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An assessment of Ecophysiology and Cyanophycean biodiversity in Gajner lake, Bikaner, Rajasthan, India.

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ABSTRACT

In an aquatic ecosystem Phytoplanktonic community dominated by Algae. Algae are the photosynthetic producers who account approx. one third of total photosynthetic activity on this planet. Our study deals with a freshwater lake ecosystem. Chlorophyceae, Cyanophyceae, Bacillariophyceae these are the dominant position occupying Algal classes in any freshwater ecosystem. Present paper deals with Ecophysiology of Gajner lake and taxonomical, morphometrical enumerations of reported algal taxa belongs to Cyanophyceae class. Gajner lake located around 33 kms away from Bikaner toward west side. Study was carried out for one-year January 2017 to December 2017.We collected algal samples from 3 sites of Gajner lake twice in a month. Gajner lake is a part of wildlife sanctuary, managed properly under Sanctuary act. A tourist spot Gajner palace also located along the Lake.So it is less polluted. Although a portion of Lake is under village panchayat which is openly accessed by the local people of Gajner village for their multiple types of needs. At this anthropogenically accessed site Cyanophycean alga were in dominant position in view of their density and number of species. The portion of lake which is under regulation of sanctuary act has less population of these Cyanoprokaryotes. However, some filamentous Cyanophycean Genus like *Nodularia*, *Calothrix* were present in accountable density during winter season at this regulated site of lake. People of Gajner village relies on lake for their multiple type of needs, numerous bird fauna also visit the lake in winter and summer season as suitable to them so water quality analysis is the worthy concern for study. Analysis of phytoplanktonic diversity can be utilised for the conclusion about water quality because phytoplankton rapidly respond against the fluctuation in hydrochemistry. So regular monitoring of phytoplanktons is an excellent source to decode the Ecophysiological environment of a lake.

Keywords: Phytoplankton, Ecophysiology, Cyanophyceae, Biodiversity, Gajner Lake, Taxonomy, Morphometry.

INTRODUCTION

Rajasthan is the largest state by area in the republic of India. State has a glorious history of Rajputana Mewar which is a keynote token to the identity of state in the world. The Geographical feature of Rajasthan include the Aravali range and the Thar desert. Most of the North-western part of Rajasthan is replete with the sandy dunes and great Indian desert Thar. Bikaner located in Northwest of Rajasthan. Coordination's of Bikaner are 28.022˚ N ,73.31˚ E. Bikaner district is the keynote region of the Rajasthan representing typical climatology of this arid state. Bikaner is the historical and monumental place having lot of sites of tourism purpose as well as bear a special world-famous token in regard of delicious Bhujia and Papad. Due to the typical arid climate poor annual precipitation, high wind velocity, extreme range of temperature, scanty vegetation, lower water table are the picture of the city. Beside the crucial scarcity of water surprisingly Bikaner has a privilege of some temporary and permanent pond Like Harsholav, Devikund Sagar, Sansolav, Shiv Bari, Kolayat, Gajner (Mali, 2002). These all ponds were the potent source of drinking water in ancient time .and bear the religious values also. Now a days IGNP Project become the lifeline for water need of Bikaner district (Santosh *et al*.,2017). Gajner lake is an artificial rainfed lake.

The maharaja Ganga Singh ruling that time (1888 AD-1943 AD) boring this lake along their hunting site. Now it is a part of Gajner wildlife sanctuary. Lake retain water throughout the year. It is located 33 kms from Bikaner towards west. We were collected our sample from different sites of lake twice in a month from January 2017 to December 2017. We also collected the water sample to assess the hydrochemistry of Lake. Morphometrical enumeration is the only way to denote the diversity of algae during the various seasons of study period. Most of these species occurs as epiphyte on the Macrophytes of lake serve as potent producers for aquatic fauna.

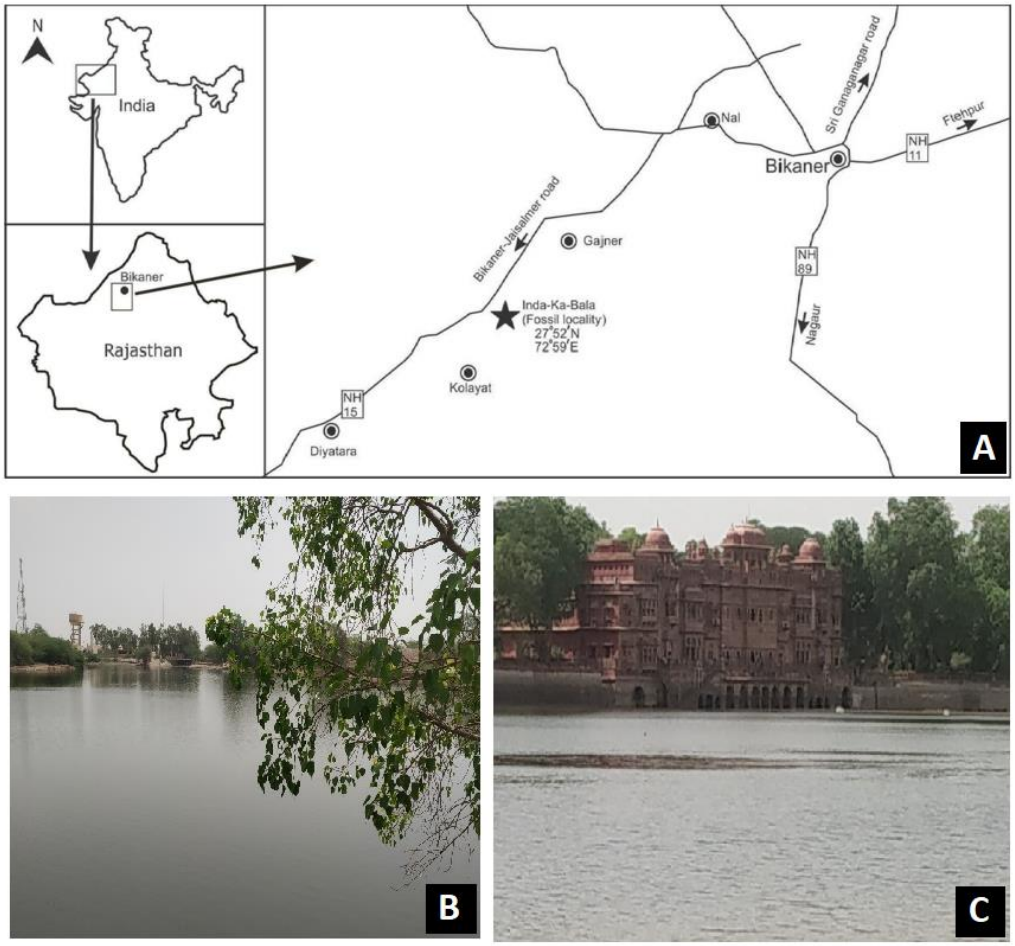

Figure 1 A: An outline map to locate the study site Gajner Lake, Bikaner District (Rajasthan)
B: View of Lake toward village **C:** View of Lake toward Gajner Palace.

Cyanophycean alga are the prokaryotic photo-oxygenic organisms which contribute a lot in photosynthetic activity of an aquatic body. Studies on these Cyanoprokaryotes in India has been carried out by numerous Phycologists. Namely are Fritsch, (1935); Anantani and Marathe (1947a); Desikachary,1959; Agarkar (1965); Bendre and Agarkar (1965); Ahmed (1967); Ashtekar and Kamat (1978); Mali,(2002); Khare *et al*. (2010); Modi and Mali (2010); Bhushan and Kumar (2013); Kasthuri *et al*. (2016); Santosh *et al*. (2017); Sreenivasan and Aruna (2018); Agarwal (2019); Wagh and Jadhav (2019); Baumataray *et al.* (2020).

MATERIAL AND METHODS

The samples were collected from different sites of lake during 9 am to 12 pm twice in a month. Algae were analysed in living condition with the help of light microscope. Because during preservation many of characters are lost. Thats why analysis in living condition preferred. After analysis of samples algae were preserved in 4% formalin solution. Along with algal sample water sample were also collected. water sample analysed for detection of numerous physico-chemical parameters. Study of Interaction of numerous physico-chemical parameters is the prima facing need to understand about the potent presence of particular algal species diversity in the lake. Due to microscopical morphology and rapid multiplication rate algae frequently respond against a minor fluctuation in the hydrochemistry of lake. Morphometrical study was done by using De winter research microscope. Microphotography also carried out for future taxonomical studies. Taxonomical enumeration was done with the concerned literature like, the structure and reproduction of algae Vol I (Fritsch, 1935), Manual of phycology (Smith,1959), Algae a review (Prescot, 1968), Cyanophyta (Desikachary, 1959) and various other monograph and research works.

RESULT AND DISCUSSION

Taxonomical and Morphometrical analysis of Cyanophycean Alga reported from Lake:
Class: Cyanophyceae

Order: Nostocales
Family: Nostocaceae
Genus: *Nostoc* Ag. Ex Born et Flah.
3-4µ broad, Cells of trichome are joined end to end to form moniliform chains. Sheath of trichome is thin and diffluent. Intercalary heterocyst is present. Heterocyst 6-7 µ broad, spores 4-8 µ broad size and two polar nodules at two ends. Cell: 3-4µ broad (Fig 2A).

Genus: *Nodularia spumigena* Mertens ex Bornet & Flahault
Trichome straight. Cells are shorter than wide. Trichome is 4.6µ -8.3µ broad. Heterocyst is 4.2-7.4µ long and 5.5-9.7 µ broad. Sheath absent Cell: 3.1-4.7µ long, 4.6µ -8.3µ broad. (Fig 2 B)

Genus: *Raphidiopsis mediterranea* Skuja
Trichome free floating mostly straight. Weakly sigmoid. Attenuated at both ends. Generally, with gas vacuole. Spore ellipsoid with rounded end Cell: 1.9-3µ broad ,40-110 µ long (Fig 2C).

Genus: *Anabaena bory* Bornet & Flahault (Fig 2D).
3.6-4.2 µ broad ,6.3-11.5 µlong, spores are 4.2 -6.3 µ in diameter, heterocyst 5.2-6.3 µ broad. Trichome are composed of single row of cells. They are contorted. Sheath is absent. Heterocyst is intercalary. Several trichomes may occur within a soft mucilaginous sheath. Heterocyst is larger than vegetative cells, and with two polar nodules. Cell: 3.6-4.2µ broad,5-6 µ long.

Genus: *Anabaena fertilissima* C.B. Rao
Trichome single straight some time slightly bent. cell barrel shaped.6 µ broad trichome, rounded apical cell. Heterocyst sub spherical 5-7 µ broad. Cell: 6µ broad, 5µ long. (Fig 2E).

Family: Oscillatoriaceae
Genus: *Phormidium sp.* Kutzing
Trichome straight or slightly curved. Unlamellated sheath present. Fine granular content in cell, trichome 3.6 µ -5.4µ broad, not constricted at cross wall. Cell: 3.6-5.4µ broad, 2-3.8µ long (Fig 2F).

Genus: *Oscillatoria tenuis* Ag. Ex Gomont (Fig 2G).
Thallus is blue green in colour. trichome is unbranched, cylindrical, and devoid of sheath. cells are 2-3 times broader than longer. cell protoplasm is granular with many vacuoles. Apical cell somewhat rounded. Trichome: 6-11µ broad. Cell: 6-11 µ broad, 2-3µ long

Genus: *Oscillatoria subbrevis* Schmidle
Trichome single .5-8 µ broad. Nearly straight not attenuated at apex. Cell short ,1/3-1/6 as long as

broad. Apical cell rounded. Calyptra absent. Cell: 1-2 µ broad,1-2 µ long (Fig 2H).

Genus: *Oscillatoria vizagapatensis* Rao, C.B.
Trichome erect and flexuous, apices attenuated. Slightly constricted at cross wall. Cell content granular. End cell hemispherical. Calyptra absent. Cell: 13-15 µ broad,2.5-6.5 µ long (Fig 2I).

Genus: *Oscillatoria chlorina* Kutzing ex Gomont
Mucilaginous thin trichome.6-8 µ broad. Straight at the ends apical cell capitate. With slightly thick membrane. Cell: 6-8µ broad.1.3-2.6µ long (Fig 2J).

Genus: *Arthrospira jenneri* Stizenb. Ex Gomont
Trichome helically coiled, left-handed helix 9-15 µ broad, Helical shape of the trichome is only maintained in a liquid environment. Cells nearly long as wide shorter than broad. Cells: 5-7µ broad ,4-5µ long (Fig 2K).

Genus: *Spirulina gigantea* Schmidle
Trichome 1.2-1.9 µ broad, Trichome formed by a single spirally twisted cell. The cell is cylindrical, and spiral may be loose or close. Cells are very active in their movement in a back-and-forth cork-screw motion. Cell: 1.2-1.9 µ broad ,2.7-5 µ long (Fig 2L).

Genus*: Lyngbya martensiana* Menegh ex Gomont
Thallus cespotose. blue green when dried violet, filamentous long, more or less flexible. sheath colourless thick trichome not constricted at the cross wall, cross wall some time granulated. Apices not attenuated. End cell rotund. Calyptra absent. Cell: 6-10µ broad.1.7-3.3µ long (Fig 2M).

Family: Rivulariaceae
Genus: *Rivularia nitida* C.Agardh ex Bornet &Flahault
Thallus is unbranched filamentous. Trichome mostly ending in a hair. Filaments are completely included within the gelatinous sheath. Filament contains a meristematic zone in intercalary position, which composed of several cells. Cell size at the base 5µ long and 12µ broad.in the middle cell size 5.5 µ long and 7.5µ broad. (Fig 2N)

Genus: *Calothrix braunii* Bornet & Flahault (Fig 2O)
Trichome at the basis 9-11µ broad, at middle 4.8-8.5 µ broad. Not clearly constricted at cross wall. Ended by hair. cell size at basis is 4.8 µ long and 5 -8.5µ broad. In the middle cells are 4.8 µ long and 5-8.5 µbroad.

Family: Gloetrichiaceae
Genus: *Gloeotrichia echinulata* J. Agardh ex Bornet & Flahault
Filament 5-7 µ diameter. Thallus is colonial. Each colony contains radiating filaments. Each filament terminates into a multicellular colourless hair. On heterocyst located at the broad basal end of the trichome. Heterocyst is 4-5 µ broad. The lower and broader portion of the filament is covered by a sheath. Cell: 5-7 µ broad (Fig 3A).

Order: Pleurocapsales

Family: Pleurocapsaceae
Genus: *Pleurocapsa* minor Hansgirg
Thallus composed of irregular groups of cells. few species are psuedofilamentous, enveloped by more or less thin firm sheaths. without sheath diameter 3.8-4.6 µ. with sheath diameter 14.6 µ. (Fig.3B

Order: Chroococcales

Family: Chroococcaceae
Genus*: Chroococcus turgidus* Kuetzing
Cell spherical or ellipsoidal. Single some time group of 2-4. without sheath diameter 8.4-12.3µ. with sheath diameter 9.2-13.1 µ. Sheath colourless and distinctly lamellated. (Fig 3C)

Genus: *Gloeocapsa rupestris* (Lyng) Bon
Thallus gelatinous. Cell spherical or oblong. Without sheath 3.2-4.6 µ diameter, with sheath 3.8-5.4 µ in diameter. Sheath hyaline unlamilated. Cells 2-4in group. Colony diameter 21-22.5 µ. (Fig 3D)

Genus: *Merismopedia elegans* A.Br.
It comprises flattened free-living plate like rectangular colonies that have one layer of cells arranged loosely in perpendicular rows and enveloped by fine colourless, usually indistinct, and marginally diffuse mucilage. Cells are spherical. Cells :3.5- 7 µ broad. 5 µ long. (Fig 3E)

Family: Microcystaceae (Fig 3F).
Genus: *Microcystis sp.* Kutzing Ex. Lemmermann
Thallus is in the form of colonies. The colony contains large number of very small cells which are spherical, ellipsoidal, and devoid of individual sheaths. Each cell has a cell wall and protoplasm which differentiated in to chromatoplasm and centroplasm. Cells: 3-5 µ broad.

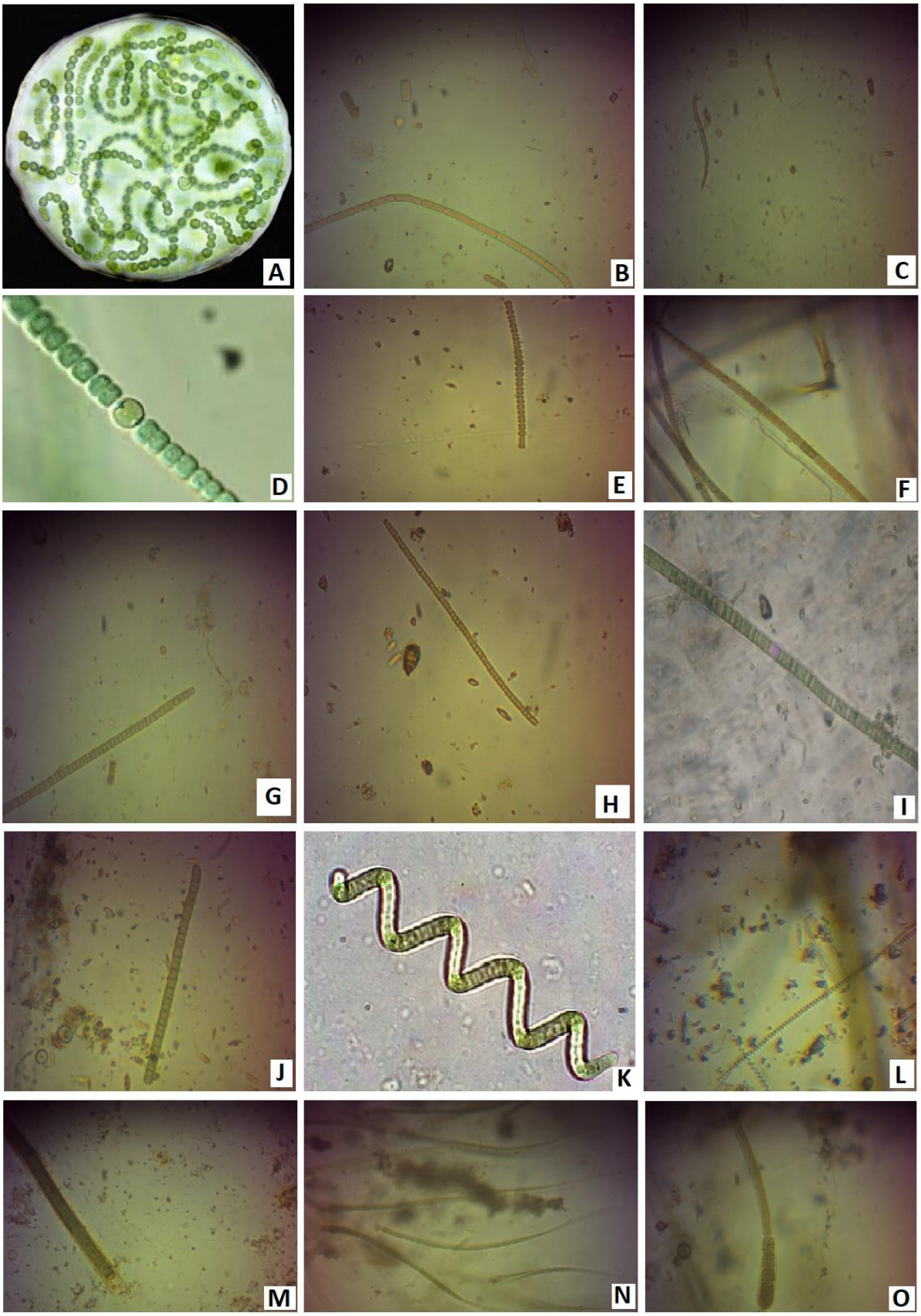

Figure 2 (A- O): Showing Microscope Stage Photograph of Cyanophycean Alga reported from Gajner Lake, Bikaner

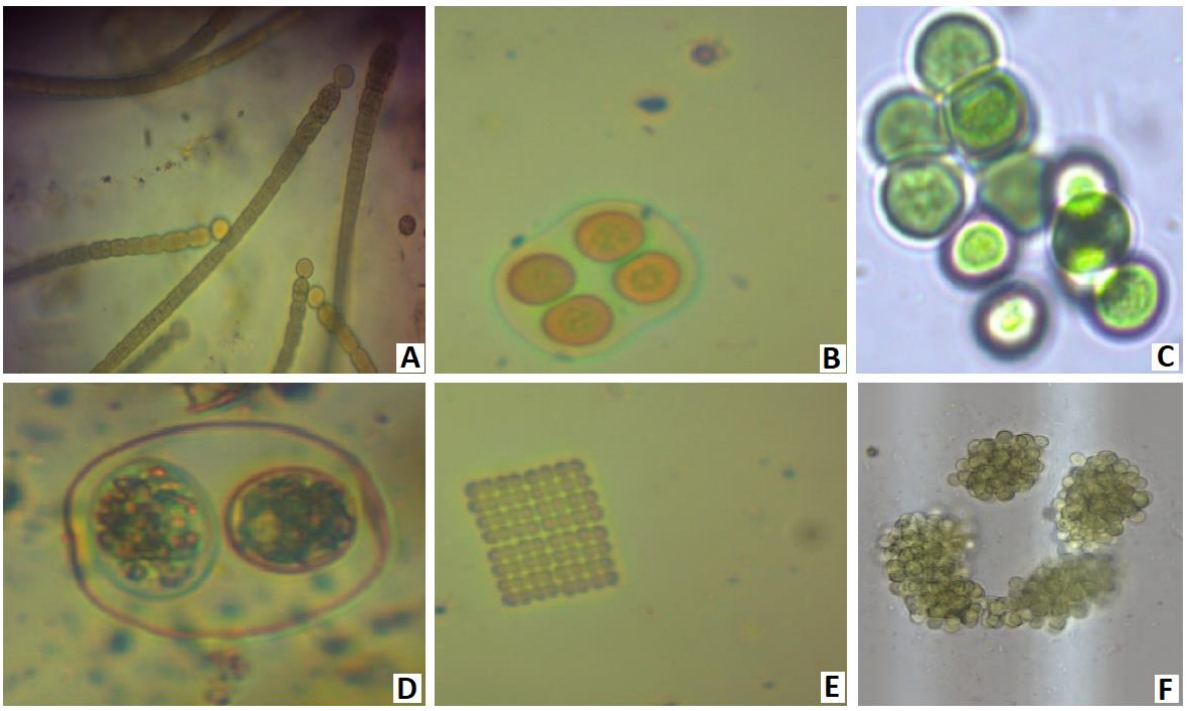

Figure 3 (A- F): Showing Microscope stage photograph of Cyanophycean alga reported from Gajner Lake, Bikaner

Table 1. showing correlation among various physico-chemical parameter along with the fluctuations in Cyanophycean diversity in study period.

Sr.	Factors of correlation	"r" Value
1	pH v/s water temperature	-0.07432
2	pH v/s Electric conductivity	-0.12045
3	pH v/s Total Alkalinity	0.10247
4	Water Temp v/s Total Alkalinity	0.522961
5	Water Temp v/s Electric conductivity	0.068067
6	Electric conductivity v/s Sodium	0.995418
7	Electric Conductivity v/s Bicarbonate	0.969521
8	Electric conductivity v/s Calcium	0.996005
9	Electric conductivity v/s Total Alkalinity	0.616363
10	Calcium v/s Magnesium	1
11	Chloride v/s Sodium	0.67836
12	Cyanophyceae v/s Water Temperature	0.011153
13	Cyanophyceae v/s Ph	-0.18435
14	Cyanophyceae v/s Sodium	-0.40843
15	Cyanophyceae v/s Specific conductivity	-0.3677

Gajner lake was alkaline throughout our study period. Total alkalinity was contributed by Bicarbonate ion only. Carbonate's alkalinity was absent. Parameters exhibit its slow migration toward eutrophication status. Total 21 taxa of Cyanophycean class were reported from Gajner Lake. Filamentous Genera like *Gloeotrichia, Calothrix, Rivularia* were in dominant position during winter season. *Pleurocapsa, Gleocapsa* were found during rainy season. *Oscillatoria, Anabaena, Nodularia, Phormidium* were present in winter as well as in summer season. *Microcystis* and *Merismopedium* reported throughout the year. Fluctuations in diversity of Cyanophyceae class show positive corelation with temperature and negative corelation with sodium, pH and conductivity. Water temperature has positive corelation with alkalinity and conductivity. But negatively corelate with P^H.High degree of correlation found between calcium and magnesium.

Table 2. Monthly variations in Physico -chemical parameters of Gajner Lake During Jan 2017-Dec 2017

Parameters	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Air Temperature (˚C)	24	23.7	26.4	33.3	39	41	39	36	32	31	30	24
Water Temperature (˚C)	15.9 ±0.22	14.8 ±0.17	20.3 ±0.17	22.6 ±0.19	22.3 ±0.17	22.6 ±0.18	24.6 ±0.11	22.3 ±0.17	20.1 ±0.11	19.1±0.22	17.1 ±0.17	16.9 ±0.22
pH	8.53	8.16 ±0.25	8.10 ±0.69	8.41 ±0.69	8.62 ±0.3	7.85 ±0.85	8.23 ±0.12	8.54	8.18 ±0.08	8.41 ±0.3	8.64 ±0.24	8.08
EC (mmhos/cm)	0.30 ±0.02	0.17 ±0.05	0.13 ±0.27	0.23 ±0.22	0.30 ±0.30	0.22 ±0.04	0.22 ±0.07	0.18 ±0.03	1.37	0.16	0.12 ±0.02	0.15 ±0.16
Ca^{+2}+ Mg^{+2} (Meq/litre)	1.60 ±.34	0.7 ±0.3	0.6 ±1.4	1 ±0.75	1.3 ±0.5	1 ±0.2	1 ±0.2	0.8 ±0.2	6.0	0.6 ±0.3	0.7 ±0.1	1 ±0.9
Sodium (meq/litre)	1.20 ±0.4	1.0 ±0.2	0.7 ±1.2	1.3 ±1.2	1.20 ±0. 8	1 ±0.6	1.2 ±0.5	1 ±0.1	7.7	0.70 ±0.3	0.5 ±0.1	0.5 ±0.7
Potassium (meq/litre)	-	-	0.10	-	-	-	-	-	-	-	-	-
Bicarbonate(Meq/litre)	2.0 ±0.2	0.07 ±0.02	0.65 ±0.85	0.8 ±1.7	1.60 ±0.4	1.5	1.4 ±0.2	0.11 ±0.84	6.5	0.80 ±0.2	0.75±0.005	0.80 ±1.0
Chloride (meq/litre)	1.00 ±0.6	0.11 ±0.03	0.6 ±0.9	0.13 ±0.8	1.30	0.7±0.3	0.8 ±0.5	0.12 ±0.75	6.5	0.60	0.69	0.65 ±0.02
Alaklinity (ppm)	113 ±1.7	120 ±0.6	121 ±1.2	131 ±2.1	145 ±1.6	140 ±1.20	135 ±1.63	137 ±1.3	159 ±.4	141 ±.6	137 ±1.6	116 ±0.30

Table 3. Monthly fluctuations in ecological factors of Gajner Tehsil Kolayat District Bikaner (Rajasthan) during Jan 2017- Dec 2017

Month	Temperature ˚C		Monthly Rainfall in MM	Highest maximum Temperature	Date	Lowest minimum Temperature ˚C	Date	Relative Humidity %		Average wind velocity (kmph)	Average evaporation (mm)
	Mean Maximum	Mean Minimum						Max	Min		
January	21.7	09.0	001.5	28.2	30	00.7	11	097	016	03.8	01.9
February	29.0	12.9	000.0	34.6	18	05.5	06	088	009	04.3	03.8
March	34.1	188	000.4	42.2	28	13.0	12	076	009	05.0	04.7
April	40.6	24.8	013.5	45.6	20	16.7	08	065	003	05.3	07.0
May	42.8	28.5	045.4	46.4	27	21.0	21	060	008	05.2	08.0
June	40.1	28.3	099.8	45.5	03	20.8	22	088	014	06.8	07.9
July	38.3	28.5	034.4	40.6	15	26.0	21	088	028	06.3	08.4
August	37.4	27.5	055.5	40.2	20	23.1	25	086	027	07.3	08.3
September	38.1	25.9	012.8	41.8	20	23.8	28	087	016	04.6	07.8
October	38.8	22.5	000.0	40.6	13	18.0	24	048	008	03.1	07.8
November	30.8	15.0	000.0	36.2	1	10.2	19	095	019	02.5	04.6
December	25.8	10.1	002.8	29.8	1	05.2	16,17	094	014	02.8	03.0

In Bikaner district of Rajasthan Ecophysiological work has been done on Kolayat, Devikund Sagar, Harsholav Pond, Kalyan Sagar and Kodam desar Pond before onset of our research work on Gajner Lake. Mali (2002) explored Phycological diversity of Devikundsagar and Harsholav pond. He mentioned 20 species of 16 genera belongs to Cyanophyceae class. Although there was not so obvious difference in physiochemical parameters of Gajner lake and Devikund Sagar. But only due to the presence of Bicarbonate Alkalinity and Little bit higher Electric conductivity in Gajner Lake, Species variability is more in contrast to Mali (2002) study on Devikund Sagar. Modi (2010) and Santosh (2017) explored Phycology of Kolayat and Kodamdesar pond, respectively. In their separate analysis of Cyanophycean diversity of their respective research site, we found more abundance of filamentous Cyanophycean alga in Gajner lake. In comparative analysis we found the difference in physico-chemical kinetics in these ponds. Due to presence of high pH, more electric conductivity in rainy season the filamentous Cyanophycean green alga were in abundance in Gajner lake. One more prominent thing in Gajner lake conductivity and cyanophycean diversity are negatively correlated in view of statistical analytics. There was negative correlation of Cyanophycean diversity with alkalinity, conductivity. However, water temperature was the principal physical factor which positively correlate to other physicochemical parameters to which Cyanophycean genera negatively correlate, but nevertheless temperature was the principal regulator of Cyanophycean diversity in Gajner lake. These Statistical analytics were slightly variable with the outcome of the study done by Modi (2010) and Santosh (2017) on Kodamdesar and Kolayat lake respectively. The cause of these variations was the meteorology of Gajner lake. Our analysis regarding Cyanophyceae diversity is quite closer to Mali (2002) study on Devikund Sagar.

CONCLUSION

The site of lake under threat of anthropogenic activity is more abundant in Cyanophycean diversity in contrast to the site which is under regulation of sanctuary act. Temperature directly regulates the growth of Cyanophycean genera in Lake. It is the more crucial point, because other algal classes show independence from temperature fluctuations regarding their population density.

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Conflicts of Interest: The authors declare no conflict of interest.

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