Lakes, reservoirs and ponds, vol. 10(2):77-95, 2016
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TAXONOMIC RICHNESS AND QUANTITATIVE CHARACTERISTICS OF THE PHYTOPLANKTON COMMUNITY IN THE EPILIMNION OF LAKE YEREVAN (ARMENIA)

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Abstract
Phytoplankton in Lake Yerevan includes about 140 species belonging to 9 genera. Diatoms were the lead contributors to the algal community species richness formation. The second subdominance shared greens and cyanobacteria (quantitative data on cyanobacteria are not presented in this paper). Euglenophyta and Dinophyta were the next, albeit with a lesser variety and frequency to occur. Certain genera, such as Charophyta, Cryptophyta, Chrysophyta, and Haptophyta, have occurred relatively rare. A trend of a remarkable increase in phytoplankton densities was observed from 2012 to 2013 with bloom formation in June and decrease to 2014. Algal numbers increased gradually from 2012 to 2013, with the low values registered in May 2012. The values of abundance in May 2013 differed significantly between the stations (about 115 times: 2540.06 cells mL^{-1} for X 1 and 293138.7 cells mL^{-1} for X 2). In 2014 was no bloom formation and relatively low algal numbers, in similar range of values for 2012, demonstrated slight decrease in algal density for the inshore stations. For the nearshore stations were observed the highest values of density in 2014, again for the right bank.

Keywords: Lake Yerevan, euthrophication, water level manipulations, climate warming, phytoplankton community, toxic algae, diatoms, greens

1 INTRODUCTION

Within the last centuries of urbanization and population rapid growth, human-produced sources of nutrients, heavily polluting the majority of aquatic ecosystems, caused significant changes in water quality and aquatic community structure (Burkholder, 2001). An intensified runoff of nutrients induces changes in the total budget of main biogen elements, which potentially will influence and change some physical and chemical properties of aquatic ecosystems (Salmaso, 2010; Salmaso&Mosello 2010; Chislock et al., 2013), and lead to shifts in their trophic status.

Phytoplankton are a key element in food webs of lakes, channeling nutrients into primary production thereby also affecting higher trophic levels. Their growth and diversity may be controlled by various physicochemical traits. Although, specific eco-physiological conditions of each lake will favor certain algal genera, algal communities are very dynamic in their composition. Water temperature, vertical mixing and nutrient availability, as well as the presence of grazers (ciliates and mesozooplankton), etc. are known to regulate the abundance and structure of phytoplankton communities (Lodge, 1993).

Eutrophication is one of the major environmental challenges to cause changes in phytoplankton composition and abundance by enhancing growth of bloom forming species. Climate warming (Schabhüttl et al., 2013) are other environmental driver to stimulate algal growth due to forming water column stability (Carey et al., 2012), though, adjustment of those changes to predict tendency of water bloom formation on local scale, especially for the short period of time is still complex (Taranu et al., 2012). Environmental facets, such as light and nutrients availability (Diehl, 2002) influence phytoplankton taxonomic richness with extensive consequences beyond changes in their species composition (Striebel et al., 2009a), such as less diverse phytoplankton community may be easily monopolized by bloom forming species (Ptacnik et al., 2008). Meanwhile water column stability due to high temperature may have contrary effect in nutrient poor- and rich environments (Rigosi et al., 2014). Air and consequently water high temperatures stimulate the competition for shared nutrients in the lakes and increases proliferation of competitive species (Jöhnk et al., 2008), especially in hot seasons.

However, differences in geographic location and, furthermore, climatic conditions had questioned if phytoplankton community of Armenian aquasystems possess certain similarities in taxonomic richness with the other lakes, and whether or not the same environmental traits control the growth and distribution of algal species in the analogous way.

Therefore, the main approach of this study was to evaluate the current trophic status of one of the Armenian freshwater reservoirs via the method of phytoplankton bioindication based on their quantitative and qualitative distribution. For that purpose a continuous monitoring program was launched from 2012 till 2014 in late spring-summer and late fall seasons in order to assess a potential risk from the Lake on the population of nearby territories.

2 MATERIAL AND METHODS

2.1 Study site

Lake Yerevan, located at 40°9′35.04″N and 44°28′36.54″E, is an artificial water body in the southwestern part of the capital of Armenia (see Figure 1). Lake Yerevan is a part of Lake Sevan - Hrazdan River - Lake Yerevan water cascade that continues as River Hrazdan joining River Arax in the Ararat valley, along with Armenian-Turkish borders, then flowing along the Armenian-Iranian and Iranian-Azerbaijan borders to meet with the Kura River and inflow into the Caspian Sea. It has low water velocity, typical low mixing and summer stratification with thermal column formation. Its surface area is 0.65 km^2, with a shoreline of 6.3 km, a maximum depth of 22 m, and a surface elevation of 908 m. The maximum permitted level of the lake water may reach 895 m (level manipulation ~13 m annually). Water temperature fluctuates from +1 to +2°C during the winter months and +27 to +28°C during the summer. During warmer seasons water transparency drops from 2 m up to 0.5 m. Water pH ranges from 7.8 to 8.4.

Figure 1. Map of Armenia

Initial reservoir volume of about 0.005 km^3 (max), in 2006 was estimated being at 0.004 km^3 level that demonstrates high sedimentation (bottom sediments volume is about 25% of the initial volume) (Javadyan, 2006). The reservoir was built with the purpose to protect the Yerevan city against flooding and to balance the humidity level of south-western part of the city. Moreover, it was meant to being used as a public water supply, for irrigation and fishing activities, etc. The Lake area became also a nesting ground for wild ducks.

Figure 2. Map of Lake Yerevan, illustrating the sampling points

The materials for the research were collected from surface waters (euphotic zone - up to 50 cm depth) of Lake Yerevan (X 1 station - left bank and X 2 station - right bank on 5 m distance from the shoreline - “inshore” hereinafter) during the three growth seasons (May-October) in 2012 and 2013. In 2014 water samples were collected for additional stations (X 3 station - entering part of river Hrazdan - “entry” hereinafter, X 4 station - center and X 5 outflow of Lake Yerevan - “exit” hereinafter, as well as X 6 and X 7 on 5 m distance (10 m from shoreline) - “nearshore” hereinafter, from stations X 1 and X 2) with the analogous regularity of sampling schedule (see Figure 2). Water samples were preserved with ethanol (to 10% final concentration) to examine the seasonal ratios of different algal genera and their species richness, as well as quantitative characteristics, such as the values of abundance.

Partly processing of the materials was carried out at the Ludwig-Maximilians University in Munich, Germany, the Department of Aquatic Ecology. Identification of phytoplankton species was carried out using a number of handbooks and guidelines (Streble, 2001; Linne von Berg&Melkonian, 2000; www.algaebase.org). The quantitative analyzes of the water samples have been performed in the Utermöhl sedimentation chambers under the inverted microscope (Utermöhl, 1931). Twenty randomly chosen fields with three replicates per sample were counted to minimize the counting error <10% (Lund et al., 1958). The abundance of phytoplankton species was calculated by direct cell counting under the microscope. Total abundance was calculated according to the following formula:

T = X * N

where T - total abundance; X - microscope correction factor; N - number of counts.

3 RESULTS

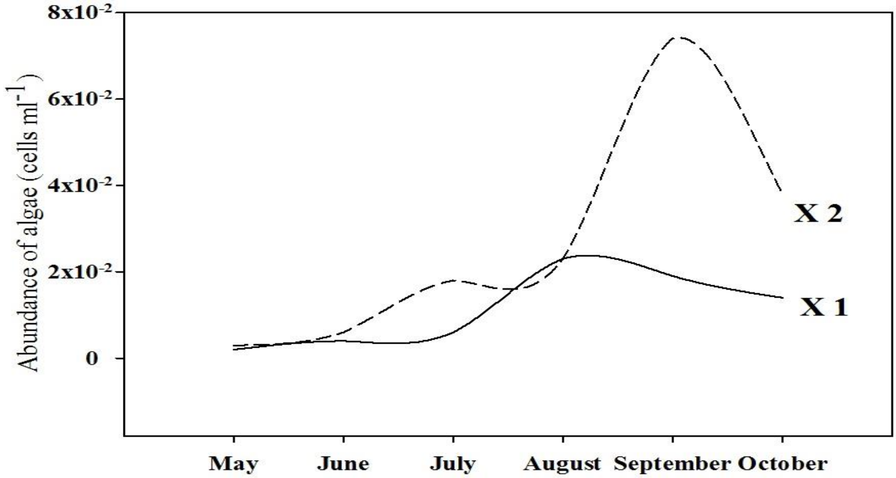
The values of biogen elements in Lake Yerevan waters (Sahakyan, 2014) coincided to the range of nutrients typical for meso- and eutrophic lake trophic stage (with dissolved and particular phosphorus in range of between 15 and 25 μg L^{-1} to classify as mesotrophic up to between 25 and 100 μg L^{-1} to classify as eutrophic). Values for total nitrogen content were in similar range typical for mesotrophic - between 401 and 600 μg L^{-1} and eutrophic - for between 601 and 1500 μg L^{-1}, classification of lake trophic stage, with higher values registered for hotter seasons when maximal water volume was taken from the Lake. TN/TP ratio in Lake Yerevan waters by a mass was > 17 (TN/TP mol: > 38), which makes euphotic zone of Lake Yerevan being phosphorus-limited. In 2012 the average annual concentration of nitrite ion exceeded the maximal allowed concentration on 4.6 (up to 0.8 mg N L^{-1}) times, respectively. In 2013 the same parameter differed up to 6.2 times. According to the concentration of phosphate ion Lake Yerevan waters coincided the eutrophic stage (The National Standards of water quality of surface waters, The Ministry of Nature Protection of Republic of Armenia, 2011, N 75 order: to coincide the water body at V class - with water quality at hypertrophic stage - max allowed concentration of nitrite ion is equaled to >0.3 mg N L^{-1}, and of phosphate ion is equaled to >0.4 mg L^{-1}).

The analyses of the phytoplankton community structure of Lake Yerevan waters distinguished high peaks of total algal density for all samples from the inshore part of the right bank of Lake Yerevan (X 2) (data on cyanobacteria are not presented in this paper, “Diversity of cyanobacteria and presence of cyanotoxins in the epilimnion of Lake Yerevan (Armenia)”, (Minasyan et al., in preparation). Mean values for three studied years differ significantly. The cells with smaller size and lesser density together with higher species richness and no bloom formation were observed in 2014. Relatively low values of abundance occurred in the spring and autumn months of all the studded years (2012-2014). Data for total algal density for 2012 were in similar range with values for 2014, with increase for the hot seasons. The highest quantitative values were observed during 2013 with early summer bloom formation tending to reduce in 2014. The maximum number (553915.66 cells mL^{-1} (August) occurred in 2013. Relatively high values of algal density occurred in summer 2013 tend to decrease up to 13175.08 cells mL^{-1} (X 1) and 145165.6 cells mL^{-1} (X 2) in fall season (Figures 3 b). For the inshore stations, the numbers of algal abundance (up to 58781.69 cells mL^{-1}) were registered in August 2012 (Figure 3 a). The value of X 2 in May 2013 was already 5 times higher (293138.7 cells mL^{-1}) and 20 times lesser for the X 1 station (2540.06 cells mL^{-1}). In August 2013, when the highest value (553915.66 cells mL^{-1}) was observed at the X 2, the value from X 1 was about 1.5 times lesser (301596.67 cells mL^{-1}). In 2014 phytoplankton community of Lake Yerevan was characterized by relatively low values of abundance in the epilimnion and nearshores (82.10 - 16078.03 cells mL^{-1}) (Figure 3c and 4). The already expected higher numbers were observed for the samples from in- and nearshore stations (X 1 and X 2, X 6 and X 7), with clear dominance for the right bank stations.

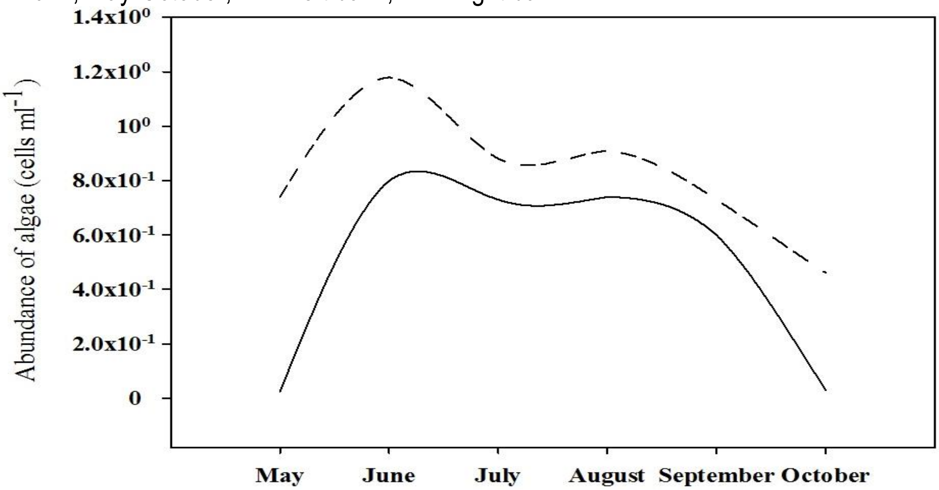
In total 72 species (2012), 85 species (2013) and 136 species (2014) were identifies in Lake Yerevan waters. Three groups of planktonic algae in Lake Yerevan waters were dominating in proportional share: diatoms (*Bacillariophyta*), greens (*Chlorophyta*), and cyanobacteria (*Cyanophyta*). Certain genera were marked with algal representatives such as *Peridinium sp.*, *Euglena sp.* etc., and some others - with an insignificant share. In 2012 and 2013 certain groups such as dinoflagellates (*Peridinium*) or Euglenophyta were only represented in very low densities, in contrast to 2014 for samples from stations X 4 - X 7, where higher number of Euglenophyta and Dinophyta were registered (Figure 5a, b, c).

Observed species structure of domination was little changeable between seasons and years for the analyzed stations. In the past, investigations on phytoplankton community structure and abundance of Lake Yerevan were performed in 2003-2006 (Stepanyan et al., 2006; Stepanyan et al., 2011), when the dominance of greens (*Coelastrum* and *Scenedesmus* genus were the most frequently observed) and Cyanophyta, up to $3.12*10^6$ cells L^{-1} in August.

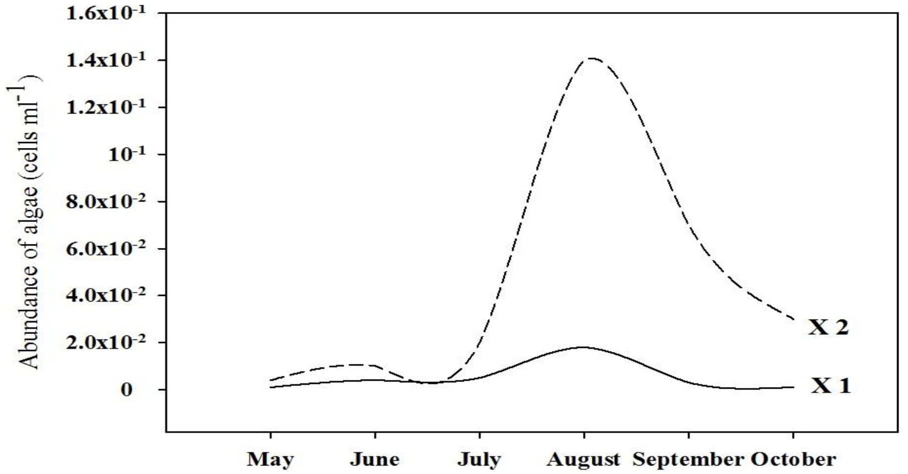
In 2012 and 2013 in the phytoplankton community of Lake Yerevan diatoms and greens were the richest in species variety. Bacillariophyta contributed with 31 % (22 species - 2012) and 38 % (32 species - 2013) and Chlorophyta with 32 % (23 species - 2012) and 26 % (22 species - 2013) to taxonomic diversity (Figure 5 a, b). The rest of the genera in the whole taxonomic spectrum contributed with lesser than 10%: Euglenophyta - with 6 % and Charophyta with 1 % for both years, Cryptophyta in 2012 had twice differing share with 4 % over 2 % in 2013, Dinophyta 3 % (2012) and 4 % (2013). Haptophyta had the lowest contribution to phytoplankton richness of 1 % (2012).



a. 2012, May-October, X 1 - left bank, X 2 - right bank



b. 2013, May-October, X 1 - left bank, X 2 - right bank



c. 2014, May-October, X 1 - left bank, X 2 - right bank

Figure 3. Total abundance of algae in inshore waters (data of cyanobacteria are not included) (X 1 - left bank, X 2 - right bank) of Lake Yerevan (cells mL^{-1}) (May-October, 2012 (a), 2013 (b), 2014 (c).

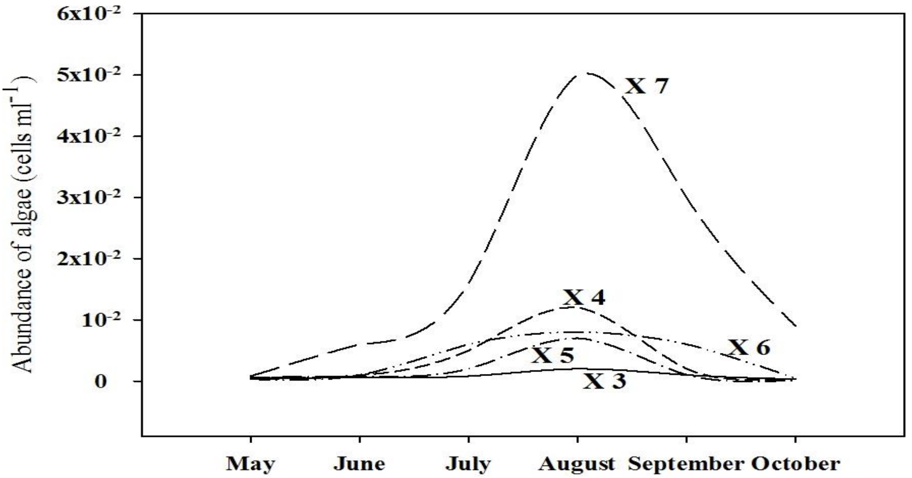
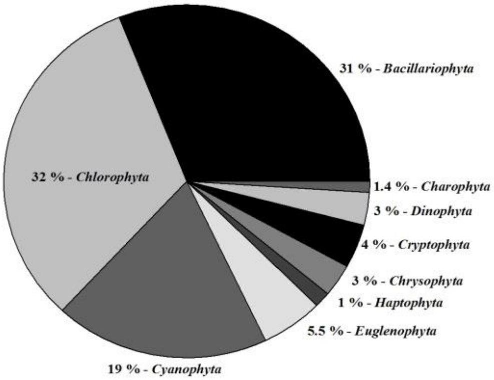


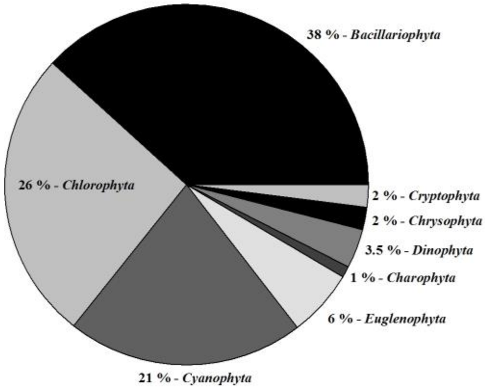
Figure 4. Total density of algae in euphotic zone (cells mL^{-1}) (data of cyanobacteria are not included) of Lake Yerevan (May-October of 2014 (entry - X 3, center - X 4, near-shores - X 6 - left bank, and X 7 - right bank, and exit - X 5)

In 2014 again diatoms and greens were dominating with species richness, but with greater numbers (in average 33 % and 30 % (45 and 41 species, respectively). Euglenophyta contributed with 6 %. Chrysophyta and Dinophyta were present with 4 species each (3 %), and Charophyta with 5 (4 %) and Cryptophyta with 3 species (2 %). Haptophyta have been observed in 2014 in the central part and X 6 - X 7 stations of the Lake with 2 species only (1.5 %) (Figure 5 c).

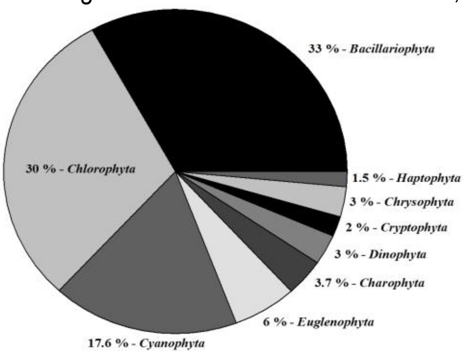
In 2014 Bacillariophyta dominated the phytoplankton community of the Lake entry with an average share of up to 80%, meanwhile, for the remaining stations diatoms were dominating the species richness in average up to 30% in total community. For the central part cyanobacteria co-dominated in share with greens (greens up to 30% at most in June), and higher share in fall season (greens up to 40%) (Minasyan et al., in preparation). The contribution of the other groups, namely Cryptophyta and Euglenophyta, in waters from the center were low enough, similarly as Dinophyta and Charophyta. In general, during our investigations the major taxa in species richness were Bacillariophyta (up to 38% max) and Chlorophyta (up to 32% max), whereas Cyanophyta were dominant group for in- and nearshore waters with quantitative parameters (Minasyan et al., in preparation).



a. 2012, May-October, sampling stations - X 1 - left bank, X 2 - right bank



b.2013, May-October, sampling stations X 1 - left bank, X 2 - right bank



c.2014, May-October, sampling stations X 1 - X 7.

Figure 5. Proportional share of genera in taxonomic richness of the phytoplankton community in epilimnion of Lake Yerevan (May-October, 2012 (a), 2013 (b), 2014 (c).

In May 2014 Bacillariophyta co-dominated with Cryptophyta for entry. In June the center of the Lake was co-dominated by Cyanophyta with Chlorophyta and lesser contribution from Euglenophyta and Dinophyta. Chlorophyta co-dominated in taxonomic spectrum over the other genera in fall season 2012 (with 23 species), except for quantitative factors of Cyanophyta. Additionally, Chrysophyta comprised low densities in spring for the central part and X 6 and X 7 stations, similarly such as Dinophyta in summer period.

In 2012 and 2013 greens were co-dominants with diatoms in species richness, but with the lesser shares in quantitative values in algal community. In 2014 spring month water of Lake Yerevan was dominated by diatoms, with consequently co-dominance of cyanobacteria during summer and early fall season, and greens occurred being co-dominant with Cyanophyta with relatively high numbers in October.

Species richness in 2012 and 2013 fluctuated within a very narrow range and was relatively constant throughout 2012 and 2013 of the studied period, and much higher in 2014. In the samples of 2012 we had identified 72 species, and 85 species in the samples of 2013. The species richness of diatoms found in May 2013 was the more divergent, than those in 2012. In 2014 for the new sampled stations we have observed the maximal species richness with dominance of diatoms for X 3 (entry) and X 5 (exit) of the Lake Yerevan, more abundant cyanobacteria and greens for the center and nearshore stations, and expected dominance of cyanobacteria for inshore waters (Minasyan et al., in preparation).

In 2014 in total 140 species representing 9 phylum were identified, which was higher than species richness in 2012 and 2013. The highest number of genus was observed within Bacillariophyta and Chlorophyta, whereas the lower numbers were after Dinophyta,

Euglenophyta, as well as Charophyta, Cryptophyta and Chrysophyta. Haptophyta, not observed in 2013, in 2014 was presented with the lowest densities (e.g. *Chrysochromulina parva* and *Prymnesium parvum*).
Diatoms that co-dominated the phytoplankton community in average 30% of total density (2012/2013/2014), mostly represented by *Aulacoseira granulata* and *Aulacoseria islandica*, as well as *Fragilaria crotonensis*, *Nitzschia fonticola*, *Nitzschia palea*. Representatives of *Fragilaria sp*. occurred with high numbers in the samples from X 3 station (the Lake Yerevan entry), meanwhile *Aulacoseira sp.* and *Cyclotella sp.* were dominating the diatoms community with the higher density contribution in all samples, especially in in- and nearshore parts (X 1, X 2, X 6, X 7) and for the exit of the Lake.

The co-dominance of greens by the representatives of *Scenedesmus acuminatus* and *Scenedesmus acutus* occurred in May and September-October 2012 and 2014 in nearshore stations and central part. *Ankyra ancora, Coelastrum sp.* noted frequently and abundantly, contributed with up to 20% in average in a total community of the greens in Lake Yerevan, meanwhile *Scenedesmus sp*. shared up to 30%. *Oocystis*, *Coccomyxa* and other species from Chlorophyta were noted sporadically in low density. *Tetrahedron*, occurred in the majority of the samples, with certain share in a total branch of the greens of Lake Yerevan phytoplankton assemblage.

In 2012 and 2013 Euglenophyta, were represented mostly by *Phacus pleuronectes* and *Phacus sp.*, while *Euglenia viridis* and *Trachelomonas hispida* occurred with less frequency. In 2014 Euglenophyta was more frequently observed, especially in the samples of X 3 and X 4 stations. The other group comprised May to June and fall samples linked with cold water temperature and water intensive circulation during the period of the study to make the low contribution into the algal assemblage of Lake Yerevan, was Cryptophyta. Dinophyta contributed with low percentages in summer season.

4 DISCUSSION

In aquatic ecology phytoplankton, due to being a highly sensitive indicator to react the environmental changes, is considered as one of the earliest warning parameter of water quality. Changing environmental conditions can cause shifts in a variety of geological, physico-chemical and biological processes occurring either in rapid or long periods.

In the last decades investigations on phytoplankton growth dependence on temperature and nutrients concentrations became one of the widely studded aspects. Eutrophic conditions in freshwater ecosystems, occurring more frequently in regions with increased nutrient loading and changed hydrology, could lead to the accumulation of algae in surface waters and further scum formation. Light regime, e.g. turbidity and consequently light limitation, available nutrients, stratification, water-level changes and mixing regimes are often recorded as the main triggers to affect the phytoplankton density and species richness. Natural deposition processes of internal (autochthonous) plant and animal remains, and mineral and organic inputs from the catchment (allochtonous) stimulate sedimentation (similarly to what we observe over last decades in Lake Yerevan) and result in lake shallower over the time (Wetzel, 2001). These processes are accelerated by human activities such as recreation, sewage runoff, agriculture and farming, resulting in increased nutrient inputs (Wolin&Stoermer 2005).

According to many investigations, diatoms are highly sensitive indicator organisms to infer environmental changes (Smol, 2008; Wolin&Stone, 2010). High mean algal densities and dominance in aquatic environments by a few taxa, which is usually diatoms or cyanobacteria, are typical for eutrophic lakes (Jensen et al., 1994). In an oligotrophic mountain Lake Laguna de La Caldera, in the Spanish Sierra Nevada, Sánchez-Castillo et al. (2008) registered diatoms community to be in tight relationship with lake-level and nutrients availability. In freshwater African lakes (Stager et al., 2005) diatoms were found being associated with turbulence regimes and water level manipulations. Some diatoms are adapted to low light and capture nutrients diffusing from the hypolimnion (Bradbury et al., 2002). In a small eutrophic lake in Northern Ireland, diatom benefited from total phosphorus increases (Rippey et al., 1997). In Lower Herring Lake, Michigan, Wolin (1996) demonstrated increases in epiphytic diatoms determined by water level manipulations.

Saros et al., (2005) described *Fragilaria crotonensis* occurring in the relative high abundances in oligotrophic alpine lakes in the Beartooth Mountain Range (Montana-Wyoming, the western USA) as a result of enhanced atmospheric nitrogen (N) deposition. In oligotrophic and ultra-oligotrophic Austrian alpine lakes Schmidt et al. (2004) found the distribution of *Fragilaria* based on abiotic influences linked to species size-variation with depth. During deep lake/lower-nutrient conditions *Aulacoseira ambigua* (Grunow) Simonsen was dominant while *Aulacoseira granulata* (Ehrenb.) Simonsen dominated during shallow-lake/higher-nutrient and lower-light stages (*Aulacoseira granulata* was leading the diatoms community of Lake Yerevan too, especially in inshore and nearshore waters). According to Bradbury et al. (2002) *Aulacoseira spp.* requires turbulence to remain in the photic zone. Rioual et al. (2007) registered often *Aulacoseira spp*. in shallow eutrophic lakes in Europe too. Verschuren et al. (2000) also found *Aulacoseira* responses to lake-level induced changes in nutrient and light levels in Lake Naivasha, Kenya. In a Michigan lake, *Cyclotella stelligera* (Cleve et Grunow) Van Heurck has been found (Wolin&Stoermer, 2005) being a nutrient and lake-level related. Those data are in concordance with observed in Lake Yerevan high density of *Cyclotella spp.* during the hot season. Moos et al., (2009) demonstrated *Fragilaria crotonensis* and *Aulacoseira subarctica* (O.Mull.) Haworth to indicate increased nutrient, meanwhile *Cyclotella* being associated with higher lake levels (Laird&Cumming, 2009).

Many aquatic ecosystems dominate by greens that require specific environmental conditions. According to Luz et al. (2002) the greens of certain genera, e.g. *Coelastrum, Pediastrum* and *Scenedesmus*, are indicating freshwater habitats and/or of fluvial influence (similarly to Lake Yerevan that is a part of Lake Sevan - River Hrazdan - Lake Yerevan water cascade). According to Striebel et al. (2009b) flagellated green algae approach necessary light and nutrients conditions via exploiting vertical gradients, which determines their vertical position in the water column. Genera *Coelastrum*, *Pediastrum* and *Scenedesmus* were identified at high abundance in the central point of the Lagoa de Cima (Huszar et al., 1987; Luz et al. 2002) being linked with high nutrients conditions. Investigations of algal community in Mysore lakes revealed *Scenedesmus* being in high density in heavily polluted Kabani Lake and Kalale Lake (Hosmani, 2013).

Thus, species composition, their contribution, as well as quantitative characteristics of Lake Yerevan algal flora, revealed, with a few exceptions, the phytoplankton predomination in Lake Yerevan waters by algal species typical for nutrient rich lakes of low mixing intensity (according to the classification of Reynolds, 1984).

Some authors (Reynolds, 1997) suggest that the correlation between the degree of mixing and the concentrations of the loading nutrient are not always the key parameters for maintaining the selection of algal life forms and their succession. According to Burkholder (2001) nutrient uncontrolled input into the lake at certain level causes water pollution with creating an overgrowth of certain phytoplankton species and disappearance of intolerant ones. Hence, based on those properties, taxonomic compositions of phytoplankton, as well as its quantitative characteristics are wildly accepted as bioindicators of assessment of water quality of aquatic ecosystems.

If to gather all the literature data and our results, most probable explanation of the obtained results could be the activation in Lake Yerevan basin of recreational activities, agricultural, sewage discharge, etc. in hot seasons. Approaching from these activities higher concentrations of available nutrients of autochtonous and allochtonous origin, increase mainly N and P inputs (Sahakyan, 2014), typical for the late spring up to early fall seasons, together with scheduled annual water-level manipulations (~13m) of Lake Yerevan, that multiplies organic matter in lesser water volume and intensifies algal cells growth.

Thus, according to modified parameters (Felfoldy, 1987) for the trophic characterization of rivers and lakes, and based on observed algal abundances in Lake Yerevan at different seasons, the lake can be characterized as being in mesotrophic - to - eutrophic stages. Suggested algal bioindicators for trophic levels from Kümmerlin (1990) again identifies Lake Yerevan as meso-eutrophic reservoir due to the presence of certain representatives of diatoms and greens. The Reynolds (1997) system confirms the similar trophic status of Lake Yerevan to be meso-eutrophic, given the presence of *Cryptomonas sp., Euglena sp., Synura sp., Ankyra sp., Rhodomonas sp.,* as well as *Anabaena sp.* and *Microcystis sp.* (Minasyan et al., in preparation) and many other identified species. According to Rawson (1956), the presence of *Fragilaria crotonensis, Pediastrum duplex,* and some others refer the reservoir to be at meso-eutrophic stage. In general, the seasonal successions that underwent the Lake Yerevan phytoplankton correspond to the stage of meso- to eutrophy, with summer maximums in quantitative values and dominance of cyanophyta frequently occurred (Minasyan et al., in preparation). Although, in the past Lake Yerevan had been characterized as mesotrophic (Stepanyan et al., 2006; Stepanyan et al., 2011), seasonal successions observed in phytoplankton assemblage in 2012-2014, species composition, their densities together with bloom formation in 2013, indicate Lake Yerevan trophic status direction toward eutrophy. The fact of presence of certain toxic algae such as representatives of Haptophyta (e.g. *Chrysochromulina parva* and *Prymnesium parvum*), confirm our assumption of Lake Yerevan trophic status being meso-eutrophic. The direction of Lake Yerevan trophic evolution in 2014 had demonstrated reverse direction to meso- eutrophic stage. This probably demonstrates the water body being in the first phase of eutrophy.

The method of using phytoplankton species as a bioindicator cannot totally replace detailed physical and chemical analyses, but according to some authors (Kitner&Poulickova, 2003) they complement them. This gain a chance to develop a tolerant bioindicator method for better assessment of the trophic stage of aquatic ecosystem compared to the chemical data (Blanco et al., 2004) and its potential harmful effect for humans and animals. EU WFD suggests the certain recommendations to reach the same goal of investigations (EC Parliament and Council, 2000). Since the data varying from the region and the lake origin, all systems for the Lake trophic status assessment has to be implemented with caution and may carry a certain error, therefore, before applying the system has to be adapted to the each region with its own calibration to minimize the error. The fact of no developed system of bioindication for Armenian aquasystems made us to use a bioindication directive developed by EU specialists.

However, the certain typical eutrophic genus occurrence and dominance, as well as cyanobacterial dominance over the period of investigations and water bloom formation (*Nostoc linckia* - June 2013) (Minasyan et. al., in preparation), gives us an obvious clue of Lake Yerevan being at meso-eutrophic stage.

5 CONCLUSION

The complexity of environmental factors in 2012-2014 most probably was the reason for observed phytoplankton high densities and dominance by certain species. Lake Yerevan has a water low mixing and wider thermal gradient, the central part of the reservoir is stratified most of the time. Physicochemical data of Lake Yerevan coincided the level of nutrients typical for lakes stepping into the first stage of eutrophy, which most probably was one of the controlling factors to determine algal species composition and dominance by certain genera.

The seasonal successions of Lake Yerevan phytoplankton community correspond to the stage of meso- to eutrophy, with picks registered for hot season and frequent dominance by certain genus. The occurrence and dominance of certain typical eutrophic genus, demonstrate Lake Yerevan being at meso-eutrophic stage.

ACKNOWLEDGMENT. A. Minasyan would like to express special gratitude to the German Academic Exchange Service (DAAD) for funding her research stay at the Ludwig-Maximilians-University, Munich, Department of Biology II, Aquatic Ecology, Germany. Profound gratitude is also expressed to Prof. Herwig Stibor for professional supervision and scientific advisory. Deep thankfulness to Dr. Stephan Behl and PhD students, Monika Poxleitner and Sara Hammerstein, for guiding in algae species identification. Very deep acknowledgment to the members of the Federation Rowing and Windsurfing for their help in sampling.

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