INFLUENCE OF LAKE SEVAN CATCHMENT BASIN PHYTOPLANKTON COMMUNITY STRUCTURE ON THE SAME OF THE LAKE

PhD Hovsepyan A.A., PhD Khachikyan T.G., PhD Hambaryan L.R.

Scientific Centre of Zoology and Hydroecology of the National Academy of Sciences, **Republic of Armenia**

ABSTRACT

Conservation and sustainable use of freshwater resources is based on comprehensive economic assessment and effective management.

The essential freshwater stocks are located in Lake Sevan and Ararat valley in Armenia.

Destabilization of Lake Sevan ecosystem has been occurred due to artificial lowering of its water level of more than 20 m (~1916 m above sea level in its natural regime), resulting changes of hydrophysical, hydrochemical and hydrobiological parameters of the ecosystem.

Since 2002 lake water level rising is implementing aimed to reduce the negative processes and recover the ecosystem natural regime.

However, a draft of the Government of republic of Armenia (RA) is being in discussion on water releases increase from Lake Sevan till 2019. New fluctuations of lake water level and especially its reduction will certainly have an influence on the processes in the ecosystem and result its further eutrophication. Also, the catchment basin influence on the ecosystem can be increased in the result of the lake's water level lowering.

The aim of this article is to reveal the qualitative influence of phytoplankton community of Lake Sevan catchment basin on the same of the lake.

Keywords: phytoplankton, eutrophication, catchment basin, resemblance of communities

INTRODUCTION

Lake Sevan is the largest lake of Caucasus, situated at an altitude 1916 m above sea level, in the mountain-forest area with moderately cold climate. The basin of the lake is a huge tectonic hollow and consists of two parts:

Minor Sevan and Major Sevan (Figure1), having different modes of formation, origin and morphometry [4]. The lake is fed by 28 rivers, and river Hrazdan is the only watercourse flowing from it, on which a cascade of six hydropower plants is built.

The history of Lake Sevan is a unique example of negative anthropogenic influence on water bodies. Due to artificial lowering of the lake water level by 19.2 m, growth of population in its water basin and nutrients load increase eutrophication processes have been occurred in the lake as in the majority of lakes in 70s of the last century.

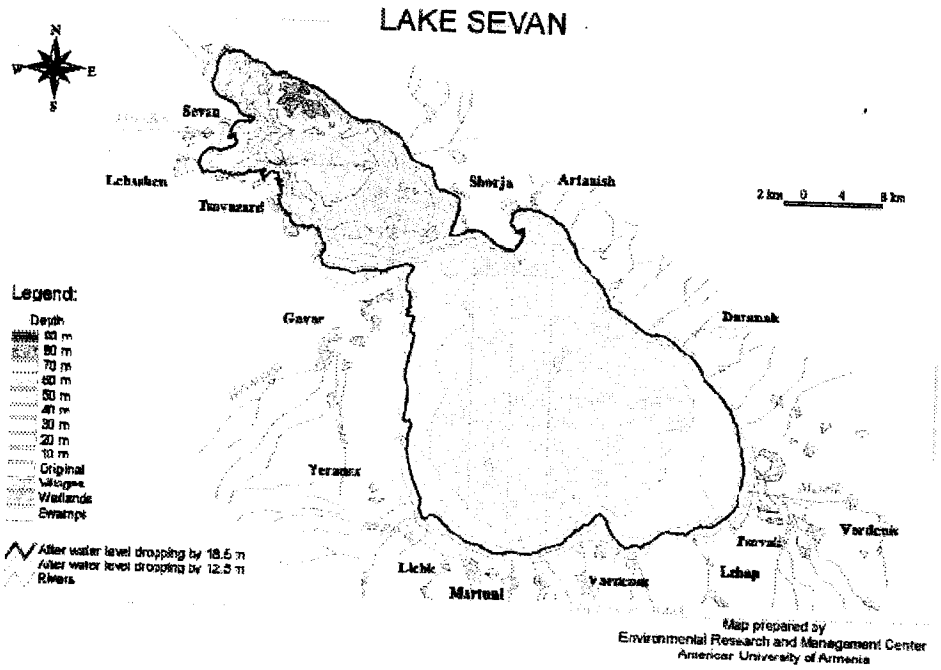

Figure 1. Map of Lake Sevan

During this period, scholars have pointed out the need to review plans for operation of the reservoir, and among the priorities was the issue of lake water level rising, study and restoration of water and biological resources [14].

In 2001 adopted a law of the RA "On approval of the annual and comprehensive measures for the conservation, restoration, reproduction and use of Lake Sevan ecosystem", in order to raise the water level (at least by 6 m) of Lake Sevan by 2030.

As a result of undertaken activities and favorable weather conditions, the lake level began to rise annually. As of December 2007, the water level of

Lake Sevan was 1898.79 meters above sea level, which is by ~ 0.5 m higher than in the same period of previous year [2]. Most of the flood banks, where in the middle of the last century trees were planted and recreational areas organized, had not been prepared and could be a source of serious effects on the limnoecosystem. Accordingly, the Commission of Lake Sevan scheduled cleaning flooded coastal areas of trees and shrubs and a gradual annual increase of the lake water level by about 21 cm to achieve the grade of 1903.5 m by 2031. In 2008 the water level of the lake compared to the previous year increased by 7 cm, 2009 - 37 cm, in 2010 - by 47 cm.

New changes of the ecosystem abiotic component will certainly occur in the result of new changes in lake water level, which in its turn will lead to new shifts in the lake interior processes as well as changes in its hydrobiological component.

Long-term monitoring of Lake Sevan main hydroecological parameters characterizing water quality revealed a link between changes in lake trophic status and phytoplankton community development. Significant changes of phytoplankton quantitative and qualitative parameters have been occurred during the different periods of lake investigation.

Formerly, one of the obvious signs of eutrophication in Lake Sevan was the succession of phytoplankton species: in pelagic plankton new species appeared, previously found only in coastal areas and bays of the lake, while some species have been found in the lake for the first time [5, 9, 10, 12, 13, 15]. During different stages of lake investigation, changes in the role of phytoplankton species were observed periodically having displaced species of planktonic algae, which were inherent in the lake natural period prior to level lowering. New species have been registered in Lake Sevan phytoplankton community during recent years as well, some of which are found for the first time in the lake, while the others were known as the representatives of the lake periphyton and its catchment basin rheoplankton [8].

The purpose of the current work is to assess the species diversity of phytoplankton of Lake Sevan and its main tributaries as well as to identify similarities in the species composition of the planktonic algae in Minor Sevan and Gavaraget, Dzknaget rivers, and phytoplankton communities in Major Sevan and Masrik, Makenis, Arpa, Vardenis, Argichi, Lichk rivers.

MATERIALS AND METHODS

The algological material was collected at two following stations: №4 - Minor Sevan, №22 - Major Sevan and 8 major tributaries. Water samples

were collected, using a Ruttner bathometer with four main horizons of pelagic part (lake surface, 10 m, 20 m and bottom layer). Phytoplankton sampling at Lake Sevan was carried out during March, April, June and October, while phytoplankton samples from the tributaries were assessed from March to November.

In general, 28 phytoplankton samples were analyzed taken from Lake Sevan and 64 samples taken from Masrik, Makenis, Arpa, Vardenis, Argichi and Gavaraget rivers, which flow into Major Sevan, and rivers Gavaraget and Dzknaget flowing into Minor Sevan.

Collection, preservation and processing of algae were implemented according to standard methods [1,18]. Identification of algal species specificity was done by using various determinants [6, 7, 17, 19].

Jaccard's (1) and Sorensen's (2) indexes were used to determine algal communities' similarity given as follows:

$$k = \frac{c}{a + b} 100\% \quad (1)$$

$$k = \frac{2c}{a + b} 100\% \quad (2)$$

Where **c** - the number of species common to both sites,

a and **b**- the numbers of species found at each site [11, 20].

The saprobic value of indicator phytoplankton species was defined [3].

RESULTS AND DISCUSSION

96 taxa of algae have been registered in Lake Sevan in the investigated period of 2010, 42 % of which were from Diatomea, 33 % - from green algae and 15 % were from phylum of blue-green algae. Quantitative predominance of green algae is being observing in the phytoplankton community, which is inherent in the lake since the second half of the1980s [5, 9, 10, 12, 13, 15, 16]. Diatoms had subdominant position quantitatively, which, however, dominated by quality, in contrast to the results of previous authors' studies, when the green algae were more diverse, and diatoms quantitatively played the most important role.

Totally, 124 phytoplankton species have been registered in phytoplankton communities of main streams inflowing into Lake Sevan during 2010. As in the lake, diatoms were the most diverse phylum among the others: 69%.

The green algae percentage was 16%, and the same of the blue-green algae was only 14%.

The most diverse genera were *Navicula* (7) and *Cyclotella* (4) from diatoms, and *Oocystis*(5) and *Ankistrodesmus* (4) from green algae in the lake, while in the catchment basin the highest rate of diversity was inherent in genera *Navicula* (16), *Nitzschia* (10), *Cymbella* (9), *Pinnularia* (5), *Fragilaria* (4) and *Melosira* (5) in the group of Diatomea, *Oocystis* (5) and *Scenedesmus* (3) among the green algae and the genera *Oscillatoria* (8), *Phormidium* (3) and *Spirulina* (3) from blue-greens. Comparatively more diverse were rivers Lichk (67) and Masrik (63), and poorer were Arpa - Sevan tunnel (35) and river Vardenis (44).

Table 1. The taxonomic composition of algae of Lake Sevan and its main tributaries in 2010.

Phylum	Class	Order	Family	Genus	Species
Bacillariophyta	2	4	14	29	95
Chlorophyta	2	5	13	18	39
Cyanophyta	2	3	7	11	25
Euglenophyta	1	1	1	3	6
Xanthophyta	1	1	1	1	1
Dinoflagellata	1	2	2	2	2
Total	*9*	*16*	*38*	*64*	*168*

According to 2010 data, a total of 168 taxa of planktonic algae belonging to 64 genera have been recorded in Lake Sevan and its main tributaries (Table 1); the index of genus' coefficient of the phytoplankton community was 2.6, while the same for diatoms was 3.3, for green algae - 2.2 and 2.3 for blue-greens. This shows that there were more favourable conditions for diatoms' development: the competition among the diatoms' species was much weaker resulting the coexistance of more then one species within the same genus, rather than in the other planktonic groups.

In both parts of Lake Sevan on the basis of geographical distribution of the phytoplankton community were dominated species which characteristics are not studied enough, while in the main tributaries cosmopolitan species had the most proportion in the phytoplankton communities and less studied species were in the second place. Solitary species were also found inherent arcto-alpine latitudes (Table 2).

Table 2. Ecological and geographical characteristics of phytoplankton in Lake Sevan and its major tributaries [3].

Characteristics of species	Minor Sevan		Major Sevan		r. Gavaraget		r. Dzknaget		r. Masrik		r.Makenis		r.Arpa		r.Vardenis		r.Argichi		r.Lic
	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N
Geographical location																			
Cosmopolites	26	33.3	21	39	19	35.1	20	40	21	34.4	22	38.5	14	40	17	38.6	18	35.2	21
Arcto-alpine	3	3.8	2	3.7	3	5.5	3	6	4	6.5	6	10.5	4	11.4	4	9	4	7.8	4
Boreals	9	11.5	9	16.6	16	29.6	15	30	20	32.7	13	22.8	8	22.8	13	29.5	15	29.4	20
Less studied	40	51.3	22	40.7	16	29.6	12	24	16	26.2	16	28	9	25.7	10	22.7	14	27.4	20
Saprobity																			
Xenosaprobs	-	-	-	-	1	1.8	1	2	1	1.6	2	3.5	1	2.8	2	4.5	1	2	1
Xeno-oligosaprobs	3	3.8	1	1.8	1	1.8	2	4	1	1.6	2	3.5	2	5.7	-	-	1	2	2
Xeno-β-mesosaprobes	-	-	1	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligosaprobes	1	1.2	1	1.8	1	1.8	3	6	4	6.5	2	3.5	1	2.8	2	4.5	3	5.8	3
Oligo-β-mesosaprobes	9	11.5	7	13	11	20.3	7	14	10	16.4	7	12.2	9	25.7	8	18.2	9	17.6	12
β-mesosaprobes	21	27	19	35.2	22	40.7	20	40	24	39.3	21	37	15	43	16	36.3	21	41.1	27
β-o-mesosaprobes	2	2.6	1	1.8	3	5.6	2	4	3	4.9	2	3.5	-	-	3	6.8	1	2	3
β-α-mesosaprobes	1	1.2	-	-	-	-	1	2	1	1.6	1	1.8	-	-	-	-	-	-	1
α-β mesosaprobes	-	-	-	-	1	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-
α-mesosaprobes	2	2.6	1	1.8	3	5.6	3	6	4	6.5	6	10.5	1	2.8	-	-	2	3.9	5
Evrisaprobes	-	-	-	-	-	-	1	2	-	-	2	3.5	-	-	2	4.5	2	3.9	2
Less studied	39	50	23	42.5	11	20.4	10	20	13	21.3	12	21	6	17	10	22.7	11	21.6	9

N – number of species, n - % from the total amount of spe

In the composition of planktonic algae of Lake Sevan and its major tributaries according to accepted saprobity scale, a large proportion fell to β-mesosaprobic species. Particularly were distinguished the following observation points: Minor Sevan - 27%, Major Sevan ~ 35%, r. Argichi and r.Lichk - ~ 41 %, r. Dzknaget - 40%, r. Gavaraget - 40.7%. The share (10% (r. Dzknaget) to (50% Minor Sevan)) of species not included in the list of saprobic organisms was also significant (Table 2). The proportion of α-mesosaprobic species in the algal list was ranged from 1.8% (Major Sevan) to 10.5% (r. Makenis). In the phytoplankton community were species which saprobic value was not found out.

Application of Jaccard's similarity coefficient revealed insignificant similarity between phytoplankton communities of the lake and its tributaries that might serve as a sign of a weak influence of the rivers species composition on Lake Sevan to form its qualitative structure (Tables 3 -5). From the other hand according to Sorensen's similarity index the influence of qualitative structure of lake's catchment basin on the same of the lakewas more significant. Comparatively higher influence has shown r. Gavaraget on Minor Sevan, and rivers Arpa, Argichi andLichkand Major Sevan (Table 3).

Table 3. The generality of phytoplankton species of Lake Sevan two parts and maintributaries inflowing in them according to Jaccard's and Sorensen's indexes

	Minor Sevan	r.Gavaraget	r.Dzknaget	Major Sevan	r.Masrik	r.Makenis	r.Arpa	r.Vardenis	r.Argichi	r.Lichk
N	78	54	51	54	63	57	35	44	52	67
c		20	18		12	10	12	11	13	14
kj		15.1	14		10	9	13.5	11.2	12	11.5
ks		30	28		20	18	27	22	24	23

Tables 3-5: N – total amount of species, c – number of species, which are common to both sites, k – Jaccard's index, ks- Sorensen's index.

Based on the summarized data for Minor Sevan with two rivers and Major Sevan with its six streams, the level of the catchment basin influence on the lake is higher then in the case of separate assessment (**Table 4**).

Table 4. The generality of phytoplankton species of Lake Sevan and its main tributaries according to Jaccard's and Sorensen's indexes

	Minor Sevan	r.Gavaragetr.Dzknaget	Major Sevan	r.Masrik, r.Makenis, r.Arpa,r.Vardenis, r.Argichi, r.Lichk
N	78	74	54	104
c		28		24
kj		18		15
ks		36		30

Comparatively high resemblance coefficient has been revealed in the result of comparison of the lake's and all the main tributaries' algocenoses.

Table 5. The generality of phytoplankton species of Lake Sevan and its catchment basin

	Lake Sevan	Rivers
N	83	124
c		38
k		18
ks		36

CONCLUSION

There is a trend of qualitative prevalence of diatoms expanding in Lake Sevan observed in the years of its level rise. This is probably contributing to changes in lake conditions as a result of its level raising.

The highest index of genus' coefficient in the phytoplankton community had phylum Diatomea which shows that there were more favourable conditions for diatoms' vegetation.

During 2010 species composition of planktonic algae revealed a significant proportion of species-indicators variations in degrees of contamination including β-mesosaprobic species.

Lake Sevan main tributaries' species richness was found in Rivers Lichk and Masrik while in Rivers Arpa and Vardenis the lowest amount of phytoplankton species was recorded.

Phytoplankton communities of Lake Sevan main tributaries were characterized by the prevalence of cosmopolitan species.

Application of Jaccard's coefficient on separate sites of Lake Sevan and its catchment basin revealed insignificant similarity of phytoplankton communities in the lake and its tributaries, while on the basis of Sorensen's index the resemblance of algal communities was much higher. Also, the comparison of lake total qualitative structure of phytoplankton community with the same of its catchment basin revealed a significant similarity among them. Thus, the emergence of particular new species in the pelagic zone of Lake Sevan can be linked to its catchment basin qualitative influence, and periodical observation of their significant quantitative contribution during some seasons, perhaps, is due to changing conditions in the lake.

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