Development of planktonic community in the different types of water bodies under the influence of priority environmental factors

E Yu Afonina¹ and N A Tashlykova
Institute of Natural Resources, Ecology and Cryology of the Siberian Branch of Russian Academy of Sciences, Chita, 672014, Russia

¹E-mail: kataf@mail.ru

Abstract. The present paper is based on the results of long-term studies of planktonic algae and invertebrates in the fresh, soda and saline and technogenically loaded water bodies. The priority abiotic factors (hydrochemical composition, hydrophysical parameters), determining the development (species number, dominant species, abundance and biomass) of the main taxonomic groups of phyto- and zooplankton were determined.

1. Introduction
The plankton community (phyto- and zooplankton) is an important flexible structural component of aquatic biocenoses; it constitutes the primary and secondary links in the trophic chains of the ecosystem and plays a particular role in the processes of transport and accumulation of substances and energy in the biogeocenoses [1]. Changes in diverse aquatic ecosystems are mainly caused by global and regional climatic fluctuations and anthropogenic factors. Any habitat transformations affect biodiversity and planktonic biocenoses in water bodies. The problem of climatic fluctuations and their ecological impact is particularly relevant for Transbaikalia with its extreme continental climate [2]. Current climatic fluctuations and local anthropogenic load induce shifts in composition and structure of the planktonic communities in water bodies of different types. The aim of the work is to determine the structure of plankton communities and the relationship with environmental factors in the different types of water bodies (fresh and saline lakes, natural and man-made reservoirs).

2. Materials and methods
We have conducted the long-term researches (for over twenty years) on fresh lakes with various trophicity (Shebety, Arakhley, Arey, Shaksha, Ivan, Tasey, Bol'shoy Undugun, Malyi Undugun, Irgen), soda lakes with various salinity (Barun-Torey, Zun-Torey, Tsagan-Nor, Bain-Tsagan, Bain-Bulak, Ukshinda, Bulun-Tsagan, Kulusu-Nur, Balyktyi, Khadatui, Nizhni Mukei, Tsagan-Nur, Narym-Bulak, Nozhii), and natural lakes and man-made reservoirs with high technogenic load (Kenon, Umykeyskeoye lakes and Kharanor and Krasnokamensk reservoirs) (figure 1).

Plankton samples were carried and processed according to standard hydrobiological techniques [3, 4]. Abiotic data (water temperature, sampling depth, transparency, total dissolved solids (TDS), dissolved oxygen, nitrogen and phosphorus contents) were taken from papers [5-9] and own unpublished data. Primary data were subjected to statistical and mathematical processing using the software package.
Microsoft Excel 2010 and add-in for the program Microsoft Excel XLSTAT (Addinsoft, USA). The principal component method (Principal Component Analysis, PCA) was used to research the relationship of the structural characteristics of plankton and environmental factors.

3. Results and discussion
Phyto- and zooplankton parameters (species number, abundance, biomass, and dominant species) in the studied lakes and reservoirs are presented in the table 1.

Table 1. Phyto- and zooplankton diversity and structure indicators in the different types of water bodies.

| Types of water bodies                  | Species number | Abundance, × 10^3 cells/L | Biomass, mg/m^3 | Dominant species                                                                 |
|----------------------------------------|----------------|---------------------------|-----------------|---------------------------------------------------------------------------------|
| Fresh mountain lakes (n=9)             | 35–144         | 23–1500                   | 40–1800         | *Coelosphaerium ketzingianum*, *Lindavia comta*, *Fragilaria crotonensis*, F. radians, *Ulnaria ulna*, *Nitzschia graciliformis*, *Diatoma vulgaris*, *Tabellaria flocculosa*, *Cyclotella meneghiniana*, *Aulacoseira islandica*, *Kephyrion doliolum*, *Chrysococcus rufescens*, *Dinobryon cylindricum*, D. divergens, D. sertularia, *Kephyrion spirale*, *Willea irregularis*, *Crucigenia tetradea*, *Monoraphidium griffithii*, *Oocystis marssonii* |
| Saline steppe lakes (n=15)             | 1–28           | 1–20575                   | 0.1–1997        | *Microcystis aeruginosa*, *Aphanizomenon flosaquae*, *Anabaenopsis un*, *Gloeocapsa sp.*, *Oscillatoria sp.*, O. amphibia, *Snowella lacustris*, *Merismopedia minima*, *Cryptomonas marssonii*, *Cryptothecotaxa setigera*, *Cyclotella sp.*, *Ulnaria ulna*, *Cocconeis placentula*, *Rhopalodia gibberula*, *Oocystis borgei*, *Tetraedron minimum*, *Ankrya ancora*, *Schroederia setigera*. |
The total data set provides conceptual view on the interrelation of plankton biocenoses and primary habitat factors in diverse water bodies under regional climatic changes (figure 2).
Figure 2. Conceptual presentations (based on the method of principal components) of the relationship of planktonic community and priority environmental factors in the different types of water bodies. Legend: T – temperature, H – depth, TR – transparency, TDS – total dissolved solids, [O] – dissolved oxygen, NO$_3$ – nitrate, NO$_2$ – nitrite, [P] – phosphorus and phosphate.

The statistical analysis has shown that, in mineral lakes, the highest factor loadings are represented by TDS and pH values. This confirms that salinity and pH are the primary factors that determine the nature of biological communities [10, 11]. Water transparency is another important factor determining structural characteristics of hydrobionts. Factor loading of this indicator is negative. Due to wind mixing of benthic sediments, species composition of phytoplankton in shallow lakes is influenced by an increased content of suspended particles, which results in dominance of benthic forms over true plankton species among diatoms and increase in specific weight of monad forms of green algae [12]. Trophic conditions are more favorable in lakes with a higher degree of transparency. There is a broad diversity of small-size plankton forms suited for diets of filter feeders and predators [13]. Cyanobacteria and Rotifera are detected as the most sensitive to the variable of salinity while Chlorophyta, Rotifera and Cladocera exhibited remarkable susceptibility to the factor of pH, and Chlorophyta to water transparency [6].

The plankton community structure in fresh waters depends on the phosphorus content (phosphates and total phosphorus), water temperature, depth, and pH (in decreasing order of factor load). In phytoplankton, quantitative indicators of Chlorophyta feature the highest factor loadings (in correlation with water temperature and phosphorus content), Dinophyta (in correlation with pH, temperature and
depth), and Chrysophyta (in correlation with phosphorus content). Within zooplankton, Copepoda are observed as the most sensitive to habitat factors (in correlation with temperature and depth) and Rotifera (in correlation with phosphorus content) [5, 14]. In mountain lakes, temperature and light level are important factors for phytoplankton [15]. Their low values are limiting factors for production, and decreasing nutrient concentrations do not contribute to intensive algae abundance [16]. The water temperature and depth are the determining factors for copepods [17]. Small zooplankton organisms (Rotifera) prefer lighted, most aerated upper lake layers, which are rich in phytoplankton mainly from green algae [18].

In water bodies with high technogenic load, total dissolved solids, pH, and temperature (in decreasing order of factor load) are the priority abiotic factors that have the greatest impact on the diversity and structure of planktonic biocenosis. In phytoplankton, Cyanobacteria, Dinophyta, and Chlorophyta are the most susceptible to the factor variables (in correlation with pH, TDS, temperature respectively); in zooplankton, Cladocera and Copepoda are in correlation with TDS and temperature [8]. Total dissolved solids and a measure of acidity are interrelated parameters that are temperature dependent. It is a known fact that an increase in temperature leads to higher water conductivity. The temperature factor cannot be the only mechanism determining the hydrobiocenoses functioning, but it can make a significant contribution to the other factors action [19].

The main factor components for reservoirs are as follows: water temperature, nitrate and dissolved oxygen contents (in decreasing order of factor load). Quantitative indicators of Cyanobacteria and Chlorophyta (in correlation with nitrogen compounds content) feature the highest factor loadings (in correlation with the content of nitrogen compound), Dinophyta and Euglenophyta (in correlation with temperature), and Charophyta (in correlation with dissolved oxygen content). In zooplankton, Copepoda is the most susceptible to the main abiotic factors [7]. Auxiliary thermal energy is one of the impactful anthropogenic factors for water biocenoses, which, along with hydrodynamic turbulence, shape the picture of ecological effects occurring locally but leading to deep transformations of water ecosystems [20]. The development of planktonic communities, both under the influence of heated waters and under natural temperature conditions, takes place in an interconnected multi-factorial system of hydrochemical and hydrophysical parameters [21].

Thus, the phyto- and zooplankton composition and structure in different types of water bodies depend on the some physical and chemical parameters (total dissolved solids, dissolved oxygen, nutrients (nitrogen and phosphorus), water temperature, transparency and depth).

Acknowledgments
The study was performed for the project of the Program for Basic Scientific Research FUFR-2021-0006.

References
[1] Ostroumov S A 2003 Aquatic organisms as a factor of regulation of the flow of matter and migration of elements in aquatic ecosystems Samara Sci. Center RAS Bull. 5(2) 249–55
[2] Obiazov V A 2014 Changes in the modern climate and assessment of their consequences for natural and natural-anthropogenic systems (Kazan: KFU Press) 39
[3] Kiselev I A 1969 Plankton of the seas and continental reservoirs vol 1 (Leningrad: Nauka) p 658
[4] Sadchikov A P 2003 The study methods of freshwater phytoplankton (Moscow: Universitet i Shkola) p 159
[5] Itigilova M Ts et al. 2013 Ivan-Arakhley lakes at the turn of the century (state and dynamics) ed N M Pronin (Novosibirsk: SB RAS Publ) p 337
[6] Afonina E Yu and Tashlykova N A 2019 Plankton of saline lakes in Southeastern Transbaikalia: transformation and environmental factors Contemp. Probl. Ecol. 12(2) 155–70
[7] Afonina E Yu and Tashlykova N A 2019 The plankton community structure in the zones with different thermal condition (Kharanorskaya TPP cooling pond, Transbaikalia) IOP Conf. Ser.: Earth Environ. Sci. 321 012055
[8] Tashlykova N A and Afonina E Yu 2019 Development of plankton communities in the anthropogenic hydrothermal conditions of Kenon Lake as a cooling reservoir (Transbaikalia) *IOP Conf. Ser.: Earth Environ. Sci.* **321** 012058

[9] Afonina E Yu, Tashlykova N A, Kuklin A P and Tsybekmitova G Ts 2020 Environmental features and dynamics of plankton communities in a mountain glacial moraine lake (Baikal Lake basin, Russia) *Nature Conserv. Res.* **5**(3) 415–23

[10] Williams W D 1998 Salinity as a determinant of the structure of biological communities in salt lakes *Hydrobiologia* **381**(1–3) 191–201

[11] Ivanova M B and Kazantseva T I 2006 Effect of water pH and total dissolved solids on the species diversity of pelagic zooplankton in lakes: a statistical analysis *Rus. J. Ecol.* **37**(4) 264–70

[12] Maksimova O B 2002 *The effect of high water turbidity due to hydroengineering works on the structural-functional characteristics of phytoplankton* (St. Petersburg: StPSU Press) p 21

[13] Echaniz S A, Cabrera G C, Aliaga P L and Vignatti A M 2013 Variations in zooplankton and limnological parameters in a saline lake of La Pampa, Central Argentina, during an annual cycle *Int. J. Ecosys.* **3**(4) 72–81

[14] Afonina E Yu, Tashlykova N A and Tsybekmitova G Ts 2019 Plankton biocenoses of the mountainous Shebety Lake (Zabaikalskii Krai, Russia) *Biol. Bull.* **46**(4) 415–24

[15] Moore J W 1981 Influence of temperature, photoperiod and trophic conditions on the seasonal cycles of phytoplankton and zooplankton in two deep subarctic lakes of Northern Canada *Int. Rev. Ges. Hydrobiol.* **66**(5) 745–70

[16] Bondarenko N A 2009 *Ecology and taxonomic diversity of planktonic algae in the lakes of the mountain regions of Eastern Siberia* (Borok: IBIW RAN Press) p 46

[17] Smyntek P M, Teece M A, Schulz K L and Storch A J 2008 Taxonomic differences in the essential fatty acid composition of groups of freshwater zooplankton relate to reproductive demands and generation time *Freshwater Biol.* **53**(9) 1768–82

[18] Catalan J et al. 2006 High mountain lakes: extreme habitats and witnesses of environmental change *Limnetica* **25**(1–2) 551–84

[19] Denisov D B and Kashulin N A 2012 Current state of algal communities in the area of Kola NPP influence (Imandra Lake) *Proc. Kola Sci. Center RAS* **3**(16) 70–96

[20] Afonina E Yu 2012 *Zooplankton in the filling cooling pond of Kharanorskaya TPP: the diversity formation dynamics and ecology* Acad. Diss. Cand. Biol. Sci. (Chita: INREC SB RAS Press) p 186

[21] Suzdaleva A L 2006 Impact of water discharge from NPP cooling systems on plankton of reservoirs *Engineer. Ecol.* **4** 51–7