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MONITORING OF PHYTOPLANKTON STATUS IN LAKE SEVAN (ARMENIA) IN 2018

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The current status of phytoplankton community in Lake Sevan (LS) was investigated. Water samples for phytoplankton and mineral phosphorus analyses were collected seasonally (spring–fall) in 2018. The results of the study showed that the unstabilized processes and nutrient pollution of the lake ecosystem led to blue-green algae bloom in July. All of this caused ecological and toxicological risks to the lake ecosystem and the environment and may lead to further algal blooms in LS.

Keywords: Lake Sevan, phytoplankton, nutrients, ecological management.

Introduction. Phytoplankton are the primary producers, which directly provide food for zooplankton, fish and some aquatic animals [1]. Compositional and temporal changes in phytoplankton communities occur under the impact of and complex interactions among physical, chemical and biological factors. Consequently, the phytoplankton community of a lake or reservoir will be dominated by the functional groups of organisms adapted to the environmental conditions of the ecosystem [2]. In some lakes phytoplankton abundance was found to increase in eutrophic conditions. In this case, phytoplankton quantitative growth is driven by phosphorus and the phytoplankton abundance is positively correlated with phosphorus concentration. To some extreme state, increased phosphorus concentration causes a phytoplankton bloom [3].

Lake Sevan (LS) is the largest high mountain lake in the Caucasus Region [4–7]. Being a major strategic resource for drinking water, the most important source of freshwater and freshwater fish, an irrigation water and hydropower source, a recreation and tourism zone, a habitat for rich and endemic biological diversity, LS was subjected to tragic events and the lake water level fell dramatically (1916.2–1897.0 *m*) due to the large-scale hydrotechnical transformation and excessive use of water supplies for energetic and agricultural purposes during the period from 1930 to the 1980s, resulting in eutrophication, biodiversity decline and the disruption of ecosystem processes [4, 8]. A decrease in the lake water level caused a number of negative phenomena in the phytoplankton community: qualitative enrichment of almost all the phytoplankton groups, permanent or temporary loss of some

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phytoplankton species, which were inherent in the natural regime of the lake, the restructuring of the phytoplankton dominant complex as well as the increased quantitative parameters of the phytoplankton community [9]. Since 2002 measures have been undertaken to raise the water level in order to restore the natural regime of the lake water (enshrined in the Law of the RA in 2001) [7]. In the conditions of lake water level rise, the tendency of a decrease in the quantitative development of phytoplankton was registered [10]. Therefore, the continuous monitoring of phytoplankton status in LS is urgently required. The aim of the present study was to investigate phytoplankton dynamics in the current stage of lake water level rise.

Materials and Methods. We investigated the seasonal dynamics of phytoplankton in LS in 2018. LS is located in the Eastern part of Armenia, in 40°19' North latitude and 45°21' East longitude at the altitude of 1900 *m* a. s. l. [7]. It consists of two parts: Big Sevan (BS), having the depth of up to 30 *m,* and Small Sevan (SS) with the deepest depth of 80 *m* [4, 11]. The current water volume of the lake is $38.2 \cdot 10^9 m^3$, the surface area is 1279 km^2 [12].

A research vessel (Yaroslavlec rm – 376) equipped with sampling instruments was used to implement sampling from LS. The sampling was done at the deepwater stations of BS (40°23'44.9"N, 45°21'43.9"E) and SS (40°32'37.9"N, 45°05'49.8"E). Water samples for phytoplankton and phosphate analyses were collected seasonally (spring–fall) in 2018, using a Ruttner's bathometer. Phytosamples were preserved with 40% formaldehyde solution (0.4% final concentration) for further quantitative and qualitative analyses. The samples for chemical analysis were kept in a cool box in low temperature conditions.

The preserved phytosamples were settled in a dark space for 10–12 days, and then the algal concentration was increased by decreasing the volume of the experimental samples from 1000 to 100 *mL* using a siphon (50 μm). Repeating the same process for the second time, the concentration of phytoplankton was totally increased by 100 times in the final volume of the experimental samples (10 *mL*).

The qualitative and quantitative analyses of phytoplankton were implemented under a microscope, using a Nageotte chamber. Taxonomic identification was performed using the keys/determinants of freshwater systems [13–17]. Mineral phosphorus concentration was measured photometrically (HI83200) based on the ascorbic acid method [18].

Results and Discussion. In May, green and blue-green algae dominated in the pelagial phytoplankton of BS according to the biomass and the abundance respectively and were subdominant groups in the pelagial phytoplankton of BS according to the abundance and the biomass respectively. Blue-green algae prevailed quantitatively in the pelagial phytoplankton of SS and diatom, and green algae subdominated in the pelagial phytoplankton of SS according to the abundance and the biomass respectively (Fig. 1). *Microcystis aeruginosa* (35.0% of the total phytoplankton abundance) from blue-green algae and *Oocystis solitaria* (25.4% of the total phytoplankton biomass) from green algae dominated quantitatively in the pelagial phytoplankton of BS. *Oocystis solitaria* was also a subdominant species according to the biomass (23%). According to the abundance (13%), the diatom algae species *Cyclotella kutzingiana* subdominated in the pelagial phytoplankton of BS. Phytoplankton representatives dominated quantitatively in the pelagial phytoplankton of SS were the blue-green algae species *Aphanothece clathrata* and *Microcystis* *aeruginosa* forming accordingly 29% and 28% of the total phytoplankton abundance and biomass. *Cyclotella kutzingiana* (20.5% of the total phytoplankton abundance) and *Sphaerocystis schroeteri* (22.0% of the total phytoplankton biomass) from green algae were quantitatively subdominant species in the pelagial phytoplankton of SS.

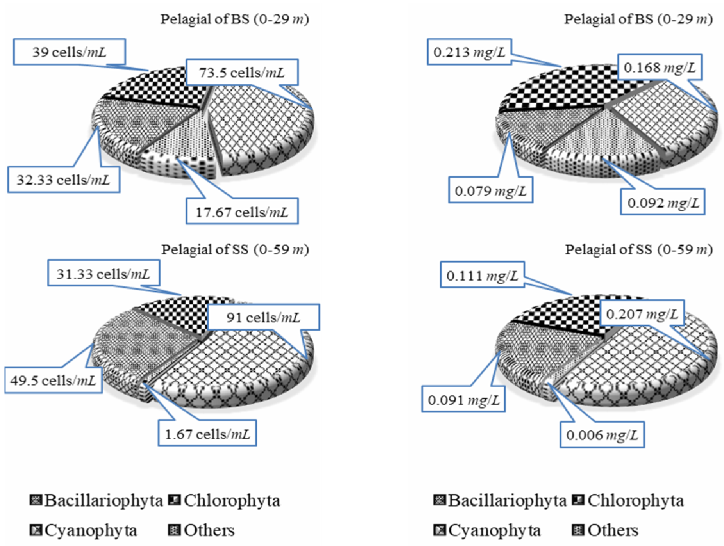

Fig. 1. Phytoplankton quantitative parameters (abundance in left side, biomass in right side) in LS in May.

In July, the quantitative parameters of phytoplankton increased drastically, which was conditioned by blue-green algae bloom registered in LS. Blue-green algae formed 98.6% (BS) and 99.6% (SS) of the total phytoplankton abundance and 66.4% (BS) and 94.0% (SS) of the total phytoplankton biomass (Fig. 2). *Dolichospermum* (formerly *Anabaena*) sp. from blue-green algae was a quantitatively dominant species, the portion of which was 98.6% and 99.7% of the total phytoplankton abundance in BS and SS respectively. Comparatively high quantitative parameters were also recorded in the development of other eutrophication indicator species of this group – *Aphanizomenon flos-aquae* (4.5–35.6% of the total phytoplankton abundance), which was in a subdominant position in the both parts of LS according to the abundance. *Dolichospermum* and *Aphanizomenon* are known to produce a variety of cyanotoxins, which is a warning of ecotoxicological risks to the lake ecosystem and the environment [19, 20]. It is necessary to mention that the representatives of the genus *Dolichospermum* were recorded in LS in 1964 for the first time and caused intense blooms in the period 1964–1977 [21–23].

It is known that the decisive drivers of blue-green algae bloom are increased nutrient concentration and water temperature [24]. The seasonal dynamics of mineral phosphorus concentration in LS water is presented in Fig. 3. It is worth mentioning that May concentration of phosphate in LS water ranged between 0.12 and 0.17 *mg/L*, exceeding the ecological norm of phosphate (0.11 *mg/L*) for the rivers waters of LS basin [25]. It can be concluded that in the conditions of high phosphorus concentration in May and of increasing water temperature, blue-green algae bloom was recorded in LS in July.

A noticeable decrease in the phytoplankton quantitative parameters was registered in October. Diatom algae became a quantitatively dominant group in the pelagial phytoplankton of the both parts of LS. Blue-green algae were a quantitatively subdominant group in the pelagial phytoplankton of BS (according to the biomass) and SS (Fig. 4). The diatom algae species *Cyclotella stelligera* (53% of the total phytoplankton abundance and 33% – of the biomass) and *Melosira granulata* (25% of the total phytoplankton abundance and 35% – of the biomass) dominated quantitatively in the pelagial phytoplankton of SS. In the pelagial phytoplankton of BS, *Melosira granulata* (45% of the total phytoplankton abundance and 67% – of the biomass) and *Cyclotella stelligera* (24% of the total phytoplankton abundance and 16% – of the biomass) were quantitatively dominant and subdominant species, respectively.

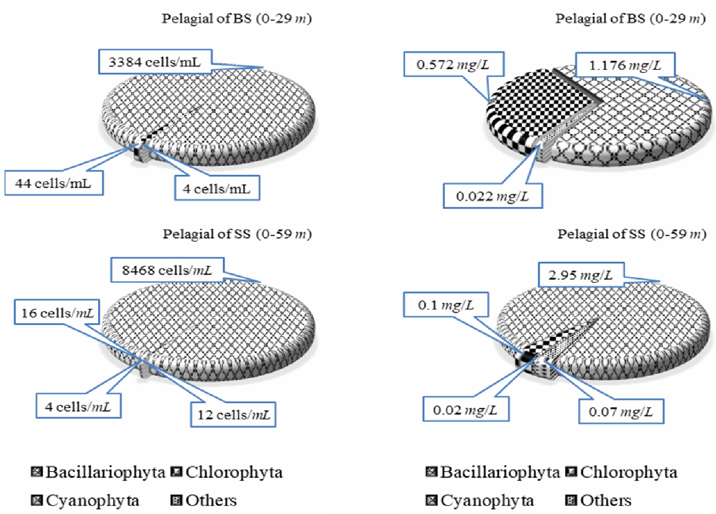

Fig. 2. Phytoplankton quantitative parameters (abundance in left side, biomass in right side) in LS in July.

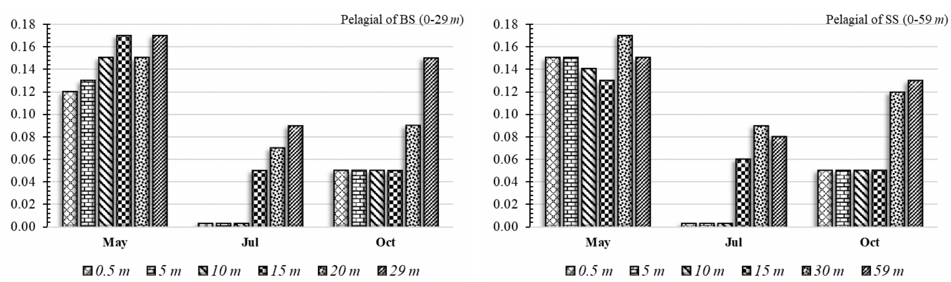

Fig. 3. Seasonal dynamics of mineral phosphorus concentration (in *mg/L*) in LS water.

A significant decrease in phosphate concentration in the lake water was registered in July and October, which can be explained by phosphate depletion by blue-green algae during the algal bloom (Fig. 3). All of this allows to conclude that significant changes in the phytoplankton composition in October was mainly conditioned by phosphorus limitation of algal growth.

According to some investigators, the tendency of a decrease in the quantitative development of phytoplankton in the conditions of lake water level rise couldn't surely indicate about de-eutrophication process in the lake ecosystem and might be conditioned by reconstructions in the trophic chain: decreased fish pressure on zooplankton caused a decrease in the quantitative parameters of planktonic algae [11, 26]. Our investigation on phytoplankton status in LS in 2018 has confirmed that the lake ecosystem is still ecologically unstable.

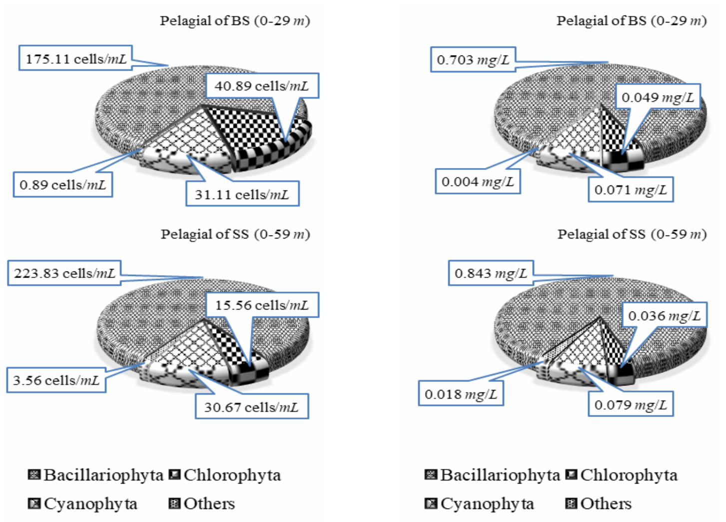

Fig. 4. Phytoplankton quantitative parameters (abundance and biomass) in LS in October.

Conclusion. In general it can be concluded that the unstabilized processes and nutrient pollution of the lake ecosystem led to unfavorable changes in the phyto-plankton status in 2018, as a result of which blue-green algae bloom occurred in the lake, causing ecological and toxicological risks to the lake ecosystem and the environment. All of this may lead to further algal blooms in LS, worsening the ecological situation of the lake. In such conditions, new scientific approaches are needed for better understanding of lake ecology and for sustainable management and use of its natural resources.

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