Development of phytoplankton communities in various ecotopes of the Sumka River (Republic of Tatarstan, Russia)

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Abstract. In summer, phytoplankton community of the small river Sumka located in the Republic of Tatarstan Russia, comprised 119 alga taxa, with a rank below the genus. Chlorophyta were the most diverse group. There were no significant differences in the structure of microalgae communities in different ecotopes of the small river; Sørensen similarity index was 67%. The dominant complex of algal species was mainly represented by Cyanophyta, belonging to the M- and H₁-types. However, in August, the dominant complex included the S₁-type representatives. The degree of organic pollution of the watercourse may be estimated as transitional from oligo- to mezotrophic type considering the phytoplankton biomass and the composition of the dominant complex of algal species.

1. Introduction

The term "biodiversity" was first proposed by Walter G Rosen in 1892, who implied its use solely to describe the number of species [1]. Subsequently, R Whittaker [2] identified the following types of diversity:

- α-diversity as a diversity within the community,
- β-diversity as a diversity between communities,
- γ-diversity as a diversity of the super-coenotic system according to the environmental gradients.

All these types of diversity are closely interrelated and allow assessing the true state of the ecosystem.

In this regard, when assessing the biological diversity of a water body, it is advisable to conduct the studies in both the open part of reservoir (β-diversity) and in the coastal area, in the communities of higher aquatic plants, at various depths, etc. (α-diversity).

It is rather difficult to carry out such detailed studies on extensive water bodies due to their large length and the presence of a significant number of ecotopes. Therefore, such studies are more expedient for small streams and small water bodies.

When studying the lakes of the Raifsky section of the Volzhsko-Kamsky Reserve (Volga River, Russia), we have arrived to the conclusion that performing research in various ecotopes significantly expanded the understanding of the species richness and biological diversity of these reservoirs [3].

The study aims to analyze and to compare the development of algal communities in different ecotopes of a small river in summer.
2. Materials and Methods

The studies were carried out in June—August 2010 in the mouth of the Sumka River, located in the Republic of Tatarstan, Russia (figure 1). Samples were taken at backwater and at the river section with rapid current (at water surface (0 m) and near the bottom). The depth was about 1 m. During the study period, the water temperature varied from 25°C (June 12, 2010) up to 32°C (July 9, 2010).

![Figure 1. Schematic map of the Sumka River](image_url)

The Sumka River is a left tributary of the Volga River. Its length is 37.5 km, the catchment area is 250 km². It flows into the Kuibyshev Reservoir near the Vasilyevo village, passing the territory of the Volzhsko-Kamsky State Nature Reserve (figure 1), which is one of the 40 most important reserves in Russia.

Samples were taken from the water surface, preserved with a 4% formalin solution, and processed according to standard hydrobiological methods [4]. The dominant species were assigned as comprising 10% or more of the total abundance/biomass.

The algae species were identified by taxonomic keys of several book series: "Keys to freshwater algae of the USSR" (1951–1986), "Flora of spore plants of the USSR" (1952–1976), "Viznachnik of the freshwater algae of the Ukrainian SSR" (1948–1990), "Diatoms of USSR" (1988, 1992), and "Susswasserflora von Mitteleuropa" (1983–2000).
The degree of similarity in the algae composition in different ecotopes was estimated by Sørensen similarity index. The coenotic diversity of the community was assessed by Shannon's index ($H$).

3. Results and Discussion

The phytoplankton of the Sumka River is very diverse; during the entire summer period, 119 taxa of algae were registered (rank below genus) (table 1). Green algae was the most diverse group of microalgae in the Sumka River, accounting for 44% of the total number of species and intraspecific taxa, followed by diatoms (22% of the total species richness), blue-green (15%), euglenic (12%). Other phylum of algae were represented only slightly.

Other phylum of algae were represented only slightly. The composition of algae in different ecotopes differed slightly. The Sorenson coefficient was 67%.

The species diversity of planktonic algal flora varied over a very wide range: the Shannon index varied from 0.9 bit/ind. in June up to 4.5 bit/ind. in July, averaging as 2.7 bit/ind. by abundance and 2.2 bit/ind. by biomass. This indicator varied insignificantly across biotopes.

Such high similarity was probably due to the fact that the watercourse was neither deep nor wide. Unlike deep lakes, characterized by a significant area of the water surface, there was a constant water mixing together with the aquatic organisms.

Low indicators of species diversity were associated with the active development of *Aphanizomenon flos-aquae* (L.) Ralfs, which accounted for about 90% of the total abundance and biomass of algae in June. The maximum indicators of the species diversity of phytoplankton were recorded in July, associated with the maximum species richness of algae during this period.

| Table 1. Taxonomic composition of the planktonic algal flora of the Sumka River |
| Phylum                   | backwater | 0 m    | bottom | common species |
|--------------------------|-----------|--------|--------|----------------|
| Cyanophyta               | 14        | 12     | 12     | 18             |
| Chryzophyta              | 2         | 1      | 1      | 2              |
| Bacillariophyta          | 18        | 18     | 15     | 26             |
| Xanthophyta              | 3         | 1      | 1      | 4              |
| Cryptophyta              | 1         | 1      | 2      | 2              |
| Dinophyta                | 0         | 1      | 0      | 1              |
| Euglenophyta             | 6         | 6      | 7      | 14             |
| Chlorophyta              | 30        | 28     | 34     | 52             |
| **Total**                | **74**    | **68** | **71** | **119**        |

During the study period, the phytoplankton abundance in the Sumka River varied from 0.9 to $18.2 \times 10^6$ cells L$^{-1}$, biomass, from 0.4 to 2.0 mg L$^{-1}$. The average abundance and biomass of phytoplankton in certain ecotopes were similar (figure 2), as well as the species composition did.

The studies were carried out in the summer, during the period of active development of blue-green microalgae. The representatives of this taxonomic division absolutely dominated by abundance, accounting for up to 90% of the total abundance of algae (figure 2). However, in terms of biomass, they were accompanied by representatives of other alga divisions characterized by large cells, namely, Bacillariophyta and Euglenophyta. Meeting even as single cells, they belonged to the rank of dominant species (table 2).

Despite the fact that the phytoplankton was studied in summer, a change in the dominant species of algae was noted in the phytoplankton. In June, *Aphanizomenon flos-aquae* (L.) Ralfs, an eurytopic,
freshwater-brackish, β-mesosaprobic species [5], was one of the blooming species. Plankton-benthic, large-celled diatom *Melosira varians* Ag. dominated by biomass. It was present both in the near-bottom layer and in the lentic areas, since the studies were carried out in the shallow part of the river.

![Figure 2. Phytoplankton average abundance (10^6 cells L^{-1}) and average biomass (mg L^{-1}) in different ecotopes of the Sumka River](image)

**Table 2.** Dominant species of algae in the Sumka River in summer; the relative abundance/biomass (%) is indicated in the brackets

| Lake          | Dominants by abundance | Dominants by biomass                  |
|---------------|------------------------|---------------------------------------|
| **June 12, 2010** |                        |                                       |
| backwater     | *Aphanizomenon flos-aquae* (87%) | *Aphanizomenon flos-aquae* (72%), *Melosira varians* (11%) |
| 0 m           | *Aphanizomenon flos-aquae* (87%) | *Aphanizomenon flos-aquae* (88%)       |
| bottom        | *Aphanizomenon flos-aquae* (88%) | *Aphanizomenon flos-aquae* (80%), *Melosira varians* (10%) |
| **July 7, 2010** |                        |                                       |
| backwater     | *Dictyosphaerium subsolitarius* von Goor (37%) | *Melosira varians* (24%)               |
| 0 m           | *Aphanizomenon flos-aquae* (37%), *Merismopedia punctata* Meyen (11%) | *Amphora ovalis* Kütz. (17%), *Aphanizomenon flos-aquae* (14%) |
| bottom        | *Coelastrum microporum* Näg. in A. Br. (14%), *Scenedesmus quadricauda* (Turp.) Bréb. (13%), *Microcystis aeruginosa* (10%) | *Trachelomonas planctonica* Swir. (14%), *T. volvocina* T. planctonica Ehr. (14%) |
| **August 29, 2010** |                        |                                       |
| backwater     | *Microcystis aeruginosa* (54%), *M. wessenbergii* Kom. (21%) | *Oscillatoria limosa* (34%), *Microcystis wessenbergii* (30%), *M. aeruginosa* (24%) |
| 0 m           | *Microcystis aeruginosa* (45%), *Oscillatoria limosa* Ag. (27%), *Pseudoanabaena limnetica* (Lemmermann) Komárek (11%) | *Oscillatoria limosa* (36%), *Cymatopleura solea* (Bréb.) W. Sm. (17%), *Cymbella silesiaca* Bleich. (14%) |
| bottom        | *Microcystis aeruginosa* (85%) | *Microcystis aeruginosa* (67%)         |
In July, small-celled green algae (class Chlorococcales) prevailed in the shallow part of the river and at the bottom. At the water surface, *Aphanizomenon flos-aquae* still prevailed; at the bottom, together with small-celled green algae, *Microcystis aeruginosa* (Kütz.) Kütz., an eurytopic, freshwater-brackish, β-mesosaprobic species [5], appeared. The last species causes summer blooming, it appears in the dominant complex after the active vegetation of *Aphanizomenon flos-aquae* [6]. The its spores usually hibernate in the bottom sediments. Probably, its high abundance in bottom samples is associated with the moment of the beginning of its active vegetation. Euglenophyta were a member of dominant complex of algal species (by biomass), preferring well-warmed shallow water bodies with a high content of organic matter [7]. In August, the blue-green algae of the genus *Microcystis* dominated by abundance. In addition, the algae previously attributed to the genus *Oscillatoria*, subsequently divided into several genera, also dominated both in terms of abundance and biomass. It is well-known that the complex of blue-green algae of M-type (*Microcystis*) and H₁-type (*Anabaena, Aphanizomenon*) may be replaced by actively developing S₁-type algae, including representatives of the ex-genus *Oscillatoria*, in the water bodies with a high degree of anthropogenic load [8]. The presence of these representatives in the dominant complex suggests if the subsequent eutrophication of this small river will continue, it is likely to be transformed to S₁-type reservoir.

In the summer, the algae characteristic of mesotrophic water bodies developed in the Sumka River [9]. The average biomass of algae in summer was 1 mg/L. This allowed us to conclude that the level of trophicity of the watercourse may be estimated as transitional from oligo- to mesotrophic type [10].

4. Conclusions
The phytoplankton of the Sumka River is characterized by high taxonomic diversity. During our study, 119 algal taxa, with a rank below the genus, are registered in summer period; when considering all-year-round studies, there might be much more. Green algae are represented by the largest number of species.

The taxonomic diversity and quantitative development of algae do not differ in different ecotopes of the Sumka River. This is probably due to the fact that the studied river is shallow, narrow, and there are similar conditions for the algae development in all the studied ecotopes.

Despite the fact that Cyanophyta dominate by species number, no change in the dominant species are noted during the summer period.

The presence of the ex-genus *Oscillatoria* in the composition of the dominant complex of algal species suggests that if the eutrophication of the river will take place, it is possible to become S₁-type water body.

The average phytoplankton biomass and the composition of the dominant complex of algal species make it possible to estimate the level of organic pollution of the watercourse as transitional from oligo- to mesotrophic type.

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