Primary Productivity and Phytoplankton Diversity of the Golestan Dam Reservoir, Golestan Province, Iran

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Abstract

Golestan Dam Lake is located 12 kilometers east of Gonbad City and was constructed in 1379. The volume of the Golestan Dam reservoir is 52 million cubic meters and its area is 1500 hectares, which was built for the purposes of agricultural and aquaculture operations.. The present study on phytoplankton biodiversity and its relationship with the primary productivity of the Golestan Dam reservoir was conducted from April to July 2019. Furthermore, water quality parameters such as transparency, pH, alkalinity, free carbon dioxide, air and water temperature, dissolved oxygen, primary productivity, conductivity, nitrate-nitrogen, and orthophosphate were analyzed along with aqualitative and quantitative estimation of phytoplankton. The results indicated that the average primary productivity or gross primary production (GPP) was 0.399 ± 0.081 gcm^3h^{-1}, Net Primary Production (NPP) (0.307±0.061 gcm^3h^{-1}), and Community Respiration (CR) 0.094±0.024 gcm^3h^{-1} in the surface. Algae in freshwater have numerous environmental functions and are based upon the recycling of nutrients. Totally 73 species of phytoplankton belonging to the different taxonomic groups were identified form 32 genera. Among these 32 genera, 12 belong to Cyanophyceae, 8 from Chlorophyceae, 10 belong to Bacillariophyceae, and 2 genera belong to Euglenophyta. On the basis of mean primary productivity, the fish production potential of reservoir Golestan Dam showed considerable scope for the enhancement of current average production.

Keywords: Golestan Dam, Phytoplankton Diversity, Primary Productivity

Introduction

Iran is a status as mega-diverse country and a major center of biodiversity. The aquatic ecosystems of Iran have been subjected to various forms of environmental stress during the past few decades. Most of such environmental problems are manufactured and thus increased human activities in the catchment area of various aquatic systems have affected the natural processes of these systems adversely thereby threatening the survival and growth of biotic communities (Khanna et al., 2012).

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Golestan Province is also endowed with varied surface freshwater resources like reservoirs, seasonal and a couple of perennial rivers, canals, small tanks and ponds. Golestan Province has around 21000-sqkm area. Furthermore, eleven reservoirs behind the dam are in operation with a volume of 183 million cubic meters three tanks are ready for operation with a volume of 132 million cubic meters and two investigated reservoirs with a volume of 30.5 million cubic meters (Javid Imanpour et al., 2013).
Golestan Dam is a shallow lake with a catchment area of 5000 sqkm, a maximum depth (Zm) of 6 m, and an area of 1500 ha. The lake is totally rain-fed and retains water throughout the year.
Phytoplankton is the main primary producer in water bodies and influences the structure and density of consumers and characteristics of water. Moreover, phytoplankton organisms are sensitive indicators, as their structure and metabolism change quickly in response to environmental changes (Mishra et al., 2012). the growth rate and variability of phytoplankton are subject to cyclic changes of fluctuation and succession. Phytoplanktons constitute a major part of aquatic vegetation, they are primary producers, which support the growth of aquatic fauna and produce oxygen through the photosynthetic process (Chinnaiah et al., 2010). Biological parameters such as temperature, transparency, pH, alkalinity, free carbon dioxide, dissolved oxygen, electrical conductivity, nitrate-nitrogen, orthophosphate of any water body grossly determine the trophy status of the water body. Such parameters influence the primary productivity and in turn the growth of the fish. The primary productivity of different water bodies has been widely investigated to assess the fish production potentialities of a water body to formulate appropriate fishery management policies (Khanna et al., 2012). Considering the local conditions in the account, an attempt was made to find out the phytoplankton biodiversity in relation to the primary productivity of the Golestan Dam.

Materials and methods

Golestan Dam Lake is located 12 kilometers east of Gonbad city and was opened in 1379. The volume of this dam reservoir is 52 million cubic meters and its area is 1500 hectares, and it was built for the purpose of agriculture and aquaculture. The study of the biological conditions of this reservoir was carried out based on the initial production of the lake for three months from April 2019 to the end of June of the same year is illustrated in Figure 1.
In the present study, five stations were selected for collection in the Golestan Dam Lake which is illustrated in Figure 1 for collection and weekly analysis. Three stations are located in south eastern, two station in the eastern, and two stations is on the western side. The geographical distribution of the selected stations is given in Table 1.

Primary productivity analysis

Primary productivity was measured at all three stations following the light and dark bottles method. For this purpose, glass stopper black and white BOD bottles of 250 ml were used. The bottles were suspended about 15 cm below the water line. The

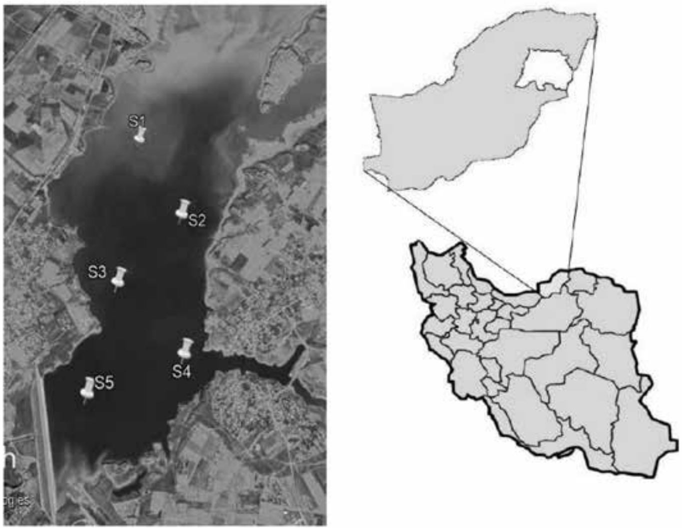

Fig. 1. Location map of Golestan Dam

Table 1. Geographical distribution of stations

	S1	S2	S3	S4	S5
Latitude	37°20'40.86"N	37°20'12.17"N	37°19'55.67"N	37°19'30.44"N	37°19'26.22"N
Longitude	55°17'49.58"E	55°18'0.77"E	55°17'32.40"E	55°17'52.36"E	55°17'16.06"E

incubation period was kept for three hours. Then, Oxygen (O_2) estimations in the BOD bottles were made following the usual Winkler's method (APHA, 2005). The calculation was done as follows.

Gross Oxygen Production (GOP) mg l^{-1} = LB-DB,

Net Oxygen Production (NOP) mg l^{-1} = LB-IB,

Community Respiration (CR) mg l^{-1} = IB-DB.

The values of GPP and NPP were calculated as follows.

Gross Primary Productivity (gcm^3h^{-1}) = GOP×0.375/1.2×h

Net Primary Productivity (gcm^3h^{-1}) = NOP ×0.375/1.2×h

Where;

LB = Dissolved oxygen in the light bottle,

DB = Dissolved oxygen in the dark bottle

IB = Dissolved oxygen in the initial bottle,

h = Duration of incubation or exposure

1.2 = A constant, 0.375 A factor value (1 g of oxygen is equal to 0.375 g carbon).

Phytoplankton identification

Firstly, 50 liters of water was filtered through bolting cloth No. 25 (mesh size 60 μm) ,and obtained planktons were preserved in Lugol's solution for further quantitative and qualitative analyses. Then, quantitative and qualitative analysis was performed according to APHA, 1989. After that, the mass density of phytoplankton was calculated (Boney, 1989; Sourina, 1978). Lastly, samples were identified using valid identification keys (Edmondson, 1959; Prescott, 1970; Maranon, 2015; Sourina, 1978; Maosen, 1983). (Senthilkumar and Sivakumar, 2008). The identification of phytoplankton was limited up to Cynophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae.

Resuts

The results of GPP and NPP analysis of Golestan Dam during the study period (April to July) are presented in Table 2. In general, the GPP ranged between 0.26 to 0.50, 0.23 to 0.47, 0.25 to 0.53, 0.25 to 0.47, and 0.25 to 0.50 gcm^3h^{-1} at stations S1, S2, S3, S4, and S5, respectively. The average values of GPP were 0.25, 0.49 gcm^3h^{-1}, and 0.40 gcm^3h^{-1}.

The statistical correlation of GPP was positive with NPP, community respiration (CR) and phytoplankton community structure. The value of net primary productivity (NPP) at stations S1, S2, S3, S4, and S5 ranged from 0.21-0.40, 0.18-0.37, 0.10-0.43, 0.2-0.37, and 0.20-0.40 gcm^3h^{-1}. Furthermore, the average values of NPP were 0.18, 0.39 gcm^3h^{-1} and 0.31 gcm^3h^{-1} (Table 2).

The statistical relationship of NPP was positive with GPP and total phytoplankton. The respective values of community respiration (CR) at stations S1, S2, S3, S4, and S5 ranged from 0.05 to 0.13, 0.05 to 0.12, 0.10 to 0.15, 0.05 to 0.13, and 0.05 to 0.15 gcm^3h^{-1}. The corresponding average values of CR were 0.06, 0.14 gcm^3h^{-1} and 0.09 gcm^3h^{-1} (Table 2).

The statistical correlation of CR was positive GPP. However, there was a negative relationship between NPP and

Table 2. Weekly observation of Physico-chemical and biological characteristics of surface water at the selected station of Golestan Dam

	Gross primary productivity gcm^3h^{-1}				
Gpp	S1	S2	S3	S4	S5
Avg.	0.39	0.37	0.43	0.39	0.42
SD	0.081	0.083	0.09	0.076	0.085
max	0.5	0.47	0.53	0.47	0.5
min	0.26	0.23	0.25	0.25	0.25
CV	0.21	0.23	0.21	0.19	0.20
	Net primary productivity gcm^3h^{-1}				
Npp.	S1	S2	S3	S4	S5
Avg.	0.31	0.29	0.31	0.30	0.32
SD	0.055	0.060	0.10	0.052	0.059
max	0.4	0.37	0.43	0.37	0.4
min	0.21	0.18	0.10	0.2	0.2
CV	0.18	0.21	0.32	0.17	0.18
	Community Respiration gcm^3h^{-1}				
CR.	S1	S2	S3	S4	S5
Avg.	0.09	0.08	0.12	0.09	0.095
S.D	0.032	0.028	0.02	0.032	0.036
max	0.13	0.12	0.15	0.13	0.15
min	0.05	0.05	0.10	0.05	0.05
CV	0.38	0.37	0.15	0.35	0.38

total phytoplankton. The results of Means analyses and resulting Weekly variations in Gross Primary Productivity (GPP), Net Primary Productivity (NPP), and Community Respiration (CR) in sampling stations of the Golestan Dam reservoir is shown in Figure 2 and Figure 3.

Phytoplankton community

The phytoplankton community constitutes the bulk of primary producers and is the base of food chains in any water body. The phytoplankton community of the Golestan Dam during the present was represented by four major groups viz., Cyanophyta, Chlorophyta, Bacillariophyta and Euglenophyta. Overall, 73 species of algae were identified (Table 3).

Overall, 73 species, belonged to 32 genera Among these 32 genera, 12 were from Cyanophyceae (blue-green algae), 8 from

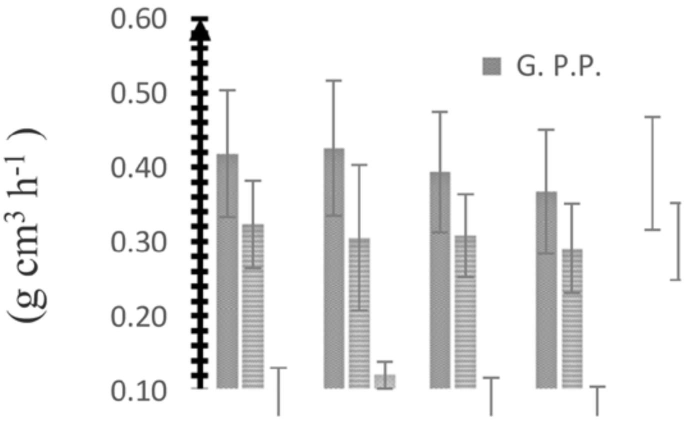

Fig. 2. Mean variations in Gross Primary Productivity (GPP), Net Primary Productivity (NPP), and Community Respiration (CR) in Sampling stations of Golestan Dam reservoir

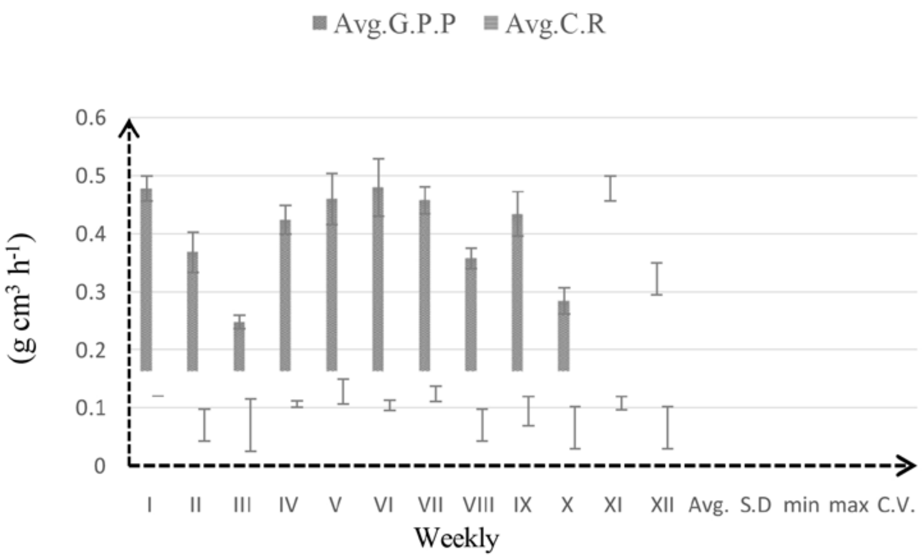

Fig. 3. Weekly variations in Gross Primary Productivity (GPP) and Community Respiration (CR) in Golestan Dam reservoir

Chlorophyceae (green algae), 10 from Bacillariophyceae (diatoms), and 2 belonged to Euglenophyta (Table 4).

Discussion

The most prominent phytoplanktons in the present study were *Microcystis aeruginosa*, *Anabeanaposis* sp., *Lyngbya* sp., *Oscillatoria* sp., and *Merismopedia* sp. from the Cyanophyceae group. *Ankistrodesmus* sp., *Chlamydomonas* sp., *Oocystis* sp., *Scendesmus* sp., and *Chlorogonium* sp. from Chlorophyceae. As a result, Cyanophyceae was the most dominant group. Some other researches on this reservoir also reported four phytoplankton phyla including Bacillariophyceae, Chlorophyceae, Cyanophyceae, and Euglenophyceae. They observed that blue green algae and diatoms are the most abundant phytoplankton in this reservoir. (Imanpour et al., 2022; Azizi et al., 2022; Ghorbani et al., 2016).

Several classes including Cyanophyceae, Bacillariophyceae, and Chlorophyceae were observed as the dominant phytoplankton in respect of the total species and density in station 1, which confirms the result obtained by Imanpour et al. (2022). Indeed, these results are

Table 3. Composition of phytoplankton population in the stations selected of Golestan Dam reservoir

Class	Order	Familly	Genus	Species
Bacillariophyceae	Chaetocerotanae	Chaetocerotaceae	Chaetoceros	Chaetoceros convolutus
				Chaetoceros peruvianus
				Chaetoceros throndsenii
				Chaetoceros simplex
				Chaetoceros mirabilis
				Chetoserus mueelleri
				Chetoserus rigidus
				Chaetoceros socialis
				Chaetoceros subtilis
	Thalassiosirales	Stephanodiscaceae	*Cyclotella*	*Cyclotella caspica*
				Cyclotella menenghiniana
	Fragilariales	Fragilariaceae	*Diatoma*	*Diatoma vulgar*
				Diatoma ochki
			Synedra	*Synedra amphirhynchus*
	Naviculales	Naviculaceae	*Navicula*	*Navicula bombus*
				Navicula cryptocephala
				Navicula sp.
	Bacillariales	*Bacillariaceae*	*Nitzschia*	*Nitzschia* sp.
				Nitzschia SP.2
				Nitzschia acicularis
				Nitzschia parva
				Nitzschia reversa
				Nitzschia sigma
				Nitzschia sigmoidea
				Nitzschia sp.1
				Nitzschia tenirustris
				Nitzschia sublinearis

				Nitzschia closterium
				Nitzschia sp.
				Nitzschia sp.2
				Nitzschia tennuis
				Nitzschia longgisma
				Scletonema costata
	Rhabditida	*Allantonematidae*	*Scatonema*	*Scletonema costatum*
				Scletonema subsalsum
	Thalassiosirales	*Thalassiosiraceae*	*Thalassiosira*	*Thalassiosira variabilis*
cyanophyceae	*Nostocales*	*Nostocaceae*	*Anabaena*	*Anabaenabergii*
				Anabaena aphanizomenoides
				Anabaena spiroides
				Anabaena hisselevii
			Aphanizomenon	*Aphanizominon flos-aqua*
				Aphanizominon sp.
			Cylindrospermopsis	*Cylindrospermopsis raciborskii*
	chroococcales	*chroococcaceae*	*Chroccoccus*	*chroococcus* sp.
	oscillatoriales	*Oscillatoriaceae*	*Lyngbya*	*Lyngbya limnetica*
				Lyngbya SP.
			Oscillatoria	*Oscillatoria limosa*
				Oscillatoria agardhii
				Oscillatoria sp.
				Oscillatoria tennuis
	Oscillatoriophycideae	*Spirulinaceae*	*Spirulina*	*Spirulina* sp.
Trebouxiophyceae	*Chlorellales*	*Chlorellaceae*	*Actinastrum*	*Spirulina laxissma*
			Chlorella	*Actinastrum hantzschii*
		Oocystaceae	*Oocystis*	*Chlorella SP.*
				Oocystis borgi
				Oocystis solitaria
Chlorophyceae	*Sphaeropleales*	*Selenastraceae*	*Ankistrodesmus*	*Oocystis parva*
		Neochloridaceae	*Golenkinia*	*Ankistrodesmus* SP.
		Scenedesmaceae	*Scendesmus*	*Golenkinia Paucispina*
				Scenedesmus bijuga
	Chlamydomonadales	*Chlamydomonadaceae*	*Chlamydomonas*	*Scenedesmus quadricauda*
		Volvocaceae	*Pandorina*	*Clamydomonas* SP.
	Volvocales	*Haematococcaceae*	*Chlorogonium*	*Pandorina morum*
Conjugatophyceae	*Desmidiales*	*Desmidiaceae*	*Cosmarium*	*Chlorogonium* SP.
Malacostraca	*Amphipoda*	*Stegocephalidae*	*Tetradeion*	*Cosmarium* SP.
Trebouxiophyceae	*Chlorellales*	*Chlorellaceae*	*Actinastrum*	*Tetradeion* SP.
	Euglenida	*Euglenaceae*	*Euglena*	*Euglena* SP.
				Euglena acus
				Euglena caudata
Euglenoidea			*Trachelomonas*	*Trachelomonas* SP.1
				Trachelomonas spiculifera
				Trachelomonas verrucosa

Table 4. contribution of different planktonic groups in the selected stations of Golestan Dam reservoir

stations	S1	S2	S3	S4	S5
			(Cells ml^{-1})		
Cyanophyta	26.6	14.2	37.4	40.4	23.2
Chlorophyta	10.6	14.8	12.6	10.2	7.2
Bacillariophyceae	13.6	11.8	11	6.6	13.4
Euglenophyta	2	0.8	1.4	2.4	1.6
Sum	52.8	41.6	62.4	59.6	45.4

in agreement with Naz Türkmen et al. (2005), Fathi and Ebrahimi (2016), and Abolhasani et al., (2019), that reported a higher abundance of Cyanophyceae and Bacillariophyceae in an Anatolian Dam Lake compared to other phytoplankton groups results are in agreement. In addition, these results are in agreement with Abolhasani et al. (2018) who reported Cyanophyceae and Bacillariophyceae as the most dominant classes in the international Gavkhooni Wetland, Iran.

Javid Imanpour et al. (2022) found that the average phytoplankton count in Golestan Dam was 32.31 Noml^{-1} composed of 39 genera belonging to Chlorophyceae, Bacillariophyceae, Cyanophyceae, and Desmidiaceae, respectively. Moreover, there is a significant decline in the biodiversity of phytoplankton compared to the present study Therefore, The monthly average values of all five stations of overall mean phytoplankton density were higher at station S3 i.e. (62.4 Cells ml^{-1}), S4 (59.6 Cells ml^{-1}), S1 (52.8 Cells ml^{-1}), S5 (45.4 Cells ml^{-1}), and S2 (41.60 Cells ml^{-1}), respectively. The trend of dominance among the five phytoplankton groups at station S1 was Cyanophyceae> Bacillariophyceae> Chlorophyceae> Euglenophyta, station S2 was Chlorophyceae> Cyanophyceae> Bacillariophyceae > Euglenophyta, at station S3, was Cyanophyceae> Chlorophyceae > Bacillariophyceae> Euglenophyta and at station S4, was Cyanophyceae> Chlorophyceae> Bacillariophyceae> Euglenophyta. However, at station S5 the relative dominance of four algal groups was Cyanophyceae> Bacillariophyceae> Chlorophyceae> Euglenophyta. Overall, the dominance of phytoplankton is similar to the trend found at station S1 (Table 4).

Kumar et al. (2015) found six groups namely Chlorophyceae, Bacillariophyceae, Desmidiaceae, Xanthophyceae, Myxophyceae, and Dinophyceae represented the phytoplankton community of water bodies. Total of 58 species were identified which 28 belonged to Chlorophyceae, 11 to Bacillariophyceae, 9 to Myxophyceae, 4 to Dinophyceae, 3 to Desmidiaceae, and 3 to Xanthophyceae (Mishra et al. 2016).

Whereas, the average phytoplankton density was 52.36± 8.9 Cells ml^{-1} (Table 4) while the highest phytoplankton density (62.4 Cells ml^{-1}) was observed in Spring 2019 at station S3 and the lowest (41.6 Cells ml^{-1}) during spring in station S2 (Tables 4). Considering the average phytoplankton biomass, Cyanophyceae was the most dominant (26.6, 14.2, 37.4, 40.4, 23.2 Cells ml^{-1}) followed by Bacillariophyceae (13.6, 11.8, 11.00, 6.6, 13.4 Cells ml^{-1}), Chlorophyceae (10.6, 14.8, 12.8, 10.2, 7.2 Cells ml^{-1}), Euglenophyceae (2.00, 0.80, 1.4, 2.4, 1.6 Cells ml^{-1}) in station S1, S2, S3, S4, and S5, respectively (Table 4). In conclusion, Cyanophyceae and Bacillariophyceae were dominant, followed by Chlorophyceae and Euglenophyta (Table 3). The statistical analysis of phytoplankton density shows a positive correlation with GPP and NPP. However, there was a negative correlation with community respiration (CR).

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