Species diversity of phyto- and zooplankton in the water bodies of Kharanorskaya State District Power Plant, Transbaikalia (according to 2019 data)

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Abstract. We described the taxonomic structure of planktonic associations in the water bodies of Kharanor State District Power Plant (cooling pond, water supply, drainage, and water intake channels of Kharanor reservoir located in the arid zone of the south-eastern Transbaikalia in a highly continental climate). Hydrobiological researches were conducted in April, July, and October 2019. We identified 141 algal taxa ranked below the genus, representing the divisions of Cyanobacteria (15 taxa), Bacillariophyta (41), Chrysophyta (10), Cryptophyta (3), Dinophyta (4), Charophyta (8), Chlorophyta (56), and Euglenophyta (4), and 52 zooplankton taxa, including 28 species and subspecies of Rotifera, 15 species of Cladocera, and 9 species of Copepoda. In the cooling reservoir, the plankton community included 135 phytoplankton taxa and 38 zooplankton species; 58 algal taxa and 27 invertebrate species were sampled in the water supply channel, 50 taxa and 26 species were sampled in the drainage channel, and 94 taxa and 24 species were collected from water intake channel respectively. Six diatom species (Stephanodiscus hantzschii, Nitzschia sigmoidea, Fragilaria radians, Asterionella formosa, Ulnaria ulna) and four zooplankton species (rotifers Asplanchna priodonta and crustaceans Daphnia galeata, Bosmina longirostris, Thermocyclops crassus) occurred in all water bodies during the entire study period.

1. Introduction
Ecologists consider the intense development of power engineering, especially thermal and nuclear power plants, to be a serious threat to the biological diversity in water bodies [1, 2]. Temperature is a principal environmental factor, which has a key effect on variations in species diversity and largely determines the species abundance in ecosystems under steady-state conditions [3-5].

The phyto- and zooplankton in the water bodies of Kharanor SDPP (State District Power Plant) were studied in 1995-1997 [6, 7], 2000-2003 [7, 8], 2005, 2007 [7] and 2012-2013 [9-11]. Our research aim was to provide a current description of species diversity in phytoplankton and zooplankton communities in the water bodies of Kharanor SDPP.

2. Materials and Methods
2.1. Study area
The Kharanor SDPP cooling pond is located in the arid zone of the south-eastern of Transbaikalia in a highly continental climate. The reservoir is formed by the embankment of the floodplain of the Onon River floodplain at the confluence of the Turga River. It is a self-leveling flat reservoir of floodplain-
valley type with seasonal regulation. The water surface area is 4.1 km² at a normal retaining level, the volume of water mass is $15.6 \times 10^6$ m³, and the average depth is 3.8 m. During the open water period, the filling and feeding of the reservoir were caused by the water from the Onon River through the water supply channel; during the freeze-up period, the water came from the drainage channel. The technical water supply system of the power plant is mixed (straight-through-circulating) in summer and fully circulating in winter. Water enters the power station through the water intake channel from the cooling reservoir and then it is discharged into the spillway channel [8]. The circular pattern of circulation of the flow of water mass causes a high intensity of internal water exchange (up to 30 times a year). The ice cover is formed only in the central part of the reservoir (about 2/3 of the area), where the ice thickness does not exceed 0.5 m.

Planktonic samples were collected from different parts of the cooling pond and channels (figure 1, table 1).

![Figure 1. Map-scheme of the water bodies of Kharanor SDPP and sampling sites.](image)

2.2. Methods

Plankton samples were collected in April, July, and October 2019. For phytoplankton, samples were collected from one or two layers with a Patalas bathometer (PB-6, Borok, Russia) [12]. Zooplankton samples were obtained using a Juday net (mesh size of 0.064 mm), with a single sampling pass from the lake bed to the surface in the case of deep waters [13]. Aliquots from the duplicate integral samples were used. Phytoplankton samples were fixed in Lugol’s solution [12]. Zooplankton samples were fixed with 4% formalin solution [13]. We used the taxonomic database of algae [14] for the valid names of species. The keys by [15-18] were used to identify zooplankters.
Table 1. Station characteristics and sampling sites in the water bodies of Kharanor SDPP.

| Station number | Station name          | Station coordinates          |
|----------------|-----------------------|-----------------------------|
| 1              | water supply channel  | 50.862828° S; 115.658760° W |
| 2              |                       | 50.864337° S; 115.661705° W |
| 3              |                       | 50.860315° S; 115.671329° W |
| 4              |                       | 50.855029° S; 115.677683° W |
| 5              |                       | 50.850155° S; 115.669138° W |
| 6              |                       | 50.859896° S; 115.688286° W |
| 7              |                       | 50.851686° S; 115.685810° W |
| 8              | cooling pond          | 50.851753° S; 115.694820° W |
| 9              |                       | 50.845140° S; 115.681193° W |
| 10             | water intake channel  | 50.849307° S; 115.697423° W |
| 11             |                       | 50.843573° S; 115.676977° W |
| 12             |                       | 50.859962° S; 115.661964° W |
| 13             | drainage channel      | 50.865428° S; 115.657088° W |

3. Results and Discussion

We identified 141 algal taxa in the phytoplankton, belonging to 8 phyla. Green algal (40 % of the total number of taxa) and diatoms (30% of the total number of taxa) had the highest species diversity (table 2).

The number of algal taxa varied from 24 to 100. The average value was 46±27. In the cooling pond, phytoplankton consisted of 135 taxa ranked below the genus level of algae, 73 taxa were in the water supply channel, 50 taxa were in the drainage channel, and 94 taxa were in the water intake channel. Six species: Stephanodiscus hantzschii, Nitzschia sigmoidea, Fragilaria radians, Asterionella formosa, and Ulnaria ulna occurred in all water bodies during the entire research period. Jaaginema woronicinii, Microcystis aeruginosa, Microcystis pulvacea, Kephyrion moniliferum, Aulacoseira ambigu, Cyclotraphonos dubius, Cocconeis pediculus, Didymosphenia geminate, Hippodonta hungarica, Diatoma vulgaris, Meridion circulare, Tabellaria fenestrare, T. flocculosa, Ulnaria capitate, Cryptomonas ovata, Ceratium hirundinellae, Tetrastrum elegans, T. triacanthum, Pseudoschroederia robusta, Ankyra ancora, Coenochloris korshikovi, Radiococcus polycoccus, Desmodesmus opolensis, D. spinosus, Lagerheimia longiseta, Oocystis marssonii, Tetrachlereola alternans, Golenkiniospis solitaria, Mucidosphearium pulchellum, Actinastrum hantzschii, Euglena longissimii, and Euglenaformis proxima were registered only in the reservoir; Epithemia sorex and Komma caudata were sampled in water supply channel, and Iconella hibernica was sampled in the water intake channel.

Table 2. Taxonomic structure of planktonic algae in the water bodies of Kharanor SDPP.

| Phyla                      | Number of classes | Number of orders | Number of families | Number of genus | Species of Intraspécific | Genus Total |
|---------------------------|-------------------|------------------|-------------------|----------------|--------------------------|-------------|
| Cyanobacteria             | 1                 | 4                | 7                 | 10             | 12                       | 3           |
| Bacillariophyta           | 3                 | 13               | 16                | 26             | 35                       | 1           |
| Chrysophyta               | 2                 | 2                | 2                 | 5              | 9                        | 1           |
| Cryptophyta               | 1                 | 1                | 2                 | 2              | 3                        | 3           |
| Dinophyta                 | 1                 | 4                | 4                 | 4              | 3                        | 1           |
| Charophyta                | 2                 | 2                | 3                 | 4              | 3                        | 5           |
| Chlorophyta               | 2                 | 4                | 13                | 28             | 55                       | 1           |
| Euglenophyta              | 1                 | 1                | 1                 | 3              | 2                        | 2           |
Long-term dynamics of phytoplankton features a rising trend in the diversity of diatoms species which are mainly represented by benthic-planktonic species from genera *Fragilaria*, *Iconella*, *Diatoma*, *Meridion*, *Tabellaria*. However, particular species of green algae (*Micractinium appendikulatum*, *M. quadrisetum*, *Coenocystis reniformis*, *C. obtusa*, *Coenochloris fotti*, and others) and chrysophytes (*Chromulina pirenigera*, *Chrysococcus cystophorus*, *Pseudokephyrion pilidum*, *P. schilleri*, *P. ellipsoidenum*, and others) have disappeared. The proportions of some dominant algae phyla have changed. In July 2001, diatoms were dominant in phytoplankton with scarce green algae and an insignificant amount of cyanobacteria [8]. Recently, cyanobacteria have been detected in summer phytoplankton in far bigger amounts, while green algae (mainly chlorococcales) have become more prevalent in autumn. Besides, under the stress of heating up, the decrease in diversity and abundance of diatoms, and a growing trend of cyanobacteria and green algae have been observed in other cooling ponds [19-21].

There were 52 taxa in zooplankton. Species and subspecies of Rotifera were accounted for 54 % of the total number of taxa, while the Cladocera and Copepoda ones were 29 %, and 17 % respectively (table 3).

| Taxa           | Rotifera | Cladocera | Copepoda | Total |
|----------------|----------|-----------|----------|-------|
| Class          | 2        | 1         | 1        | 4     |
| Ordo           | 5        | 2         | 3        | 10    |
| Family         | 11       | 6         | 3        | 20    |
| Genus          | 16       | 12        | 8        | 36    |
| Species and subspecies | 28 | 15 | 9 | 52 |

The species number varied from 10 to 27 with the average value of 15±5. In the cooling reservoir, zooplankton included 38 species, 27 species were in the water supply channel, 26 species were on the drainage channel, and 24 species were in the water intake channel. Four species (*Asplanchna priodonta*, *Daphnia galeata*, *Bosmina longirostris*, *Thermocyclops crassus*) occurred in pond and channels during the entire research period. Rotifers (*Proales sp*, *Epiphanes macroura*, *Brachionus quadridentatus quadridentatus*, *B. variabilis*, *Keratella cochlearis tecta*, *K. c. hispida*, *Trichocerca (Diurella) sp.*) and crustaceans (*Alona guttata*, *Monospilus dispar*, *Macrocylops albidus*) noted only in the pond; species *Epiphanes brachionus*, *Notholca squamula*, *Trichocerca stylata*, *Simocephalus vetulus*, *Alona costata*, *Macrocylops albidus* were in the water supply channel, species *Notholca acuminata*, *Chydorus ovalis*, *Macrocylops albidus* were in the drainage channel, and cladocerans *Ilyocryptus sordidus* in the water intake channel.

Long-term studies also have shown a higher diversity of rotifers following their decrease in dominance and the reduction of crustacean species that had become more prevalent in plankton. The higher dominance index denotes the growing abundance of one and/or two species, which is typical of eutrophic water bodies [22]. In 2019, the increase was registered in the number of Calanoida that were not observed in plankton in 2007 [7] and were sporadical in 2012-2013 [9]. According to the researches [23], *S. sarsi* were the most abundant throughout the peak growth of cyanophytes. We have observed that rotifers are also growing in abundance while having been almost absent from zooplankton in 2012-2013 [9].

In conclusion, we registered the highest species diversity in the reservoir (135 algal taxa and 38 zooplankton species). Among the channels, the highest species richness was noted in the water intake channel (94 phytoplankton taxa) and water supply channel (27 zooplankton species). Six diatom species (*Stephanodiscus hantzschii*, *Nitzschia sigmoidea*, *Fragilaria radians*, *Asterionella formosa*, and *Ulnaria ulna*) and four zooplankton species (rotifers *Asplanchna priodonta* and crustaceans *Daphnia galeata*, *Bosmina longirostris*, *Thermocyclops crassus*) occurred in all water bodies during the entire study period.
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