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INVESTIGATIONS OF ALGAL BLOOM IN "YEREVANYAN LICH" RESERVOIR

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During investigations carried out in "Yerevanyan Lich" reservoir from 2015 to 2016 water bloom with different groups of algae was registered. The change of dominant groups from dominance by diatoms to cyanobacteria was observed in the phytoplankton community of reservoir during the study period. High quantitative values of diatomic algae were the result of quantitative growth of *Melosira varians*, *Fragilaria crotonensis* and *Stephanodiscus hantzschii* species. High quantitative values of blue-green algae were the result of quantitative qrowth of *Anabaena cylindrica* and *Oscillatoria limnetica* species. The values of saprobic index in the reservoir in the study period fluctuated from 1.5 to 1.99. The saprobity in the reservoir was changed from α-oligosaprob to β-mezosaprob level. The highest value of the Shannon biodiversity index was recorded in May of 2015, and the lowest in September of 2016, which shows that there was quantitatively monodominancy of blue-green algae *Oscilatoria limnetica*, which is pressing diversity of algae in the reservoir.

***Keywords*:** algal bloom, water quality, eutrophycation.

Introduction. Artificial reservoirs are built for specific purposes such as agricultural or technological, in order to provide reliable and well-managed resources.

"Yerevanyan Lich" reservoir was built in the Hrazdan River canyon in Yerevan City in 1966. It has water volume of 4.8 mln m^3. The reservoir is used for irrigation, recreation and fishery [1].

As a result the insufficient sewage and wastewater management in Yerevan City, the aquatic ecosystems in this area are endangered due to pollution, qualitative deterioration and unfavorable changes in aquatic biodiversity.

Phytoplankton, as a very reactive element of the hydroecosystem, is the first to react to changes in the environment. These changes concern both quantitative and qualitative phytoplankton structure. The algal biomonitoring are necessary to provide sufficient information in water quality degradation in reservoir [2].

Algal bloom and phytoplankton community of "Yerevanyan Lich" reservoir has been investigated by different specialists during 2004–2015 periods [3–8].

The aim of the study is the investigation of phytoplankton community and saprobic state of "Yerevanyan Lich" reservoir and observation of water bloom by different groups of algae.

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Materials and Methods. Sampling was carried out from the observation site located in the coastal area of "Yerevanyan Lich" reservoir in May, July and September of 2015 and in May and September of 2016.

Field sampling was done by standard hydrobiological methods. Further analyses were carried out under laboratory conditions [9].

The species identification of planktonic algae was done by the keys and the guides of freshwater systems [10–14]. The qualitative and quantitative analyses of phytoplankton were executed by a XSZ-107 BN microscope in Nageotte chamber ($V = 0.1\ mL$). Saprobity index for algae was calculated [15].

Shannon–Wiener biodiversity index of algae was determined on a scale from 0 to 4, with 4 being the highest level of biodiversity and 0 indicating the near-complete or complete absence of algae

$$H' = -\sum_{i=1}^{R} p_i \ln p_i,$$

where H' is the index of species diversity, p_i is the ratio of the number of species of the taxonomic group to the total number of species in the community [16].

Results and Discussion. Totally six groups of algae such as Bacillaryophyta (diatoms), Chlorophyta (green algae), Cyanophyta (blue-green algae), Xantophyta (yellow-green algae), Euglenophyta (euglenoids), Dinophyta (dinoflagellates) were registered during the whole study period. Chlorophyta quanlitatively dominated the community with a marked 42% of the total phytoplankton biodiversity, Xantophyta contributed a small portion to the phytoplankton with 1% respectively in both years (see Table). Algae bloom of the "Yerevanyan Lich" reservoir has been observed during all the seasons of the observation period.

The bloom of *Fragilaria crotonensis* species in July led to the quantitative domination of diatom algae in 2015 (see Table).

Percentage of major groups of phytoplankton community of the "Yerevanyan Lich" reservoir in terms of species composition, quantity and biomass in 2015 and 2016

Year	Bacillaryophyta			Cyanophyta			Chlorophyta			Euglenophyta			Dinophyta			Xantophyta		
	A*	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
2015	35	51	56	16	38	22	42	7	14	4	2	6	2	1	1	1	1	1
2016	33	25	24	13	69	58	44	5	11	4	1	2	2	0	0	4	0	5

* A – quality, B – quantity, C – biomass.

89 algae species were registered in 2015. The highest number of species was registered in the genera Nitzschia (6 species). Diatomic algae dominated quantitatively in May and July. High quantity and biomass (1 027 500 cell/L and 5.1 g/m^3) of diatomic algae *Melosira varians* were registered in May. The subdominant species was *Fragilaria capucina* which formed 17% of quantity and 10% of biomass of the total phytoplankton composition. Succession was registered in species composition of diatoms in July. Water bloom in this seasson was the result of high quantity (18 625 000 cell/L) and biomass (52.2 g/m^3) of *Fragilaria crotonensis*. Not less important is, that both, *Melosira varians* and *Fragilaria crotonensis*, are α-β-mezosaprob species of organic pollution (Fig. 1).

The change of dominant group was registered in the phytoplankton community of the reservoir in September. The same pattern has been registered in our previous studies [3–6]. The quantitative parameters of diatom algae reduced and quantitative

parameters of blue-green algae increased (14 255 000 cell/*L* by quantity and 19.8 *g*/m^3 by biomass) causing water bloom of reservoir. The high quantitative value of blue-green algae was due to abundancy of *Anabaena cylindrica* (10 452 500 cell/*L* and 3.6 *g*/m^3) species. *Oscillatoria limnetica* was subdominant (2 965 000 cell/*L* and 11.9 *g*/m^3).

Our previous studies show that, green algae became a quantitatively dominant group in the phytoplankton community of the reservoir in June 2015 [7]. During the months of investigation, compared with June, the quantitative parameters of green algae decreased. The dominant composition of green algae was represented by *Ankistrodesmus falcatus* and *Chlorella vulgaris* species, which are β- and α-mezo-saprob species of organic pollution. Big colonial species such as *Volvox aureus, Volvox globator, Pandorina morum* were registered as well. In spite of their small quantity they promoted high biomass of green algae in the reservoir. The highest species diversity was recorded for the genera *Scenedesmus* and *Oocystis* (4 species each).

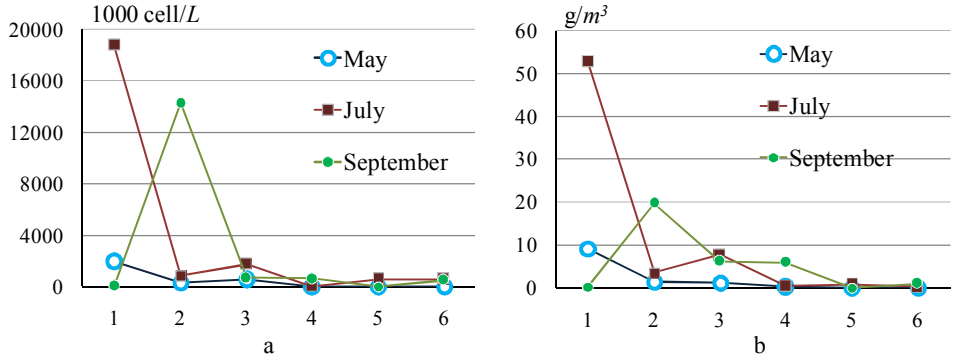

Fig. 1. Seasonal dynamics of algae in the "Yerevanyan Lich" reservoir in 2015: a – quantity, b – biomass. 1– Bacillaryophyta; 2 – Cyanophyta; 3 – Chlorophyta; 4 – Euglenophyta; 5 – Xantophyta; 6 – Dinophyta.

The values of saprobic index fluctuated from 1.5 (May) to 1.99 (July). The saprobity in the reservoir was changed from α-oligosaprob to β-mezosaprob level.

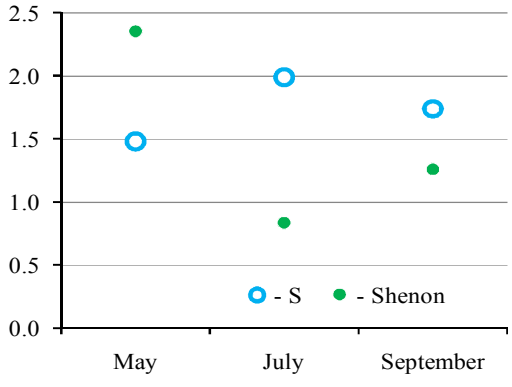

Fig. 2. Values of saprobic and Shannon biodiversity index in the "Yerevanyan Lich" reservoir in 2015.

The highest value of the Shannon biodiversity index was recorded in May, and the lowest in July, which showed that there was biodiversity suppression in the reservoir in July.

Blue-green algae dominated quantitatively in the "Yerevanyan Lich" resevoir in 2016 (see Table). The biodiversity of phytoplankton community was poorer than in 2015. 70 species of algae were recorded. The species composition in the registered genera's was poor as well (maximum 3 species) (see Fig. 2).

Diatomic algae dominated quantitatively in May. Water bloom in this seasson was the result of high quantity and biomass of diatomic algae *Stephanodiscus hantzschii* (3 912500 cell/*L* and 17.6 *g*/m^3), which formed the 78% of total quantity and 62% of total biomass of phytoplankton community in the reservoir (Fig. 3).

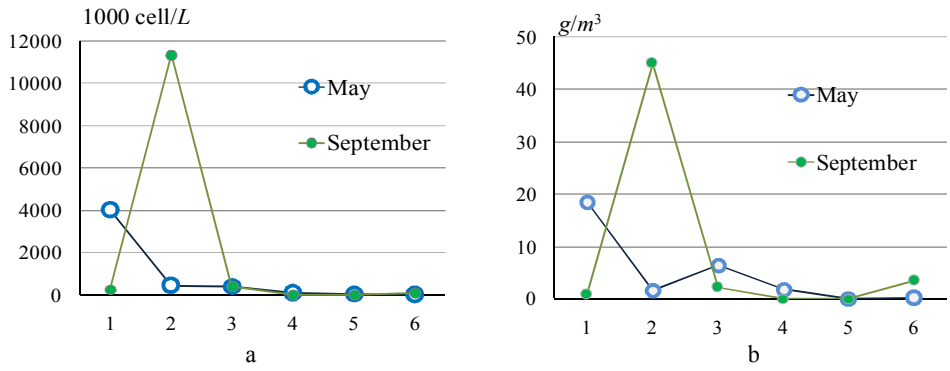

Fig. 3. Seasonal dynamics of algae in the "Yerevanyan Lich'' reservoir in 2016: a – quantity, b – biomass. 1– Bacillaryophyta; 2 – Cyanophyta; 3 – Chlorophyta; 4 – Euglenophyta; 5 – Xantophyta; 6 – Dinophyta.

The centric diatom *Stephanodiscus hantzschii*, is regarded as a representative indicator of eutrophication worldwide. The bloom of this species can typically be attributed to anthropogenic eutrophication. The high density of brownish-colored *S. hantzschii* reduces water transparency and causes bad odor and taste [17].

The blue-green algae were subdominant by quantity and the green algae were subdominant by biomass. *Oscilatoria lacustris* (145 000 cell/*L*) and *O. aghardii* (195 000 cell/*L*) species led to the high number of blue-green algae in the reservoir. The big colonial species *Volvox aureus* 2.6 and *Pandorina morum* 1.8 (g/m^3) led to the high biomass of the green algae in reservoir.

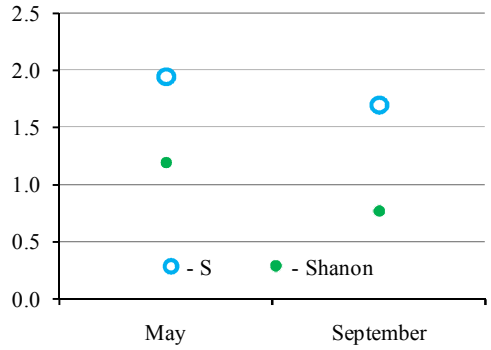

Fig. 4. Values of saprobic- and Shannon biodiversity index in the "Yerevanyan Lich reservoir in 2016.

The succession from dominance by diatoms to cyanobacteria was observed in September. The bloom has led the blue-green algae *Oscilatoria limnetica,* the quantity of which formed 84% (10 126 500 cell/*L*) of the total quantity of phytoplankton community in the reservoir. The biomass formed 76% (40.5 g/m^3) of the total biomass of phytoplankton community. It is known that blue-green algae *Oscilatoria limnetica* in addition to the oxygenic photosynthesis is capable of anoxygenic photosynthesis using sulfur (S) for it and can readily shift from one to the other. Thus, these species are capable to grow in the water rich with H_2S [18].

Poor species composition for Dinophytas and Euglenophytas were recorded in the "Yerevanyan Lich'' reservoir during the study period. 3 species belonging to Peridinium genera (*Peridinium* sp., *P. Aciculiforum, P. bipes*) from class of Dinophytas and 3 species belonging to Trachelomonas genera (*Trachelomonas volvocina, T. oblonga, T. hispida*) from class of Euglenophytas were recorded in the reservoir.

The values of saprobic index in the reservoir fluctuated from 1.95 (May) to 1.7 (September), and the saprobity level in the reservoir was β-mezosaprob. The high value of saprobic index in May is the result of quatitative growth of *Stephanodiscus hantzschii*, which is α-β-mezosaprob species of organic pollution.

In May the value of Shannon biodiversity index was higher than in September, which shows that there was a quantitative monodominancy of blue-green algae *Oscilatoria limnetica*, which was pressing biodiversity in the reservoir (Fig. 4).

Conclusion. Thus, investigations implemented since 2004 show that there was continous blooming in the reservoir with different eutrophic species.

Succession from dominance by diatoms followed by Cyanophytas was registered in the phytoplankton community of the reservoir.

The current study revealed the increase of the quantitative parameters of blue-green algae. The quantitative growth of blue green algae *Oscilatoria limnetica* led to the bloom in the reservoir, which reduced the diversity in the phytoplankton assembledge.

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