station no. 2. At the same time, the maximum biomass for the entire study period was registered here in May. Green and diatom algae had the most impact to total biomass, similarly to station no. 1.

The lowest abundance and biomass in May were noted at station no. 3 in the area of the planned water intake of the AGCC. At this station, phytoplankton was formed only by Bacillariophyta representatives, their abundance was comparable to the values at station no. 1.

At station no. 4 in May, representatives of diatoms, green, and golden algae were found. Like at station no. 2, representatives of Ochrophyta and Bacillariophyta contributed the most to total abundance, Chlorophyta and Bacillariophyta, to total biomass. At this station, a high abundance of representatives of diatoms of the genera *Pinnularia* and *Tabellaria* Ehrenberg was registered.

The average phytoplankton abundance in the studied area in May 2018 was 173777.05 ± 84301.84 cells/L, biomass, 4180.75 ± 1472.29 mg/m³.

In July 2018, a both the abundance and biomass of phytoplankton decreased at most stations compared to May of the same year, which could be due to unfavorable weather conditions during the study period. At station no. 1, the phytoplankton abundance has decreased by more than two orders of magnitude. This change was associated primarily with a significant decrease (more than 500 times) in

Table 1. Abundance and biomass of phytoplankton of the Zeya River in May and July 2018.

Taxonomic group	May 2018				July 2018			
	Station no.							
	1	2	3	4	1	2	3	4
Phytoplankton abundance, cells/L								
Bacillariophyta	37196.3	82125.1	32996.7	57949.7	1533.0	1660.9	3033.0	4799.5
Chlorophyta	1599.8	3555.2	0	3555.2	833.0	867.0	0	1244.0
Cyanobacteria	1999.8	0	0	0	1112.0	722.0	0	0
Ochrophyta	417958.2	49772.8	0	6399.4	778.0	1227.0	850.0	81414.0
Dinophyta	0	0	0	0	0	289.0	0	0
Total	**458754.1**	**135453.1**	**32996.7**	**67904.3**	**4256.0**	**4765.9**	**3889.0**	**87457.5**
Phytoplankton biomass, mg/m³								
Bacillariophyta	829.9	3054.9	746.9	1509.9	27.0	86.0	2804.0	334.0
Chlorophyta	704.3	5247.6	0	3980.5	343.0	237.0	0	575.0
Cyanobacteria	505.9	0	0	0	57.6	23	0	0
Ochrophyta	126.2	15.0	0	1.9	89.7	15.2	104.2	173.9
Dinophyta	0	0	0	0	0	25.4	0	0
Total	**2166.3**	**8317.5**	**746.9**	**5492.3**	**517.3**	**386.6**	**2908.2**	**1082.9**

the abundance of golden algae, which accounted for more than 90% of the total phytoplankton abundance at this station in May. Phytoplankton biomass decreased by 4 times at station no. 1 in July; mainly Chlorophyta representatives were present. However, Ochrophyta still made a significant contribution to the biomass at this station, which was associated with the appearance of new representatives of this department, which had larger cells comparing with the dominant ones in spring (*D. divergens*).

At station no. 2, the phytoplankton abundance in July decreased by 28 times, which was primarily due to a significant decrease in the abundance of diatoms and Ochrophyta. Simultaneously, a representative of cyanobacteria (*Anabaena variabilis* Kutz) appeared in phytoplankton. Also, only at this station, a representative of dinophyte algae, *Ceratium hirundinella* (O.F.M.) Bergh was registered. The decrease in abundance in July resulted in a 21-fold decrease in phytoplankton biomass at this station. The biomass here was formed mainly by green algae and diatoms.

In July, at station no. 3, the phytoplankton abundance has decreased also by about 8 times. In May, phytoplankton at this station was represented only by diatoms; in July, Ochrophyta were also encountered in addition to diatoms. Along with that, the biomass at station no. 3 increased by July, which was associated with the appearance of larger algae belonging to Bacillariophyta division.

At station no. 4 in July, an increase in the phytoplankton abundance was observed, which is associated with the appearance here in a large abundance of golden algae *D. divergens.* However, the biomass values at station no. 4 decreased by about 5 times, as the abundance of diatoms and green algae, dominated by biomass in May, had decreased by July.

The average phytoplankton abundance in the study areas in July 2018 was 25092.11 ± 18004.01 cells/L, biomass, 1223.75 ± 503.56 mg/m^3. The decline in abundance and biomass in July was probably due to the flood developed at that time, which caused a significant water level rise in the Zeya River and high flow velocity. In general, the quantitative indicators of phytoplankton at the studied sites of the water area of the Zeya River correspond to oligotrophic conditions.

Saprobity indices, calculated from the phytoplankton abundance, varied from oligosaprobic to β-mesosaprobic values at different stations of the watercourse, which was associated with an uneven distribution of indicator species in algocoenoses (Fig. 4). In spring, the index values varied from 1.0 (station no. 3) to 1.58 (station no. 4), in July, from 1.24 to 1.7, respectively. In general, the values of the saprobity index at the stations nos. 1 and 3 corresponded to the oligosaprobic zone, and at the stations no. 2 and 4, to the β-mesosaprobic zone. At the same time, it should be noted that the saprobity index values were close to those for the oligosaprobic zone, even when their absolute values were the maximum observed.
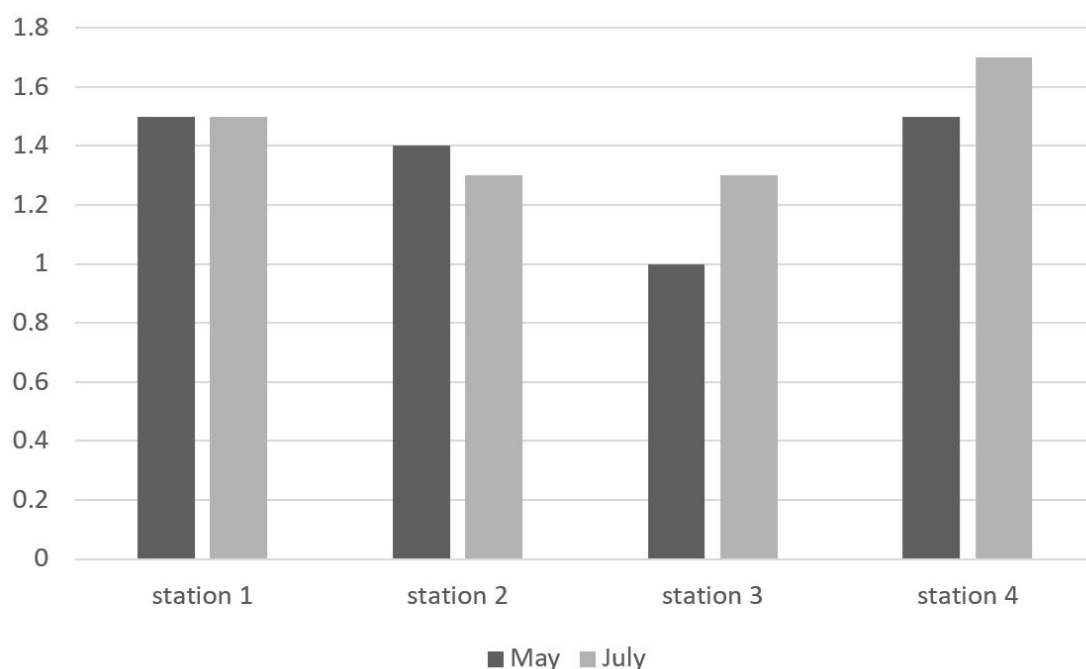

Fig. 4. Saprobic indices for phytoplankton at the sampling sites in May and July 2018.

Zooplankton

Zooplankton of the surveyed area of the Zeya River was represented by 32 species, among which Rotifera prevailed (20 species), copepods and cladocerans were also found (3 and 9 species, respectively). Cladocera accounted for 28.13% of the total abundance, copepods, 9.37%, and rotifers, 62.5%.

The most common species were of *Synchaeta pectinata* Ehrenberg, 1832, *Euchlanis dilatata* Ehrenberg, 1832, and the genera *Asplanchna* and *Keratella.* The representatives of the genus *Asplanchna* were found in all the samples. Similar species were previously noted for tributaries of the Zeya River (Ermolaeva, 2014).

Cosmopolitan species dominated in zooplankton community (56.3%), followed by Palearctic (21.9%) and Holarctic species (9.4%), all the others comprised 12.5% total. By the ecological groups of zooplankton, eurytopic species predominated (52.9%), followed by littoral (23.5%), planktonic (17.6%), and phytophilic (11.7%).

The highest zooplankton abundance in May and July was noted at station no. 1, which was the downstream point in the water outlet area (Table 2). The zooplankton community at station no. 1 was influenced by the zooplankton of the Gashchina River, inflowing into the Zeya River near this station. Small rivers with a low flow rate are characterized by stable development of the zooplankton community, and here the abundance and biomass of zooplankters may reach significant values (Krylov, 2005). Some zooplankton is carried by the current into the Zeya River, which provides higher quantitative indicators of zooplankton in the area of the mouth of the Gashchina River.

For the same reason, zooplankton biomass also reached the highest values at station no. 1, which exceeded that by 11.2 times in May and by 12.9 times in July at station no. 2. Here, rotifers made the largest contribution both in terms of abundance (88.9–95.0%) and biomass (71.7–92.8%) in May and July (Fig. 5).

In the area of the water outlet (station no. 2), slightly upstream of the Zeya River, the zooplankton abundance and biomass were low both in May and July. It should be noted that cladocerans were absent at this station in both study periods. Higher values of these parameters were noted in May at station no. 3, which was located in the area of water intake. Rotifers dominated here by abundance (77.4%), Copepoda, by biomass (46.7%). An increase in both abundance and biomass of zooplankton in this area was preconditioned by the transport of zooplankton from the bay (at the site of the former quarry), which was located slightly upstream. Similar to small rivers, the zooplankton community successfully developed in the bay in the absence of strong currents, as a result, part of the zooplankton community entered the Zeya River.

Table 2. Abundance and biomass of zooplankton of the Zeya River in May and July 2018.

Taxonomic group	May 2018				July 2018			
	Station no.							
	1	2	3	4	1	2	3	4
Zooplankton abundance, ind./m^3								
Cladocera	300.0	0	133.3	0	426.7	0	20	866.7
Copepoda	920.0	800.0	1733.5	400.0	823.4	933.4	120.0	1386.5
Rotifera	23251.0	5000.0	6400.8	3000.0	10020.7	533.4	154.0	3000.2
Total	**24471.0**	**5800.0**	**8267.7**	**3400.0**	**11270.8**	**1466.8**	**294.0**	**5253.4**
Biomass of zooplankton, mg/m^3								
Cladocera	10.30	0	2.40	0	29.50	0	0.80	65.14
Copepoda	3.80	4.08	15.70	2.00	18.02	9.73	6.20	52.09
Rotifera	182.90	13.50	15.50	11.00	120.30	3.23	0.90	10.23
Total	**197.00**	**17.58**	**33.60**	**13.00**	**167.82**	12.96	7.90	127.46

We noted the lowest quantitative indicators of zooplankton in May for station no. 4 – upstream of the designed water intake and upstream of the channel connecting the former quarry (bay) with the river Zeya. The low biomass and zooplankton abundance are associated with the presence of a current and the absence of macrophytes on the rocky bottom of the river. No cladoceran crustaceans were found here; rotifers predominate in terms of abundance and biomass (88.2 and 84.6%, respectively).

The average zooplankton abundance in the study areas in May 2018 was 10484.68 ± 4772.40 ind./m^3, and biomass, 65.27 ± 44.16 mg/m^3. The zooplankton composition in May was dominated by rotifers (77.4–95.0% in abundance and 46.13–92.84% in biomass).

In July, in the period preceding the sampling of zooplankton, there were heavy rains in the Amur Region, which caused a flood situation and an overflow of the Zeya River. The water level in the river rose significantly, the flow rate increased, many coastal areas were flooded, and a significant amount of wood debris accumulated along the banks (Fig. 6). All this undoubtedly had a negative impact on the development of the zooplankton community.

The lowest quantitative indicators of zooplankton in July were observed at station no. 3. Rotifers dominated here in abundance (52.3%), and Copepoda (78.5%) in biomass. Somewhat higher abundance and biomass of zooplankton in July were noted at station no. 4, where, while rotifers predominated in abundance (57.1%), cladocerans dominated in biomass (51.1%).

In general, in July 2018, low quantitative indicators of the zooplankton community were observed. The average zooplankton abundance was 4571.3 ± 2474.1 ind./m^3, while the biomass was slightly higher than in May, 79.05 ± 40.49 mg/m^3. This is due to the better development of crustacean plankton in July compared to May.

The values of the abundance and biomass of zooplankton indicate the oligotrophic status of the studied areas of the water area of the Zeya River (Andronikova, 1996). The average value of the species diversity index for the study period was 2.14 ± 0.28, which corresponds to the mesotrophic type of the watercourse (Andronikova, 1996).

Zooplankton saprobity index values according to Pantle–Buck saprobity index (Fig. 7) characterize the waters of the Zeya River near the water intake and outlet as oligosaprobic. Only in May at station no. 4 and July at station no. 1, these values correspond to β-mesosaprobic conditions. However, the saprobity indices in these cases also have values closer to the boundaries of oligosaprobic conditions.

Trophy coefficient according to Mäemets was 3.75, which characterizes the waters of the studied areas of the Zeya River as eutrophic. The E/O index according to Hakkari, equal to 2.67, also classifies
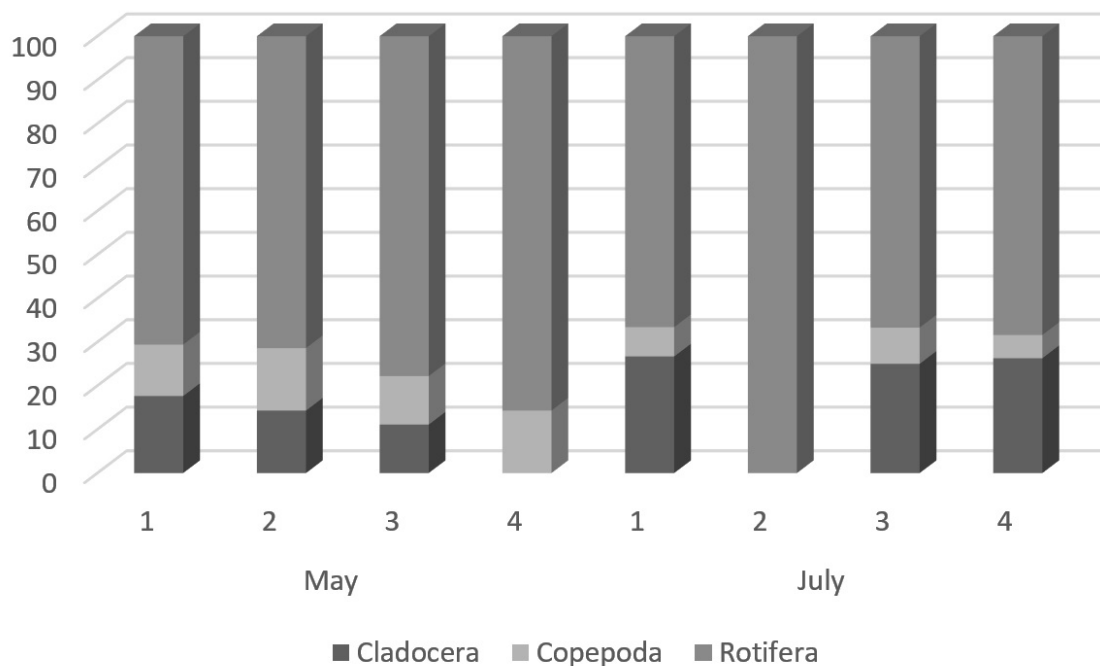

Fig. 5. Taxonomic structure of zooplankton (%) at the sampling sites in May and July 2018.

the waters of the studied areas as eutrophic. This is due to the fact that in the composition of zooplankton we noted quite a lot of species that can develop in the water area of the Gashchina River and carried out with the course of the Zeya River. Similar species were noted earlier for tributaries of the Zeya River (Ermolaeva, 2014). The species diversity of zooplankton in the studied section of the river is also influenced by hydrological conditions (flood situation and the presence of a current).

Zoobenthos

Taxonomic structure of the benthos community in the studied area of the Zeya River was represented by 37 species, among which the representatives of the class Insecta are the most common – 47.2% (18 species). The class Oligochaeta is represented by 9 species (25% of the abundance of species encountered), Bivalvia by 4 species (11.1%), Gastropoda by 5 species (13.9%); 1 species of Nematoda was also recorded (2.8%).

The zoobenthos was dominated by cosmopolitan species (40% of the total abundance of identified species), Eastern Palearctic (15%), Palearctic (25%) and trans-Palaearctic species (10%) were present, and others accounted for 10%.

The most common bentonts were representatives of the Chironomidae family, which were present in all samples at all stations in May and July 2018. Chironomids are represented by species belonging mostly to the *Chironomus* genus. Also, among the chironomids, representatives of the genus *Tendipes*

Fig. 6. Wood debris (drift-wood) and flooded willow on the shore of the Zeya River in July 2018.

were often found, which were not found only at station no. 4. Of the gastropods, the most common were representatives of the genus *Cincinna,* among bivalves – representatives of the genus *Pisidium.* The occurrence of different taxonomic groups in the composition of benthos depended mainly on the season of the year and on the nature of the soils at the sampling sites.

The highest abundance of benthic organisms in May 2018 was noted at station no. 1 in the outlet area (Table 3). In July, this indicator in this zone decreased significantly, but remained the highest compared to other sampling sites. This is due to various factors, in particular the confluence of the Gashchina River, a high flow rate and the presence of sandy-silty masses at the bottom, which is the reason for the presence of a large abundance of mollusks and oligochaetes that prefer soft soils. Among the oligochaetes, the most common were representatives of the genera *Tubifex* and *Ophidonais.*

In May and July, the smallest abundance of benthos was noted at station no. 2 (rocky soil). In May, insect larvae were mainly found, which were able to lead a sedentary lifestyle at one of the stages of the development cycle. In July, other taxonomic groups were identified in benthos, Nematoda and Oligochaeta, in addition to insects. The average abundance of benthos at the studied sites in May was 271.9 ± 153.9 ind./m^2.

The structure of the benthic community changed significantly in July: the species richness and abundance of organisms decreased, which was associated with the flooding of the river and the coastal area, rising water level and high flow velocity. Juvenile stages of insects from the orders Ephemeroptera, Diptera, Odonata, and Plecoptera dominated. Oligochetes and mollusks were found singly in the samples, their abundance decreased in July due to changes in the habitat conditions. In the samples obtained at stations nos. 2 and 3, several individuals of nematodes were noted. The small size and shape of the body allowed nematodes to move between soil particles. The average abundance of benthos at the studied sites in July 2018 was 118.8 ± 47.2 ind./m^2.

The highest biomass of benthos in May 2018 was observed at station no. 1, where bivalves and gastropods were found (represented mainly by the genera *Sphaerium* and *Cincinna*). The lowest biomass was noted at station no. 2, where only insect larvae were present, mainly representatives of the orders Ephemeroptera and Diptera. The average biomass of benthos at the studied sites in May 2018 was 1.8 ± 0.9 g/m^2.

Gastropods had a significant share in the benthos biomass in July. The highest value of this indicator was noted at station no. 3, where large gastropods of the genera *Lymnaea* and *Cincinna* were found.
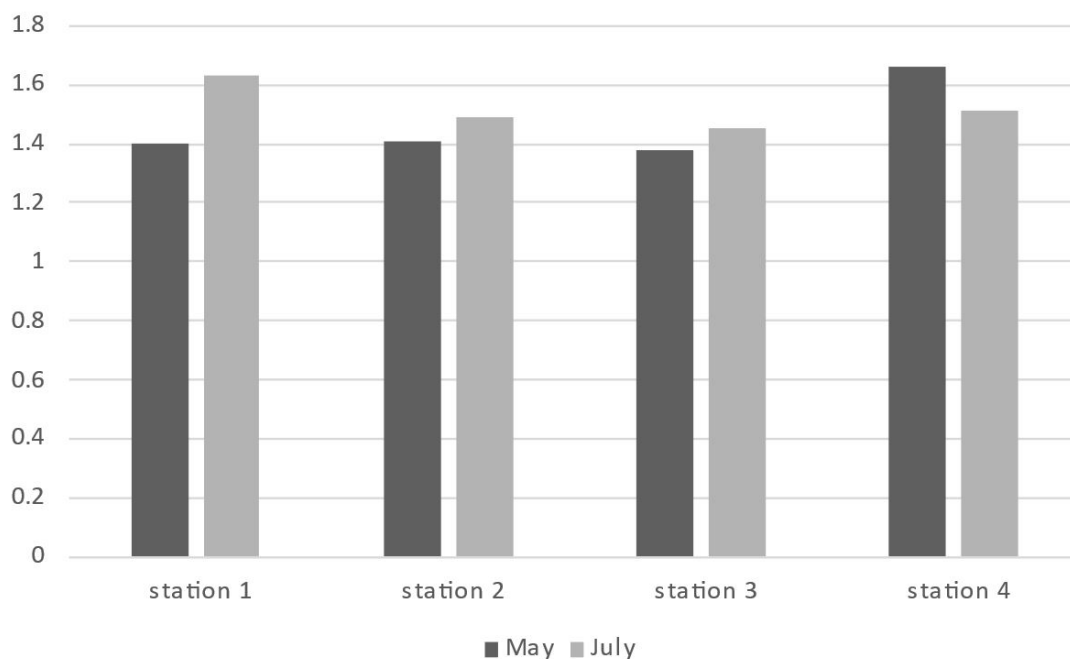

Fig. 7. Saprobic indices for zooplankton at the sampling sites in May and July 2018.

The flood in July affected the benthos community, changing not only the diversity and abundance of organisms, but also shifting the ratio of ecological groups towards larger representatives and animals capable of attaching to the substrate. The average biomass of benthos at the studied sites in July 2018 was 2.0 ± 0.5 g/m^2.

In general, at the studied sites of the Zeya River, insects and bivalves dominated both by abundance and biomass. The greatest diversity of benthic fauna was typical for July, when many benthic organisms reproduced actively. During this period, *Nemurella pictetii* Klapálek, 1900 (Plecoptera), *Ophiogomphus cecilia* Fourcroy, 1785 (Odonata), *Ephemerella ignita* Poda, 1761, and *Heptagenia sulphurea* Müller, 1776 (Ephemeroptera) were registered, which were absent in May. At the same time, mayflies of the genera *Ephemera* and *Baetis,* as well as *Atherix ibis* Fabricius, 1798 (Diptera) did not occur in July.

Generally, benthos biomass values characterized the studied area of the Zeya River in May and July as oligotrophic (Kitaev, 1984), although, the biomass indicators corresponded to the mesotrophic status at some stations due to local conditions (Table 3). The average Shannon–Weaver diversity index for the study period was 1.76 ± 0.19. The Goodnight–Whitley index was 31.3% in May and 3.98% in July, which indicated a good ecological state of the studied sections of the river. The Parele's index, which characterized the class of water quality in watercourses via the ratio of tubificids and other benthic animals by abundance, was 0.31 in May, which made it possible to attribute the river to a slightly polluted type. In July, the Parele's index was 0.04, which corresponded to relatively clean conditions (Shitikov et al., 2003). The differences of the Parele's index by the stations and within the season were insignificant; in most cases, it characterized the studied areas as oligosaprobic with a good ecological state. In the Zeya River, stoneflies, mayflies, and caddisflies (i.e., representatives of benthic animals sensitive to pollution) were found. The Woodiwiss index was 9 points (quality class I–II, conditionally clean water). The Mayer index, which takes into account the confinement of aquatic organisms to water bodies with a certain degree of pollution, was 19 (quality class II, a relatively clean water).

Table 3. The abundance and biomass of benthos in May and July 2018 at the studied sites of the Zeya River.

| Taxonomic group | May 2018 | | | | July 2018 | | | |
| | Station no. | | | | | | | |
	1	2	3	4	1	2	3	4
	Abundance of benthos, ind./m^2							
Insecta	50.0	62.5	12.5	62.5	162.5	62.5	162.5	162.5
Oligochaeta	362.5	0	12.5	125.0	0	12.5	12.5	0
Nematoda	0	0	0	0	0	50.0	25.0	0
Bivalvia	300.0	0	75.0	12.5	25.0	0	0	25.0
Gastropoda	12.5	0	0	0	12.5	0	12.5	12.5
Total	**725.0**	**62.5**	**100.0**	**200.0**	**200.0**	**25.0**	**50.0**	**200.0**
	Biomass of benthos, g/m^2							
Insecta	0.10	0.45	0.01	0.13	0.07	3.45	1.57	0.43
Oligochaeta	1.60	0	0.04	0.37	0.27	0.03	0.01	0
Nematoda	0	0	0	0	0	0.06	0.03	0
Bivalvia	2.50	0	1.80	0.15	0.33	0	0	0.51
Gastropoda	0.30	0	0	0	1.06	0	3.40	0.64
Total	**4.50**	**0.45**	**1.85**	**0.65**	**1.73**	**3.54**	**5.01**	**1.58**

Discussion

In the areas of water intake and water outlet of the AGCC (under construction) at the Zeya River, 37 taxa of algae (below the genus rank), 32 species of zooplankton, and 37 species of benthic animals were found.

The highest taxonomic diversity was noted for Bacillariophyta, whose representatives accounted for 36–100% of total species richness of planktonic algae at all sampling sites in the study area on the Zeya River in May and July 2018. The frequency of occurrence of diatoms of the genera *Asterionella, Aulacoseira,* and *Pinnularia* was 100%, which indicated their ubiquitous distribution in the studied section of the river and thus was consistent with the results of studies by other authors (Medvedeva, 2021, Medvedeva and Semenchenko, 2019). The frequency of occurrence of the golden algae *D. divergens* was 87.5%. In general, the phytoplankton species composition was poor in the study area of the Zeya River.

Cladocerans were among the dominant taxa. The identified species composition was consistent with the studies of zooplankton in the tributaries of the Zeya River (Ermolaeva, 2014). According to our data, the Zeya River is characterized by low biomass and zooplankton abundance, but they are somewhat higher than those given earlier (Ezhegodnik..., 2018, 2020). This is due to the fact that we took samples not in the medial (as in these studies), but in the zones of the future water intake and outlet, which were located in ripal, where the composition of zooplankton was influenced by inflows of the Zeya River. The values of the saprobity index practically coincide with the data of other studies (Ezhegodnik..., 2018, 2020).

Bivalves and insects dominated in zoobenthic communities of the studied areas of the Zeya River, which was typical for the rivers of the Amur River basin in general and of the Zeya River in particular (Vdovina and Bezmaternykh, 2020; Yavorskaya, 2016, 2020). In May, high abundance was also characteristic of oligochaetes, whose share had decreased by July. Among insects, larvae of the Chironomidae family dominated by abundance, which was also noted by other researchers (Vdovina and Bezmaternykh, 2020; Yavorskaya, 2020). The values of bioindicative indices coincide with the data of other authors: Woodiwiss index (8 points) and Goodnight–Whitley index (3–49%) for the Bolshaya Pera River, the tributary of the Zeya River (Yavorskaya, 2020) characterized its waters as clean (quality class I–II).

The cosmopolitan species and ubiquitous forms (by halobity) dominated in the phytoplankton community. The zooplankton community was mainly represented by cosmopolitan species, although the share of Palearctic species was significant. Eurytopic and planktonic species predominated as the ecological groups of zooplankton. The cosmopolitan and Palearctic species dominated in zoobenthos also.

In general, the abundance and biomass of all groups of aquatic organisms were quite low, which may be due to both the hydrological regime of the river and the weather conditions during the study period. In May, the abundance and biomass were higher than in July, which was due to the flood occurred in summer.

Saprobity indices for phytoplankton in May and July corresponded to the oligo- and β- mesosaprobic zone and water quality class II. Most of the values of Pantle–Buck saprobity index (in regard to zooplankton) characterized the waters of the Zeya River near the water intake and outlet as oligosaprobic. The Shannon–Weaver species diversity index in the studied area corresponded to mesotrophic conditions; its value was influenced by such factors as current, low water temperatures, and flood. The values of the Mäemets' trophic coefficient and the Hakkari index (E/O) characterized the waters of the studied areas of the Zeya River as eutrophic, which was associated with the transport of aquatic organisms by the waters of the Gashchina River. It is obvious that these are local conditions that do not apply to areas remote from the mouths of the inflowing tributaries of the Zeya River. The indicators of benthos biomass characterized the studied sections of the river mainly as oligotrophic. The Goodnight–Whitley, Parele, Woodiwiss, and Mayer indices indicate relatively favorable environmental conditions at the studied sites.

Conclusions

The communities of phytoplankton, zooplankton, and zoobenthos may serve as indicators of the ecological state of watercourses, including such large ones as the Zeya River. It is also necessary to take into account the influence of local factors, such as the delta sections of watercourses of the second order (in relation to the studied one) when assessing the indicators of aquatic communities in general.

In terms of species composition, quantitative indicators of communities, and contemporary ecological indices, the ecological state of the studied sites of the Zeya River allows us to conclude on the almost pristine conditions for developing the aquatic communities in the surveyed water area in 2018, so they depended to a greater extent on the local meteorological, hydrological, and climatic factors.

It should be also noted that constant monitoring of the state of the environment is desirable in the areas of construction of large industrial facilities; the water bioindicator analysis is the most important part of such surveys. Data on the biota of the Zeya River at the plant construction site may serve as the basis for long-term monitoring of the ecological state of the river. This will allow to implement timely the necessary measures in order to minimize damage to the natural ecosystems.

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