Seasonal dynamics of phyto- and zooplankton and their relationships in a small urbanized reservoir, by the example of the Lake Bolshoe Vasilievskoe (Togliatti city, Samara region, Russia)

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Abstract. The abiotic environmental factors and the composition of phyto- and zooplankton were homogeneous along the entire water body in a shallow polymictic hypereutrophic urbanized Lake Bolshoe Vasilievskoe (Togliatti city, Samara region, Russia). The species composition of phytoplankton was quite diverse and corresponded to the type characteristic of small water bodies of the middle and lower reaches of the Volga River. Zooplankton was represented quite poorly, mostly by eurybiont species, which were the indicators of a high degree of organic pollution. During the year, the species composition of the entire phytoplankton and the complex of dominant forms of algae corresponded to a certain stage of the seasonal periodicity and successive change of hydro-climatic phases for shallow hypertrophic water bodies. We analyzed the communities of phyto- and zooplankton and their relationships under the influence of eutrophication and seasonal changes in abiotic environmental factors. Summer cycles of phyto- and zooplankton abundance and biomass dynamics had opposite dynamics. In autumn, there was a synchronous decrease in both abundance and biomass of phyto- and zooplankton, associated with the natural seasonal cycles of abiotic environmental factors. In winter, the abundance of warm-water zooplankton species was higher than that of typical cold-water species; the opposite pattern was observed in summer. The method of the correlation pleiades of Terentyev revealed that phytoplankton was the main environment-forming component of the ecosystem in the Lake Bolshoe Vasilievskoe. It was also found that an increase in the level of trophicity of the Lake Bolshoe Vasilievskoe, including an increase in the concentration of biogenic elements (nitrogen, phosphorus), affected the zooplankton community through phytoplankton community indirectly.

1. Introduction
Small urban water bodies are of great ecological importance [1, 2, 3]. They affect both micro- and mesoclimate, contribute to the circulation of substances and energy, and participate in bioremediation processes. In addition, they are of significant aesthetic and recreational value for city dwellers [4, 5]. The increasing anthropogenic load leads to unfavorable changes (Toxicification, silting, eutrophication, etc.), which destroy the course of their natural cycles [5, 6, 7].

Phyto- and zooplankton are the most important components of the aquatic environment that are directly involved in the transformation of organic matter and in the cycles of matter and energy in
aquatic ecosystems. In addition, these organisms are sensitive indicators of the state of the environment [8, 9, 10]. Their diversity, abundance and biomass serve as an integral indicator of the cumulative impact of factors characterizing the state of the entire water body, the trophic status, and the degree of pollution [11, 12, 13]. In this regard, the study of particular components of plankton in urbanized water bodies and searching for the patterns of their interaction are among the most important issues of aquatic ecology nowadays.

The study aims to analyze the development of phyto- and zooplankton in a small urbanized reservoir during the season and to identify the main environmental factors affecting this process.

2. Materials and Methods

The Vasilievsky Lakes System is located on the northeastern border of Togliatti city. The Lake Bolshoe Vasilievskoe is a channel lake of the former Piskala River, the oldest of the group of the lakes, located in the upper part of the system (53.54 N, 49.52 E). It is a reservoir of irregular configuration, stretching from north to south. Its total area is about 75 hectares; the average depth is 1.6 m, the maximum depth, 3.5 m. According to morphometric parameters, the lake belongs to the category of small and very small reservoirs [14].

The anthropogenic load on the lake comes from the industrial enterprises located near the city of Togliatti, such as Togliatti CHP plant; treatment facilities of Volga Automotive Plant and Togliatti Automotive Plant (AvtoVAZ group). The village Vasilyevka and dacha area, located on the lake shores, and numerous vacationers affect the lake directly [15, 16].

According to the results of complex studies of the lake, the trophic state of the Lake Bolshoe Vasilievskoe was assessed as highly eutrophic in the late 1980s—early 1990s [15-18].

In 2013, the study of the lake was resumed due to the introduction of the microalgae Chlorella vulgaris IPPAS C-111 into the lake for algolization (biologic rehabilitation through correction of algocenosis), according to the method suggested by N.I. Bogdanov [19].

Sampling was carried out monthly from June through October 2013 and in February 2014 in the surface and near-bottom water layers at three stations (nos. 1, 2, and 3). At the same time, physical and chemical parameters, composition of water and content of biogenic elements were determined at the same stations (figure 1).

![Figure 1. General view of the Lake Bolshoe Vasilievskoe and location of sampling sites (●).](image)

2.1. General characteristics of abiotic factors

The Lake Bolshoe Vasilievskoe is a shallow polymictic water body. Hydrophysical and hydrochemical parameters at different stations of the lake during the study period did not differ significantly (table 1).
In 2013, the ice melting occurred in the second half of April. The maximum water temperature in the surface layer was noted from June through August. Temperature stratification in the lake was recorded only in certain periods in its deepest part (station no. 3).

Almost the entire water column was oxygenated throughout the season; only in summer and autumn, short-term hypoxia was noted from time to time in the near-bottom layer of the deep-water station no. 3. During the ice period, the conditions in the lake were anoxic; an insignificant oxygen content was noted only at station no. 3, directly under the ice.

In all parts of the lake, water was slightly alkaline and/or alkaline in the surface layer, reaching a maximum of pH < 10 in the late summer-early autumn period, which was probably associated with the active development of phytoplankton [21, 22].

During the whole study period of 2013, low water transparency, high concentrations of chlorophyll $a$ and total phosphorus were observed in the Lake Bolshoe Vasilievskoe; according to these indicators, the lake status was assessed as hypertrophic [21, 22], belonging to sodium bicarbonate class [22].

### 2.2. Research methods

Samples of phyto- and zooplankton were taken and processed according to standard hydrobiological methods [23-25]. The biological material was fixed with a 4% formaldehyde solution.

The module of ecological analysis "FW-Zooplankton" was used to process the dataset of ecological parameters affecting the development of zooplankton [26]. The species composition and frequency of occurrence ($Pb$, %) of phyto- and zooplankton were used from the databases "Phytoplankton of small natural reservoirs of anthropogenically transformed landscape of the Samara region: floristic composition, indicators of quantitative development and structural characteristics" and "Zooplankton of pelagic and higher aquatic vegetation of an urbanized reservoir (the Lake Bolshoe Vasilievskoe, Togliatti, Samara region): species composition, quantitative development and structural characteristics", respectively [27, 28]. The data in the tables are presented as $m \pm SD$ (mean ± standard deviation), $n$ is the number of replicates.

The dendrogram of the similarity of phyto- and zooplankton composition has been developed by the method of correlation pleiades of Terentyev [29], based on the Sørensen coefficient, where the vertices of the graphs are located in a circle, and the thickness of the ribs changes depending on the similarity coefficient. The range of similarity coefficients is: A – 0–40%, B – 41–50%, C – 51–60%; D – 61–80%; E – 81–100%. Spearman's rank nonparametric correlation coefficient has been calculate with threshold values $r < 0.5$. The Mann-Whitney U-test has been applied to compare two independent samples; multiple comparison of parameters has been performed using the Kruskal-Wallis test (KW), as well as the Fisher test ($F$), at the significance levels of $p < 0.05$ and $p < 0.01$. The method of correlation pleiades of Terentyev has been applied for detailed analysis of the material [29, 30].

The dominant species were set as comprising 10% and more of the total abundance and/or biomass. The $B_{zoo}/B_{ph}$ ratio of zoo- and phytoplankton biomass was estimated [31]. The trophicity level of the lake was determined by the total biomass of phytoplankton [8]. The water saprobity was assessed by the Pantle-Buck method with Sláděček modification, using the known indicator values of the saprobity of certain species [32–36].

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**Table 1.** Hydrophysical and hydrochemical characteristics of the Lake Bolshoe Vasilievskoe ($n = 30$) [20]: $P_{total}$ – total concentration of phosphorus; “—” – data are absent.

| Year/Month | $T_{water}$ (°C) | pH | Eh | $O_2$ (%) | $P_{total}$ (mg/L) | N-NH$_4$ (mg/L) |
|------------|------------------|----|----|----------|--------------------|-----------------|
| 2013       |                  |    |    |          |                    |                 |
| VI         | 24.5±0.87        | 9.3±0.15 | 346.6±34.48 | 10.47±0.56 | 0.30±0.15 | 1.1±0.30 |
| VII        | 25.9±1.43        | 9.9±0.70  | 286.4±18.75 | 98.90±2.49 | 0.31±0.12 | 0.90±0.11 |
| IX         | 20.2±0.83        | 10.1±0.45 | 281.2±21.02 | 114.4±3.68 | 0.44±0.10 | 0.82±0.16 |
| X          | 9.6±0.79         | 9.3±0.12  | 297.5±31.32 | 107.6±9.61 | 0.31±0.15 | 0.45±0.20 |
| 2014       | 1.44±1.68        | 7.2±0.15  | 390.5±3.69  | 0.33±0.20  | –           | –               |
The data were analyzed using Statistica 8.0 (StatSoft Inc., USA) and R 3.3.2 (FSF Inc., USA) programs.

3. Results

In the Lake Bolshoe Vasilievskoe, no significant differences were found for the abiotic characteristics of the environment (water temperature, pH, O₂ content, P_total, and N-NH₄) from June through October (KW = 9.15, p < 0.01; F = 5.9, p < 0.01), except for those in February (KW = 7.91, p < 0.05; F = 4.2, p < 0.01).

In total, 316 species and intraspecific taxa of phytoplankton algae, which belonged to 14 classes, 22 orders, 51 families and 115 genera, were found in the Lake Bolshoe Vasilievskoe. The greatest species richness was a characteristic of green algae (39% of the total number of species, varieties and forms), followed by diatoms (21%) and blue-green algae (16%). The share of other divisions of algae was significantly lower and did not exceed 10%.

Zooplankton community comprised 76 species, which belonged to 3 classes, 14 families, and 33 genera. Crustacea were characterized by the highest species richness (57%), followed by Rotifera (43%).

The average relative number of phyto- and zooplankton species was practically the same in different parts of the lake (stations nos. 1, 2, and 3): 76±70.07/64.88–87.11 for phytoplankton (hereinafter, mean value / the 95% confidence interval are indicated), 17±2.41/10.5–23.50, for zooplankton. The maximum diversity of phytoplankton was observed in June (94-110 species, varieties and forms of algae), the minimum, in February (41-47 species); for zooplankton, the highest in September (20-29 species) and the lowest in June (13-19 species) and February (9-21 species).

The similarity of the phytoplankton species composition was higher than that of zooplankton both in terms of time and space. On average, Sørensen similarity index (Ks) was 69±9/67–71 for phytoplankton, and only 35±18/10–71 for zooplankton, largely due to the specific species composition of zooplankton community in winter.

The similarity of phyto- and zooplankton in terms of time and space are presented in the form of correlation pleiades of Terentyev (figures 2, 3).
Four main groups may be distinguished based on the similarity of the phytoplankton species composition in the space of correlation pleiades of Terentyev (figure 2):

1. Early summer (family Ooeystacea (Pb = 79%), Chlorellaceae (Pb = 86%), Scenedesmaceae (Pb = 100%), Botryococcaleae (Pb = 72%), Coelastraceae (Pb = 72%)),
2. Late summer—early autumn (family Scenedesmaceae (Pb = 100%). Families Pseudanabaenaceae (Pb = 100%), Anabaenaceae (Pb = 100%), and Phormidiaceae (Pb = 100%) prevailed),
3. Late autumn (Family Scenedesmaceae (Pb = 100%), Navicula (Pb = 79%), Nitzschia (Pb = 73%), and Fragilaria (Pb = 73%));
4. Winter (Navicula (Pb = 73%), Nitzschia (Pb = 73%), Fragilaria (Pb = 73%), Cryptomonas (Pb = 47%)).

The basis of each group is a set of stations at a certain sampling date. Groups nos. 1 and 2 are the closest and form a single association in accordance to the similarity exceeding 50%. Groups nos. 3 and 4 may be designated as the most independent.

Three main groups may be distinguished based on the similarity of the zooplankton species composition in the space of correlation pleiades of Terentyev:

1. Early summer—late autumn species complex: Brachionus bennini Leissling, 1924 (Pb = 73%), B. diversicornis (Daday, 1883) (Pb = 80%), Chydorus sphaericus (O.F. Müller, 1776) (Pb = 67%), Moina brachiatia (Jurine, 1820) (Pb = 40%), M. macrocopa (Straus, 1820) (Pb = 53%), Scapholeberis mucronata (O. F. Müller, 1776) (Pb = 33%), and Metacyclops gracilis (Liljeberg, 1853) (Pb = 67%);
2. Summer—autumn species complex: B. angularis Gosse, 1851 (Pb = 80%), B. diversicornis (Pb = 80%), Microcyclops varicans (Sars G.O., 1863) (Pb = 73%), Thermocylops oithonoides (G.O. Sars, 1863) (Pb = 71%);
3. Winter species complex: Filinia terminalis (Plate, 1886) (Pb = 67%), Trichocerca capucina (Wierzejski & Zacharias, 1893) (Pb = 47%), Bosmina (Eubosmina) coregoni Baird, 1857 (Pb = 27%), C. sphaericus (Pb = 67%), and Daphnia (Daphnia) cucullata G.O. Sars, 1862 (Pb = 20%).

As in the case of phytoplankton, the closest connections within each group were noted between stations of the same sampling date.

In the summer period (June—first half of July), when the water was warmed the most (< 20 °C), the smallest blue-green algae began to develop actively (figures 4, 5). The main role belonged to alga of M-type Microcystis pulvorea (Wood) Forst. emend. Elenk. (abundance of (142–270)×10^3 cells/m^3, biomass, 0.51–0.11 g/m^3) and filamentous non-heterocyst algae of S1-type (Phormidium molle (Kütz.) Gom., (38–127)×10^3 cells/m^3, 0.86–2.58 g/m^3) and Planktothylaceae limnetica (Lemm.) Kom.-Legn. et Cronb., (6–11)×10^3 cells/m^3, 0.08–0.13 g/m^3).

Rotifers dominated in summer (< 100×10^3 ind./m^3, 0.3–0.7 g/m^3) (figures 4, 5). Rotifers were the most abundant species, namely the filter feeder B. diversicornis ((40–44)×10^3 ind./m^3, > 0.11 g/m^3) and occasional predator Asplanchna priodonta Gosse, 1850 (< 30×10^3 ind./m^3, ~ 0.71 g/m^3), as well as euryphagous copepod Acanthocyclops vernalis (Fischer, 1853) (< 14×10^3 ind./m^3, 0.56 g/m^3). Euryphagous copepods dominated by biomass: Eucyclops macrurus (Sars, 1863), E. serrulatus (Fischer, 1851) (2.5–5.0)×10^5 ind./m^3, 0.1–0.3 g/m^3) and M. gracilis (< 65 % of the total biomass of zooplankton), which might consume protozooplankton, small Crustacea, algae (< 25 μm), detritus, etc. due to the fact that they avoided the water layers with a high concentration of blue-green algae with dense mucus.

In late summer—early autumn (second half of July—September), the phytoplankton abundance decreased, but the biomass increased (figure 3). During this period, large M-type species (Microcystis aeruginosa (Kütz.) Kütz., (87–165)×10^6 cells/m^3, 3.38-10.22 g/m^3), M. wesenbergii (Komárek) Komářek, (30–48)×10^6 cells/m^3, 5.97-9.61 g/m^3) dominated; even low abundance of these species resulted as high biomass. Other divisions of algae (Cyanoprokaryota, Bacillariophyta, etc.) during this period reached their minimum (figure 3).
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Figure 4. Total abundance (N) and share of various groups of phyto- and zooplankton in the Lake Bolshoe Vasilievskoe (n = 30).

- Cyanoprokaryota
- Bacillariophyta
- Chlorophyta
- Other
- Phyto
- Rotaria
- Cladocera
- Copepoda
- Zoo

Figure 5. Total biomass (B) and share of various groups of phyto- and zooplankton in the Lake Bolshoe Vasilievskoe (n = 30).

- Cyanoprokaryota
- Bacillariophyta
- Chlorophyta
- Other
- Phyto
- Rotaria
- Cladocera
- Copepoda
- Zoo

In late summer—autumn, the abundance and biomass of zooplankton have increased due to the fact that *M. aeruginosa* and *M. wesenbergii* may serve as a food if the size of their colonies does not exceed 100 µm (figures 4, 5). However, as the "blooming" degree increases together with an increase in the size of algal colonies, the zooplankton abundance starts to decrease. The share of euryphagous copepods decreases (> 20%), but at the same time, the contribution (< 10%) of filter-feeding rotifers increases (< 200×10³ ind./m³, < 0.9 g/m³), since new species of the genera *Trichocerca, Polyarthra*, etc. have appeared. At the same time, the biomass remains stably high, mainly due to the development of euryphagous and predator copepods *T. oithonoides* (50–60) ×10³ ind./m³, < 0.2 g/m³) and *M. varicans* (40–50) ×10³ ind./m³, < 0.1 g/m³), but the contribution of filter-feeding cladocerans becomes significant (< 10%; < 0.3 g/m³), for example, due to *M. brachiata* ((30–33) ×10³ ind./m³, < 0.15 g/m³) and *M. macrocopa* (25–30) ×10³ ind./m³, < 0.14 g/m³). Accordingly, the intensity of trophic relationships between communities increases. In September, the curves of the abundance of phyto- and zooplankton pass through the so-called “equilibrium point” of the intensity of trophic relationships between communities (figure 3).

The autumn period (October) was characterized by a decrease in both total abundance and biomass of phytoplankton, due to a decrease of the active growth of *M. aeruginosa* (38-46) ×10⁹ cells/m³, 2.34-2.82 g/m³) and *M. wesenbergii* ((11-21) ×10⁹ cells/m³, 2.21–4.24 g/m³) (figure 3). During this period, the green alga *Scenedesmus quadricauda* (Turp.) Brèb started to dominate ((11-14) ×10⁹
cells/m³, 2.82-3.58 g/m³). The total species richness increased due to an increase of diversity of green algae and diatoms. During this period, a decrease in the total number and biomass of zooplankton was noted, but crustaceans (< 65% of the total zooplankton abundance) and rotifers (< 35%) still dominated; in general, compared to June, their share was less (> 20%) (figure 3). First specimens of D. (D.) cucullata was noted (5,000 ind./m³, ≤ 0.07 g/m³). However, in terms of abundance and biomass, filter-feeding and predatorial copepods T. oithonoides (33 × 10³ ind./m³, < 0.02 g/m³) and euryphagous E. serrulatus (30× 10³ ind./m³, ≤ 0.02 g/m³) dominated. The filter-feeding rotifers were represented by the species of genera Brachionus (≤ 60× 10³ ind./m³, ≤ 0.12 g/m³) and Keratella (≤ 33× 10³ ind./m³, ≤ 0.03 g/m³), which dominated.

In the winter period (February), the abundance of phytoplankton was the lowest (figures 4, 5). Cryptophyte algae made a significant contribution to the total species richness. The filamentous blue-green alga P. limnetica ((24–49) · 10⁶ cells/m³) prevailed by abundance during this period, by biomass, P. limnetica (0.29–0.59 g/m³) and cryptophyte Cryptomonas ovata Ehr. (0.11–0.17 g/m³). The zooplankton abundance gradually decreased, even at a minimal level of “bloom” in the lake, but they were quite high compared that observed in October, due to favorable fodder base (figure 3). Large crustaceans (≤ 67%) and rotifers (≤ 30%) dominated in winter. Warm-water cladocerans (primary filter-feeders) of genus Bosmina (≤ 32× 10³ ind./m³, ≤ 0.16 g/m³) and D. (D.) cucullata (5× 10³ ind./m³, ≤ 1.13 g/m³) prevailed, as well as the first copepodite stages of filter-feeding, phytophagous, and detritivorous copepods of genus Eudiaptomus (≤ 8× 10³ ind./m³, ≤ 0.37 g/m³). Rotifers were represented by Filinia terminalis (< 12× 10³ ind./m³, ≤ 0.05 g/m³) and species of the genus Keratella (≤ 11× 10³ ind./m³, ≤ 0.01 g/m³).

The ratio of the biomass of zoo- and phytoplankton in the Lake Bolshoe Vasilievskoe ranged from 0.41±0.1/0.11–0.52 to 0.59±0.1/0.4–0.64 depending on the season, which corresponded to the hypereutrophic type. The average biomass over the observation period was 17.54±10.42 / 4.12–6.94, which also corresponded to the hypereutrophic type [8]. The Pantle-Buck saprobity index for phytoplankton (2.19±0.2 / 0.15–3.36) and zooplankton (1.8±0.1 / 1.4–2.2) made it possible to characterize this water body as β-mesosaprobic, moderately polluted, water purity class III.

Rank nonparametric correlation analysis was applied to assess the strength of the relationship between phyto- and zooplankton and to identify the most significant environmental factors (table 1). The correlation pleiades of Terentiev was built for the ecosystem of the Lake Bolshoe Vasilievskoe based on the most significant links (figure 6). The nitrogen to phosphorus ratio and pH were the most statistically significant abiotic environmental factors (r < 0.50), so they were set as the graph nodes.

Figure 6. Correlation pleiade of phyto- and zooplankton and abiotic parameters of the Lake Bolshoe Vasilievskoe (n = 30). Phito N – phytoplankton abundance, Phito B – phytoplankton biomass, Zoo N – zooplankton abundance, Zoo B – zooplankton biomass, pH – pH index, N:P – nitrogen to phosphorus ratio, r – Spearman correlation (r < 0.50), * – Mann-Whitney test at p < 0.05, ** – Mann-Whitney test at p < 0.01.
4. Discussion
The Lake Bolshoe Vasilievskoe is a shallow-water polymictic reservoir with a uniformly high concentration of nutrients in each part of the lake (table 1). The communities of both phyto- and zooplankton were homogeneous and quite similar along the entire lake area.

The phytoplankton was characterized by a high species richness, it belongs to green-diatom-blue-green algae type. On the contrary, the species composition of zooplankton was very poor. Crustaceans and rotifers dominated by the number of species. Generally, the taxonomic structure of phyto- and zooplankton corresponds to that observed in high-trophic aquatic ecosystems that have been formed for a long time, as the lakes of Belarus, shallow highly eutrophic Lake Nero (Yaroslavl region), and some others [17, 37, 38].

During the year, the species composition of plankton communities was different. Each independent phytoplankton complex corresponded to a certain stage of the seasonal periodicity and a sequential change of hydro-climatic phases. In early summer and autumn, the species composition differed from the classical PEG model of the seasonal succession of a certain “standard” lake, which was probably due to the high trophic status of the lake [4].

The increase of the lake trophicity had an indirect effect on zooplankton through phytoplankton. The intensive development of blue-green algae, associated with the eutrophication of the lake, led to forming of three seasonal complexes of zooplankton; their succession coincided with the changes in the dominant forms of blue-green algae. This pattern was observed most clearly in winter. In winter, the zooplankton complex in the Lake Bolshoe Vasilievskoe was represented by rather large warm-water species of crustaceans and rotifers, which usually developed actively in clean waters in early summer, according to the classical PEG model. It is known that the key factors affecting the development of aquatic invertebrates are temperature and food supply. For example, the zooplankton biomass of epilimnion depends directly both on water temperature and on the algae biomass in the stratified deep-water eutrophic lakes of Karelia, of the Yaroslavl region, and in the number of lakes in Belarus [9]. The species composition of zooplankton in the hallow-water polymictic hypereutrophic Lake Bolshoe Vasilievskoe was quite different, since summer complex of short-cycle cladocerans and rotifers was recorded in winter, while cold-water crustaceans (Cyclopidae) with a longer life cycle were recorded during the period of warm water. This was probably due to the intensity of the blue-green algae “bloom” and to specific composition of the fodder base.

The analysis of the seasonal dynamics of abundance and biomass of phyto- and zooplankton evidences on the environment-forming role of phytoplankton as a component of the biocenosis of the Lake Bolshoe Vasilievskoe. Dominance of small-cell blue-green algae of the M-type, with filamentous non-heterocystal algae of the S1-type co-dominated periodically, contributed to dominance of rotifers and copepods most of the time. These zooplankton species are opportunists with a short life cycle [39–42], which may dominate due to their better adaptation to high concentrations of suspended particles.

From June through September, the dynamics of abundance and biomass of phyto- and zooplankton were opposite, reaching the “equilibrium point” of the trophic relationships in September. Further on, both abundance and biomass of these communities decreased synchronously under the influence of seasonal changes in abiotic environmental factors. The average ratio of phyto- to zooplankton biomass over the observation period was not high and was comparable to that obtained in other shallow-water hypertrophic water bodies of Karelia, Yaroslavl Region, and lakes of Belarus. In large stratified water bodies with a lower level of water trophicity, the course of the reversed phases of short-term cycles of planktonic communities is not so pronounced, and the intensity of trophic links in summer is not so high [9].

Based on the analysis of the correlation pleiades of Terentyev, the phytoplankton may be named as the main environment-forming factor in the aquatic biocenosis of the Lake Bolshoe Vasilievskoe, which is confirmed by both floristic and quantitative analyzes. It is generally admitted that water temperature and food supply are the factors determining the development of aquatic invertebrates. Food spectra of zooplankton in a shallow hypertrophic Lake Bolshoe Vasilievskoe is represented almost exclusively by blue-green algae.
In the Lake Bolshoe Vasilievskoe, the temperature did not serve as a trigger for the development of aquatic invertebrates, since the intense "bloom" of blue-green algae promoted interchange of "summer" and "winter" dominant zooplankton species in time.

The concentrations of biogenic elements (P, N), their ratio, and pH are the most significant abiotic environmental factors for the ecosystem of the Lake Bolshoe Vasilievskoe, which is a consequence of the dominant role of phytoplankton in the ecosystem. It is known that the algae growth depends on the concentrations of these biogenic elements. At the same time, a number of studies have shown that the change in the N:P ratio preconditions which of these elements will act as the limiting one and, accordingly, certain phytoplankton species gain an advantage [8]. Also, this refer to the well-known interrelationship between the intensity of phytoplankton growth and the pH of the environment, since rapid alkalization of water is observed during the massive development of blue-green algae [8, 9].

5. Conclusions
In a shallow polymictic hypereutrophic urbanized Lake Bolshoe Vasilievskoe, both abiotic environmental parameters and the composition of phyto- and zooplankton were homogeneous from surface to bottom and along the lake water area.

The species composition of planktonic communities differed within the season. The species composition of the entire phytoplankton community and the complex of dominant algae corresponded to a certain stage of seasonal dynamics and successive changes of hydroclimatic phases in shallow hypertrophic water bodies.

In summer, the dynamics of the abundance and biomass of phyto- and zooplankton were opposed. In autumn, there was a synchronous decrease in the abundance and biomass of phyto- and zooplankton, associated with the natural seasonal cycles of abiotic environmental factors. In winter, the zooplankton species of the summer complex dominated over typical cold-water species; on the contrary, the latter were recorded during the warm period.

The increase of the trophic status of the Lake Bolshoe Vasilievskoe has an indirect effect on the zooplankton community through phytoplankton. In addition to the food factor itself, these changes are expressed as a response to temperature and hydrochemical regimes. The environment-forming role of phytoplankton as a component of the ecosystem of the studied reservoir is confirmed by the correlation pleiades of Terentyev.

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Compliance with ethical standards
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