Phytoplankton Population Structure in Mighan Salt Lake (Arak, Markazi Province)

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Abstract

Mighan lake with the surface area of 112 km^2 is located eight kilometers northeast of Arak city, the main phytoplankton population and food chain of which include *Dunaliella salina* (Dunal) Teodoresco. The salinity of the lake ranges between 20-120 g/l depending on season and water input. The present study evaluated the effect of salinity and physicochemical factors on phytoplankton communities in the lake. To this end, sampling was performed monthly during March to December 2019. In addition, species and phytoplankton density were determined through inverted microscopy. Based on the results, 12 algal species were identified, among which *D. salina* was 87.3% of phytoplankton composition. Indeed, salinity, as a major limiting factor, reduced phyto-plankton diversity in Mighan Lake.

Keywords: Algal composition, Diversity, Hypersaline, Mighan lake, Salinity

Introduction

Hypersaline environments are defined as the places with the salt concentration higher than that of seawater (3.5% total dissolved salts) (Das sarma and Arora, 2001). The environments are related to biogeochemical processes and considered as an integral and dynamic part of the biosphere (Mohebbi, 2010; Shadrin, 2009). Prokaryotic and eukaryotic algae can contribute to primary production in salt waters (Borowitzka, 1981). The management and protection of hypersaline lakes depend on the effects of salinity level on biological productivity and community structure. Consequently, phytoplankton composition may influence *A. partenogenetica* Bowen and Sterling, as the major macrozooplankton in hypersaline waters. A continuous reciprocal interaction was observed between *A. partenogenetica* and phytoplankton population in hypersaline environments (Mohebbi, 2010). Mighan Lake is located in central Iran, about 8km far from the Arak, as the capital of Markazi province at altitude 1660m above sea level. The annual average temperature and precipitation of the lake are 11.7 ˚C (Ghahroodi Tali et al., 2012) and 258 mm (Ansari, 2008), respectively. Additionally, the surface area of the lake fluctuates depending on the entered water

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and season (Environment Conservation Organization, 2016), and its depth is about 1-1.5 m during wet period. The main water suppliers in the lake include precipitations, floods, a few rivers, springs in its bed, and sewage water effluents from Arak. *A. partenogenetica* is a brine shrimp thriving in Mighan wetland, as well as a major food chain for migratory birds, the main food source for which is *Dunaliella salina* (Dunal) Teodorescoa, a unicellular green algae.

Hypersaline environments are considered as a significant economical, ecological, and natural habitat, the management and protection of which depend on the effect of salinity levels on biological productivity and community structure. The present study assessed the effects of salinity levels on microalgal structure and dynamics in Mighan Lake. In the hypersaline lakes, salinity is the principal abiotic variable affecting phytoplankton species richness. Further, *Dunaliella* sp. can tolerate higher salinities, which results in outcompeting other algal species (Larson and Belovsky, 2013). Furthermore, salinity is negatively correlated to species richness in all of the lakes.

Materials and Methods

In the present study, samples were monthly collected from 18 sampling sites selected in Mighan wetland during March to February 2019 (Fig. 1). Phytoplankton samples were preserved in cold and dark conditions after fixation by lugol solution. After settling phytoplankton to the bottom of 5ml-settling chambers, they were counted and identified by using Nikon TS100 inverted microscope at 400× magnification based on the Utermöhl method (1958).

At least 50 fields or 100 individuals of the most abundant species were counted in each sample (Venrick, 1978). Phytoplankton taxa were determined according to Prescott (1962), Tiffany and Britton (1971) and Bellinger (1992).

In each site species composition, and density of phytoplankton community were analyzed. Salinity was measured by a refractometer model ATAGO (Japan). Temperature was measured in situ by alcoholic thermometer. EC, TDS, and pH were measured by WTW LF 320 EC meter and a Testo 320 PH meter, respectively. Transparency of water was measured by Secchi disc (30 cm diameter). Correlation among some variables were calcu-

Fig. 1. Samplings sites in Mighan Lake

lated (Excell, 2013). The data were standardized (mean= 0, variance= 1) and correspondent analysis was performed. Multivariant analysis was done to observe distribution of the sampled waters based on environmental parameters.

Based on distance matrix method UPGMA tree was constructed, Two-way clustering of environmental parameters was carried out using UPGMA. Indeed, the Euclidean distance was determined among standardized data. Statistical analysis were performed by PAleontological STatistics (PAST) version 3.04 (Hammer et al., 2001).

Results

In this study 12 algal species were identified in Mighan Lake. Cyclic pattern of water temperature fluctuations presented in Figure 1. Bacillariophyta were the most conspicuous taxa (5 species) (Table. 1). While Cyanobacteria and Chlorophyta and included 3 and 4 species, respectively. *D. salina* a halophilic green algae composed 87.36% of phytoplankton composition (Fig. 2).

Based on the results in Fig. 3, the maximum and minimum temperature in Mighan Lake was recorded in September and December as 32.4 and 5.7 ˚C, respectively.

As shown in Fig. 4, the salinity of the lake is

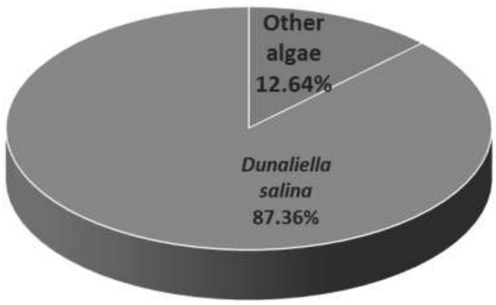

Fig. 2. Algal population structure in Mighan Lake

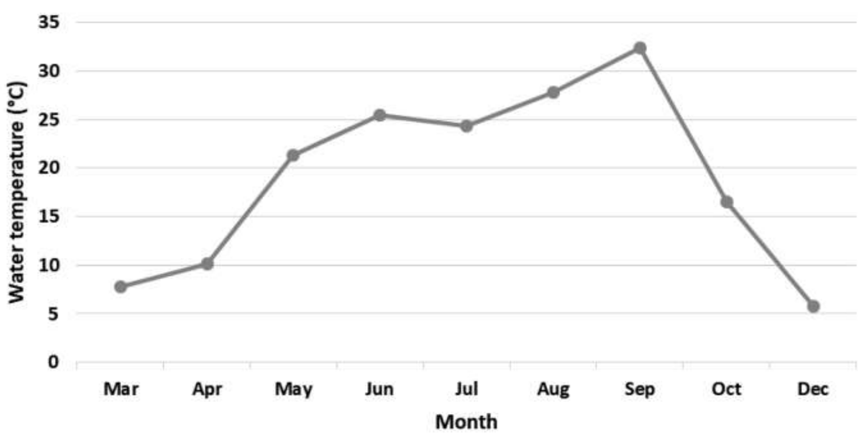

Fig. 3. Water temperature changes in Mighan Lake

Table 1. Algal species density in Mighan Lake during the study period

Density (%)	Mean (Ind/L)	Density	Algal species	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Dec	Density (%)
87.36	377033		*Dunaliella salina* (Dunal) Teodoresco	+	+	+	+	+	+	+	+	+	87.36
12.64	4142		*Navicula* sp.	+	+	+	+	+	-	-	+	+	12.64
	39613		*Nitzschia* sp.	+	+	+	+	+	+	+	+	+	
	3278		*Chlorella vulgaris* Beijerinck	+	-	-	-	-	-	-	-	-	
	731		*Gomphosphaeria* sp.	+	-	-	-	-	-	-	-	-	
	365		*Symbella prostrate* (Berkeley) Cleve	+	-	-	-	-	-	-	-	-	
	2947		*Oscillatoria* sp.	+	+	+	+	+	-	-	-	-	
	365		*Oocystis crassa* Wittrock	+	-	-	-	-	-	-	-	-	
	2947		*Closterium* sp.	-	+	+	+	+	-	-	-	-	
	644		*Microcystis* sp.	-	+	+	-	-	-	-	-	-	

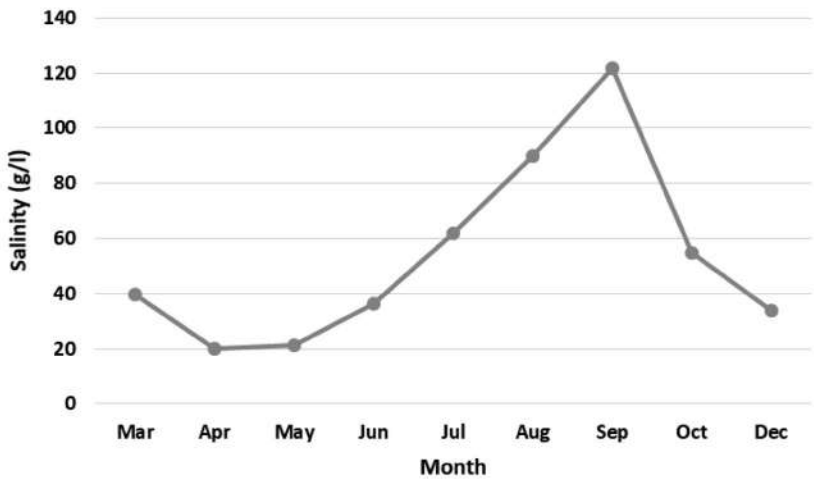

Fig. 4. Salinity fluctuations in Mighan Lake

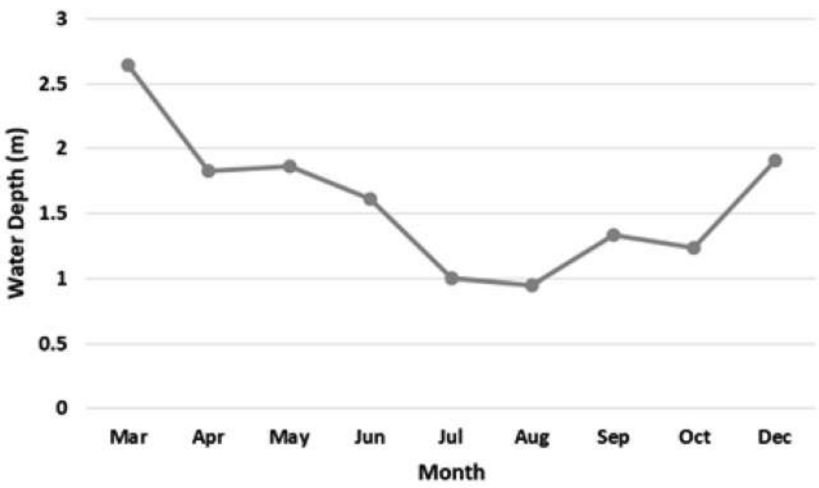

Fig. 5. Water depth fluctuations in Mighan Lake

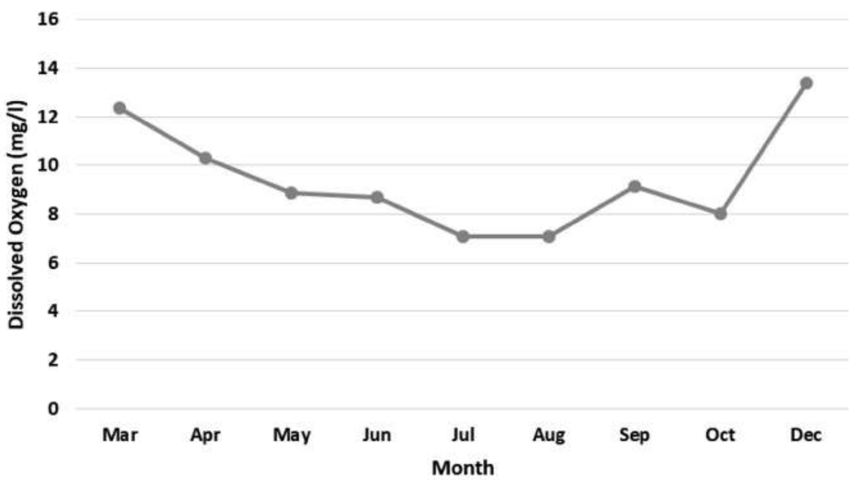

Fig. 6. Water DO fluctuations in Mighan Lake

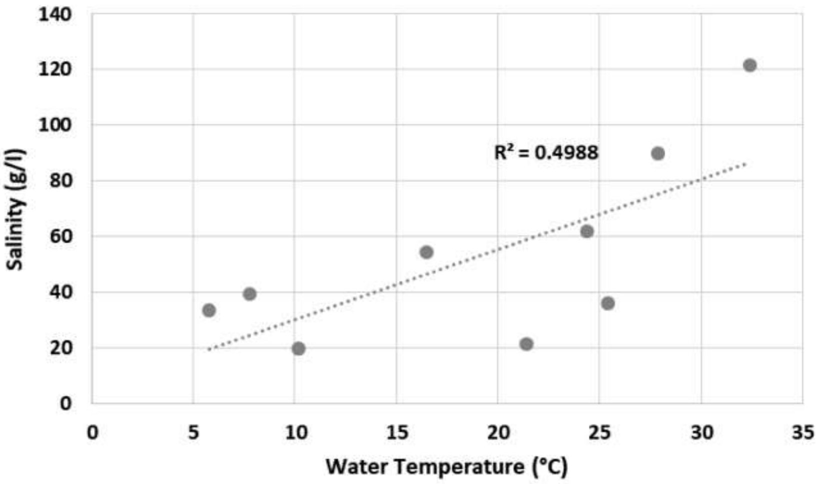

Fig. 7. Correlation between water temperature and salinity in Mighan Lake

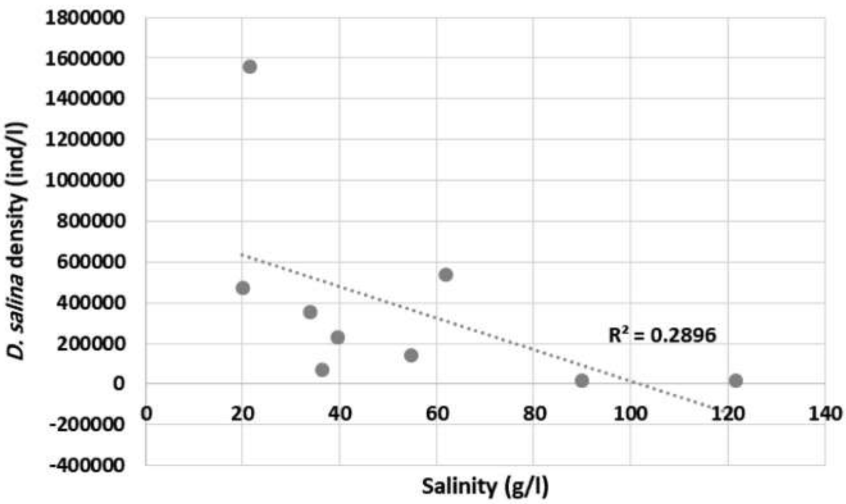

Fig. 8. Correlation between water salinity and *D. salina* density in Mighan Lake

between 19.9 g/l in April to 121.6 g/l in September, respectively (M: about 33.8 g/l). Further, water depth was respectively measured 0.95 and 2.64 m in August and March (Fig. 5). Furthermore, the highest and lowest dissolved oxygen content (DO) was 13.3 and 7 mg/l in December and August, respectively (Fig. 6).

As displayed in Fig. 7, a significant positive correlation is observed between salinity and water temperature (R=0.71). However, the results in Fig. 8 demonstrated a relatively negative significant correlation among salinity and *D. salina* density (R= 0.54), which confirms a decrease in *D. salina* by increasing salinity. The results of PCA analysis and CA analysis that provided two distinct groups are represented in Fig. 9 and 10.

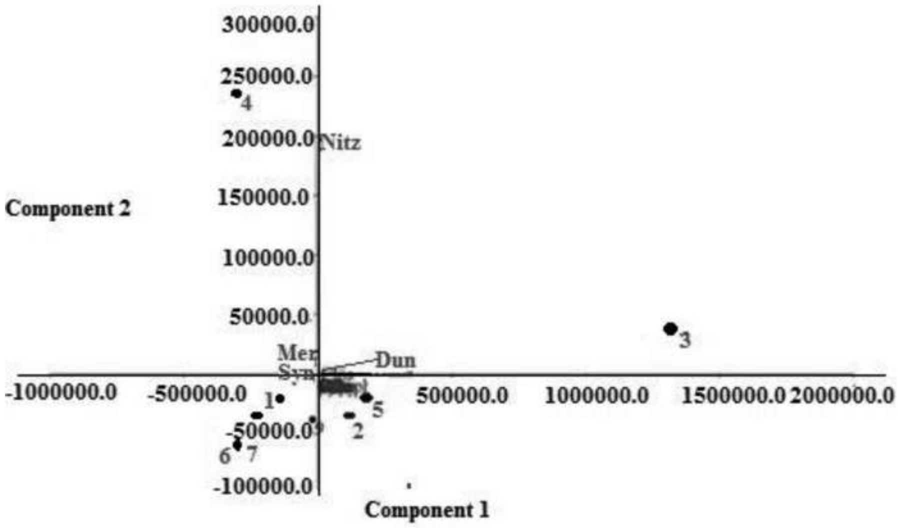

Fig. 9. PCA analysis of phytoplankton taxa and sampling months in Mighan Lake

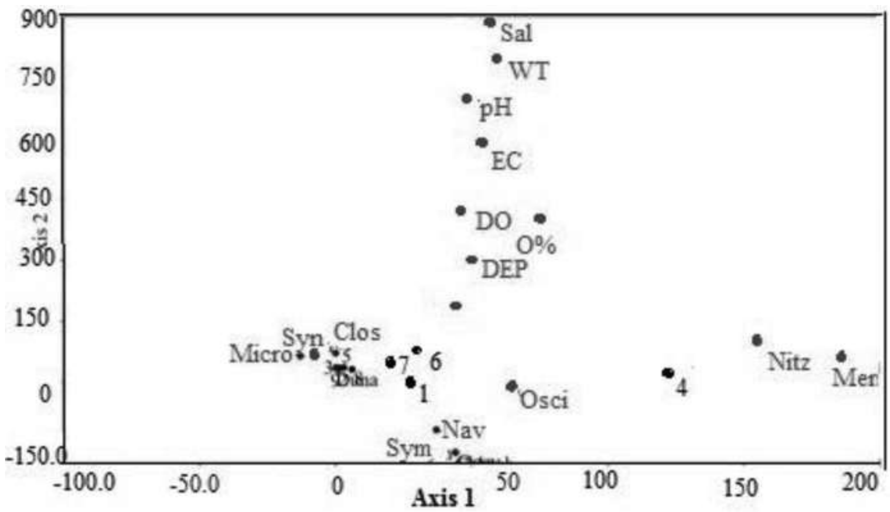

Fig. 10. CA analysis of phytoplankton taxa and physicochemical parameters in Mighan Lake

Discussion

Physicochemical factors influence the phytoplankton population of aquatic ecosystems. In the hypersaline lakes, the population is affected by salinity, as a dominant parameter. In fact, temperature and nutrients have a direct effect on algal composition. In addition, *D. salina* is observed in all hypersaline lakes although the participation of species in total phytoplankton density depends on the salinity level, which is 99 and 87% of algal composition in the Urmia Lake with salinity above 200 g/l and Mighan one with lower salinity level (M:33 g/l), respectively.

Based on the results, the highest and lowest density of *D. salina* was observed in May and September, respectively. Indeed, *D. salina* density, water level, and nutrients increased simultaneously during spring, which is consistent with those obtained in other hypersaline lakes such as Urmia (Mohebbi, 2020). *A. parthenogenetica* feeds on *D. salina* the density of which reduces in September (Hesami et al., 2017). The results of the present study indicated that the maximum species richness was related to spring and early summer, while the minimum was achieved in late summer, autumn, and winter, which are in line with those concerning Urmia Lake (Esmaeili Dahesht et al., 2010; Mohebbi, 2020) and Great Salt Lake in the United States (Barret and Belovsky, 2020). However, the red color observed in Urmia Lake (Mohebbi et al., 2011) was not reported in the Mighan. Further, salinity concentration remained below the saturation level in which halobacterial density reaches 10^7-10^8 cells/ml in Urmia Lake. Ghadimi (2020) found municipal wastewater as a major source of heavy metal pollution in Mighan Lake.

The results of PCA analysis reflected that two main components included 99.94% of total vari-ance (Fig. 9) so that the first and second allocated 96.57 and 3.37% of total variance, respectively. In fact, the PC_1 was positively correlated with the main phytoplankton species (*D. salina*), water temperature, and salinity. Furthermore, PCA ordination represented three distinct regions indicating the connection of environmental variables and phytoplankton community changes. Most of the sampling months were included in the central region, while the upper was related to sampling in June and higher *Nitzschia* density in the month. Finally, sampling in May was pre-sented in the right end of PCA biplot because of measuring the maximum density of *D. salina* in the month. Thus, salinity and water temperature are considered as the main driving factors which contribute to the separation of three groups in PCA analysis.

The results of CA analysis provided two different groups, the first of which included sampling during June when *Nitzschia* density increased and *Merismopedia* species appeared (Fig. 10). The results of PCA analysis demonstrated that CA analysis classified the data by considering the salinity and water temperature.

Based on the results, hypersaline lakes are not a simple ecosystem. Therefore, there is a need for enhancing the knowledge about the factors affecting diversity and coexistence patterns in the unique ecosystem.

Paturej and Gutkowska (2015) examined the effect of salinity on zooplankton population in Vistula lagoon and reported that salinity influences species number and biomass, while it has no effect on species diversity. Additionally, salinity level affects ecosystem processes in wetlands such as phytoplankton diversity and biomass (Gao et al., 2008). Further, *Dunaliella*, as a halotolerant species, mainly occurs in high salinity levels such as Mighan Lake (Hesami et al., 2017). According to Kondo et al. (1990), the effectiveness of salinity levels on phytoplankton composition is more than that of temperature changes.

Finally, phytoplankton assemblages adapt to habitat properties at different salinity levels, which these levels are the main limiting factor determining phytoplankton associations. However, the presence of *Artemia* species, as well as nutrient levels, should be considered. Thus, further studies should be conducted to explore the ecosystem structure of Mighan lake.

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