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Distribution and Diversity of Chlorophyceae in Saroornagar Lake, Hyderabad

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Abstract: *The present paper deals with the study of Chlorophyceae in Saroornagar Lake. Samples were collected from four sampling stations for a period of two years and comprehensive physico-chemical analysis was carried out. Linear multiple regression analysis (MRA) has been carried out in evaluating the importance of various physico-chemical variables on the growth and development of Chlorophyceae with SPSS software. The physico-chemical parameters played an important role in distribution and diversity of algae. Higher peaks of green algae were reported during summer and were represented by Chlorella vulgaris, Ankistrodesmusfalcatus, Scenedesmus sp. and Coelastrummicroporum. The species of Ankistrodesmusfalcatus, Chlorella vulgaris and Scenedesmus sp., Pandorinamorum, Actinastrumhantzchii, Pyrobotrysincurva and Micractiniumpusillum confirm eutrophic condition of the lake and act as indicators of organic pollution and represent pollution tolerant species. The indicator species of Chlorophyceae were represented by microphotographs.*

Keywords: *Chlorophyceae, diversity. physico-chemical parameters, pollution.*

I. Introduction

Fresh water lakes are vital resources for any country and have greater prominence as they are linked to human welfare. They regulate the urban climate (Benjamin, 1996) and also have a prominent effect on ground water quality and ground water table (Ravikumar, 2013). Lakes have environmental significance as sources of surface and ground water recharge, maintain nutrient and energy exchange with watersheds and air sheds and support diversified aquatic life. Population growth, various human development activities, industrialization, urbanization, improper management of water resources, exploitation of catchment and command areas have led to severe water quality impairment. The value of the water is lost for many uses when it gets altered in its physical, chemical and biological properties (Rawal, 1978).Sewage discharge, improper agricultural practices and urban run offs leads to eutrophication of the inland water bodies and disrupt aquatic ecosystems. The deterioration and undesirable changes in physico-chemical and phycological characteristics of water body leads to water pollution which will ultimately effect the planktonic flora (Mishra, 1992). Green algae, blue green algae, diatoms, desmids and Euglenoid flagellates are the basic link in the food chain of all aquatic flora and were ecologically significant (Airsang, 2013). The present investigation involves distribution and diversity of Chlorococcales, influence of physico-chemical parameters on Chlorophyceae, representation of Chlorophyceae in the form of microphotographs and identification of algae as bio indicators in the Saroornagar Lake.

II. Materials And Methods

The water samples were collected on monthly intervals for a period of two years (September 2013 to August 2015) at four sampling stations in the lake. Priyadarshini Park, Pochamma temple, Singareni colony and Green park colony represent station I, II, III and IV respectively. The samples were analyzed as per the standard procedures of APHA (1995). For planktonic study the drop method of Pearsal (1946) was followed for frequency measurement. American optical binocular research microscope fitted with Cat Com Digital Image camera was used to take microphotograph of each specimen. The organisms were identified by following different monographs (Prescott 1968, and Gary E Dillard 2000). Linear MRA was employed to establish the interaction of physico-chemical parameters and Chlorophyceae. The proposed models contain the minimum number of variables, required to explain the variation of algal number to maximum extent in a statistically significant way. Percentage of variability is evaluated following the F-test to determine the good fit model. The regression equation is constructed with beta values and variables are excluded with backward regression. The most significant predictors will be elevated by forward step ward regression.

III. Results And Discussion

The samples were collected and analyzed from the four sampling stations within the Saroornagar Lake on monthly intervals for a period of two years from September 2013 to August 2015. The average, maximum and minimum analytic results of each parameter during the period of investigation are summarized in Table 1.

TABLE 1: Ranges and average values of Physico-chemical parameters

All values are expressed in mg/L except pH and Temp (OC)

S.NO	Parameters	Station-I			Station-II			Station-III			Station-IV		
		Average	Range		Average	Range		Average	Range		Average	Range	
			Min	Max		Min	Max		Min	Max		Min	Max
1.	Temperature	25.6	23.5	26.5	25.3	23.0	26.5	25.6	23.5	27.6	25.7	23.5	26.8
2.	pH	8.37	7.46	9.27	8.37	7.36	9.31	8.37	7.48	9.35	8.36	7.32	9.38
3.	Carbonates	22.3	27.0	38.0	20.8	25.0	36.0	23.2	28.0	38.0	18.3	26.0	36.0
4.	Free CO_2	0.86	2.2	4.4	0.91	2.2	6.6	0.91	2.2	4.4	1.46	2.2	8.8
5.	Bicarbonates	538.9	518.6	584.7	536.7	549.1	554.3	592.4	549.1	597.8	558.8	510.1	547.8
6.	Chlorides	581.1	574.5	550.0	559.5	597.6	587.0	556.3	539.0	550.9	559.8	574.5	587.0
7.	DO	0.6	0.2	2.4	0.5	0.2	2.4	0.5	0.2	2.6	0.3	0.2	2.4
8.	BOD	238.7	140.0	300.0	192.0	30.0	300.0	218.3	120.0	300.0	226.6	90.0	300.0
9.	OM	63.7	30	100	80.8	30	240	88.3	20	260	101.6	20	260
10.	COD	141.0	80.0	216.0	153.8	80.0	210.0	288.3	220.0	328.0	343.9	280.0	384.0
11.	Total hardness	648.0	552.0	832.0	602.4	500.0	750..0	605.5	520.0	830.0	615.8	520.0	810.0
12.	Calcium	145.2	100.0	192.0	154.3	31.8	288.0	136.9	52.6	192.0	133.6	34.4	192.0
13.	Magnesium	51.7	17.0	94.8	53.2	14.1	102.1	57.8	29.2	99.8	60.8	29.2	126
14.	Phosphates	16.9	14.6	20.4	20.3	18.0	23.8	20.1	17..8	23.5	17.8	15.6	21.4
15.	Silicates	1.37	1.35	1.42	1.22	1.20	1.25	1.88	1.86	1.91	1.99	1.95	2.1
16.	Sulphates	247.7	238.0	260.0	257.7	248.0	270.0	255.7	246.0	268.0	252.9	243.0	265.0
17.	Nitrates	16.5	14.6	19.3	19.8	18.0	22.7	19.6	17.8	22.5	17.4	15.6	20.3
18.	Nitrites	1.07	0.92	1.15	1.54	1.46	1.62	1.09	1.02	1.13	1.43	1.36	1.53
19.	Total Solids	2814	2791	2845	2715	2691	2745	2755	2731	2785	2804	2781	2835
20.	TDS	2615	2582	2648	2521	2491	2638	2556	2531	2584	2606	2584	2638

From the table it is evident that the physico-chemical parameters such as chlorides, total hardness, calcium, magnesium, phosphates, sulphates, BOD, total solids and total dissolved solids were higher than permissible limits and dissolved oxygen is in very low concentration in the lake. The pH is an important factor for plankton growth (Chisty, 2002) and also influence survival and nourishment of biological life. The pH of the lake is 8.37 and represents alkaline nature of the lake. Alkaline nature of the lakes in India was reported by Altaf H. Ganai (2014) and Ratna V Airsang (2015).

The high values of bicarbonates (HCO_3^-) at all stations can be attributed to increase in organic decomposition during which CO_2 is released which reacts to form bicarbonates. Similar observation was made by Mahadev and Hosamani (2010) and Airsang (2013). Chloride (Cl^-) indicates the presence of high organic matter and plays a very important role to determine water quality. Higher chloride concentration represents high degree of pollution (Ameetha Sinha, 2014 and John Mohammad, 2015) and is the very important parameter to determine the water quality.

The present investigation revealed very low values of dissolved oxygen and very high values of biological oxygen demand (BOD) were recorded at all stations. Higher BOD values indicate the decomposition and mineralization of organic matter, high nutrient loading and organic pollution. Similar observation was made by Suresh (2015). Chemical oxygen demand(COD) is a reliable parameter for judging the extent of pollution in water (Amirkolaie, 2008).This may be due to inorganic matter from domestic sewage and oxidation of the organic waste by natural microorganisms (KundurSurender Reddy, 2014).The total hardness (TH) of the lake was very high compared to their permissible limit of BIS (1998). High hardness may be due to addition of detergents or sewage contamination.

In the present observation high values of phosphates (PO_4^{3-}) and sulphates (SO_4^{2-}) confirms the lake receiving sewage influx (Amin Hossaini, 2013).Total dissolved solids were higher than BIS permissible limits of 2000 mg/L. The major sources of total solids in the water body are domestic sewage, detergents, runoff, leaching of substances from rocks in surrounding area and may also be attributed to the catchments watershed.

The lake chiefly represented by Chlorococcales, less number of Volvocales and complete absence of desmids. The total absence of desmids in the present investigation proves that the high degree of pollution and very poor water quality. This is in conformity with Hosmani (2002) who reported the absence of desmids is an

indication of heavy pollution of water. The species is represented by *Chlorella vulgaris, Ankistrodesmusfalcatus, Coelastrummicroporum, Crucigeniaqudrata, C. rectangularis, S. quadricauda, S. dimorphus, S. quadricauda var. quadrispina, Actinastrumhantzchii*and *Micractiniumpusillum. Pandorinamorum*and *Pyrobotrys incurve* were the species of Volvocales which was represented.

Chlorophyceae found in maximum numbers in summer and monsoon. Summer bloom of *Chlorella vulgaris, Coelastrummicroporum*and *Scenedesmus sp.* was observed. *Ankistrodesmusfalcatus*bloom was found during summer and monsoon. The lowest peaks were observed in winter and represented by the bloom of *Crucigenia sp.*

The Linear MRA reveals the R^2 value for all the 20 independent factors is 0.963 at station I, 0.901 at station II, 0.968 at station III and 0.973 at station IV respectively. The best regression model obtained by backward elimination method represented the factors accounting algal variance significantly and eliminated insignificant factors. The coefficients in the best model are given in Table 2, 3, 4 and 5 and the best regression model obtained by backward elimination method is given by equation 1, 2, 3 and 4 at Station I, II, III and IV respectively.

At station I, Chlorococcales occurred in high numbers in the first year of investigation during June, July and September and in the second year of investigation during May, June and September. In both the years of investigation green algae were found in low numbers from November to January and also in the month of August. The Linear MRA analysis reveals that all the physico-chemical factors together account for 96.3%variation in algae (Table 2) Among them temperature, pH, Free CO_2, chlorides, DO, BOD, TH, phosphates, silica, nitrites (NO_2^-)and nitrates (NO_3^-) are the minimum factors that could influence the growth of green algae to the maximum extent of 95%.Temperature (Temp), pH, Free CO_2 and phosphates are found to be exerting significant negative influence on the growth of Chlorophyceae at 1% level and DO at 5% level. The indirect relationship of temperature and algae is reported by Ananthaiah (2010).The positive relationship of chlorides and the negative influence of pH, DO, phosphates on algal growth is observed by TarakeshwarSenapati (2011) and Suresh (2015).Chlorides and BOD exhibited strong positive influence at 1% level, total hardness at 5% level and nitrates at 8% level. Direct relationship of BOD and Chlorococcales is reported by Sudha Rani (2004). In accordance to Agale (2013) total hardness positively influences the density of Chlorococcales.

Table 2: Multiple Regression Analysis of Physico-Chemical Factors on Chlorophyceae at Station I

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
10	(Constant)	60018.044	10522.210		5.704	.000
	Temp	-723.285	95.498	-.586	-7.574	.000
	pH	-949.771	308.342	-.383	-3.080	.010
	FreeCO2	-394.048	114.573	-.439	-3.439	.005
	Cl^-	12.560	2.513	.523	4.997	.000
	DO	-587.089	241.556	-.324	-2.430	.032
	BOD	19.789	4.214	.749	4.696	.001
	TH	4.190	1.695	.241	2.472	.029
	PO_4^{3-}	-789.594	211.896	-1.148	-3.726	.003
	SiO_2	-24092.939	5655.62	-.356	-4.260	.001
	$N0_3^-$	511.087	266.907	.530	1.915	.080
	NO_2^-	-9326.262	1961.902	-.541	-4.754	.000

a. station = STATION I,b. Dependent Variable: Chlorophyceae (CP)

$$CP = 600018.044 - 723.285\ Temp - 949.771\ pH - 394.048\ FreeCO_2 + 12.560\ Cl^- - 587.089\ DO + 19.789\ BOD + 4.190\ TH - 789.594\ PO_4^{3-} - 24092.939\ SiO_2 + 511.087\ NO_3^- - 9326.262\ NO_2^- \quad \text{.....(1)}$$

At station II, the Chlorococcales attained high numbers during monsoon throughout the investigation period. Their presence is comparatively low during winter.The Linear MRA analysis at this station reveals, all the physico-chemical factors together account for 90.1%of algal variance in a statistically significant manner. Temperature, carbonates, chlorides, DO, TH, calcium, phosphates, TS and Free $CO_2$are the minimum factors that could influence the growth of green algae to the maximum extent of 83.9%.Carbonates, chlorides and total hardness influence the growth of Chlorophyceae positively at 1% level and total solids at 5% level. Temperature, DO, calcium, phosphates negative influence at 1% level. The negative influence of calcium on the growth and abundance of Chlorophyceae was reported by Sudha Rani (2004) and Airsang (2013).The highest peaks of Chlorococcales are associated with deficiency of calcium at station II.

Table 3: Multiple Regression Analysis of Physico-Chemical Factors on Chlorophyceae at Station II

Coefficients[a, b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
12	(Constant)	-32304.873	18158.752		-1.779	.097
	Temp	-350.506	84.847	-.505	-4.131	.001
	CO_3^{2-}	37.822	12.671	.708	2.985	.010
	FreeCO_2	253.203	120.530	.575	2.101	.054
	Cl^-	4.335	1.537	.440	2.821	.014
	DO	-527.551	142.475	-.586	-3.703	.002
	TH	5.725	1.575	.528	3.635	.003
	Ca^{2+}	-10.422	2.334	-.745	-4.466	.001
	PO_4^{3-}	-225.156	67.547	-.574	-3.333	.005
	TS	15.235	7.026	.377	2.168	.048

a. station = STATION I, b. Dependent Variable: Chlorophyceae (CP)

$$CP = -32304.873 - 350.506\ Temp + 37.822\ CO_3^{2-} + 253.203\ Free\ CO_2 + 4.335\ Cl^- - 527.551\ DO + 5.725\ TH - 10.422\ Ca^{2+} - 225.156\ PO_4^{3-} + 15.235\ TS. \quad \ldots\ldots\ldots\ldots\ldots (2)$$

At station III, high peaks were noticed during June and July in the first year, May and June in the second year of investigation. They were recorded low during winter. Linear MRA revealed all the factors together constitute 96.8% of algal variance significantly. Among them Free CO_2, chlorides, organic matter, sulphates and nitrites are the minimum factors that explain the variation in Chlorococcales to the maximum extent of 86.9%.Organic matter and chlorides accounted a strong positive significance at 1% level. Organic matter positively influencing algal growth was reported by Ananthaiah (2010). Free CO_2, sulphates and nitrites exhibited negative influence at 1% level (Table 8c). The growth of Chlorococcales was positively influenced by phosphates and nitrates at 5% level. Phosphates accounted for 18% algal variance at 1% level and nitrates exhibited 17% of algal variance at 5% level. Similar relationship between green algae, phosphates and nitrates was observed by Malik (2014).

TABLE 4: Multiple Regression Analysis of Physico-Chemical Factors on Chlorophyceae at Station III

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
16	(Constant)	35112.089	10562.928		3.324	.004
	FreeCO_2	-178.172	78.341	-.212	-2.274	.035
	Cl^-	12.463	2.663	.449	4.680	.000
	OM	15.301	2.421	.655	6.321	.000
	SO_4^{2-}	-85.593	25.061	-.416	-3.415	.003
	NO_2^-	-20278.060	5185.380	-.564	-3.911	.001

a. station = STATION III, b. Dependent Variable: Chlorophyceae (CP)

$$CP = 35112.089 - 178.172\ Free\ CO_2 + 12.463\ Cl^- + 15.301\ OM - 85.593\ SO_4^{2-} - 20278.060\ NO_2^-. \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

At station IV, high peaks were observed during March to June and low during winter. All the physico-chemical factors together account for 97.3%of algal variance in a statistically significant manner. The factors which statistically influence the algal variance significantly are up to 85.7% according to linear MRA are pH, carbonates, Free CO_2, OM, sulphates and nitrites.Carbonates, Free CO_2, OM and sulphates are found to be exerting strong positive significance at 1% level and pH showed negative significance at 1% level (Table 8d). The indirect relation of alkalinity and algal growth was reported by TarakeshwarSenapati (2011), Ratna V Airsang (2013) and Suresh (2015). Carbonates positively influencing the growth of Chlorophyceae were repoted by Ananthaiah (2010).

TABLE 5: Multiple Regression Analysis of Physico-Chemical Factors on Chlorophyceae at Station IV

Coefficients[a,b]

Coefficients[a,b] Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
15	(Constant)	-6498.838	8132.316		-.799	.435
	pH	-2458.909	607.418	-1.076	-4.048	.001
	CO_3^{2-}	167.490	28.009	2.010	5.980	.000
	FreeCO_2	494.263	124.480	.822	3.971	.001
	OM	7.814	2.163	.475	3.612	.002
	SO_4^{2-}	133.318	25.705	.662	5.187	.000
	NO_2^-	-6480.050	3314.655	-.231	-1.955	.067

a. station = STATION IV, b. Dependent Variable: Chlorophyceae(CP)

$$CP = -6498.838 - 2458.909\ pH + 167.490\ CO_3^{2-} + 494.263\ Free\ CO_2 + 7.814\ OM + 133.318\ SO_4^{2-} - 6480.050\ NO_2^- \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

*Pandorinamorum*and *Pyrobotrys incurve* were the species of Volvocales which was represented during summer and in the month of February and August throughout the investigation period at all stations.*Pandorina*occurs predominantly only at the point where the medium containing high organic matter was observed by Paramasivan and Sreenivasan (1981). *Ankistrodesmusfalcatus*was the dominant species which is represented throughout the investigation period at all stations. The presence of *Ankistrodesmus sp.*in organic polluted water was reported by Ayodhya D. Kshirsagar (2013). UdayBhan Singh (2013) reported it as pollution tolerant species in sewage polluted urban eutrophic lakes and fresh water bodies which are polluted by industrial waste and sewage. Diversified *Scenedesmus*species had their presence in numerically good numbers at all stations except in the months of December and January. *Chlorella vulgaris* was reported in considerable number and their absence was observed during winter.

The presence of *Scenedesmus sp.* and *Chlorella sp.* indicate high organic pollution and rich nutrient status of the lake. These species are considered as indicators of highly organic polluted waters and represent eutrophic nature of the lake. This is in accordance with Verma (2010) and UdayBhan Singh (2013).

Coelostrum sp. showed summer peaks, found to be absent during winter and *Crucegenia sp.* represented by *Crucigeniaqudrata, Crucigeniarectangularis*and are in numerically high numbers during winter. Their presence in nutrient rich water is supported by Ansari Ekhalak (2013). According to Standards ISI 10500: 1991- Annexture-I, *Scenedesmus sp., Chlorella sp.* and *Coelostrum sp.* are found in polluted waters. *Actinastrum sp.* and *Pyrobotrys sp.* was not represented considerably throughout the investigation period and recorded maximum in monsoon especially in the month of July. *Actinastrum sp.* is the indicator of high organic polluted water (Ashesh Tiwari 2006), grow in nutrient rich waters (Ansari Ekhalak 2013) and it is a pollution tolerant species (Ayodhya D. Kshirsagar 2013). *Micractinium*was reported as indicator of organic pollution by Ashesh Tiwari (2006).The pollution indicators of algae were given in the form of microphotographs in Fig.1,2 and 3.

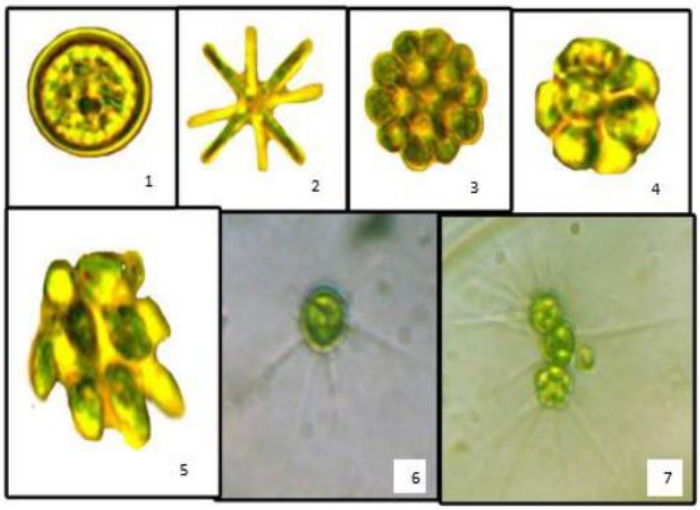

Figure.1: *1) Chlorella vulgaries* Beijerinck 2) *Actinastrum hantzschii.* Lagerh
3) *Coelastrum cambricum* Archer *4) Pandorina morum 5) Pyrobotrys elongate*
6) Golenkinia radiate (Chod) Wille 7) *Micractinium pusillum* Fresenius

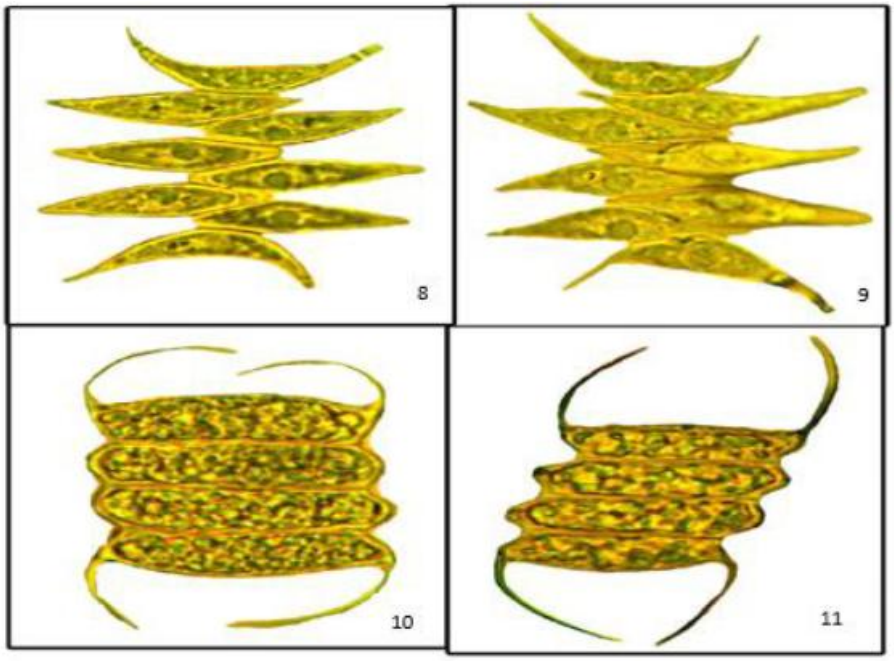

Figure.2: *8) Scenedesmus dimorpus* (Turp.) Kutezing 9) *S. arcuatus var. platydisca* G.M.Smith *10) Scenedesmus armatus var. major* G.M.Smith *11) Scenedesmus quadricauda* (Turp) Brebisson *var. westii* G.M.Smith

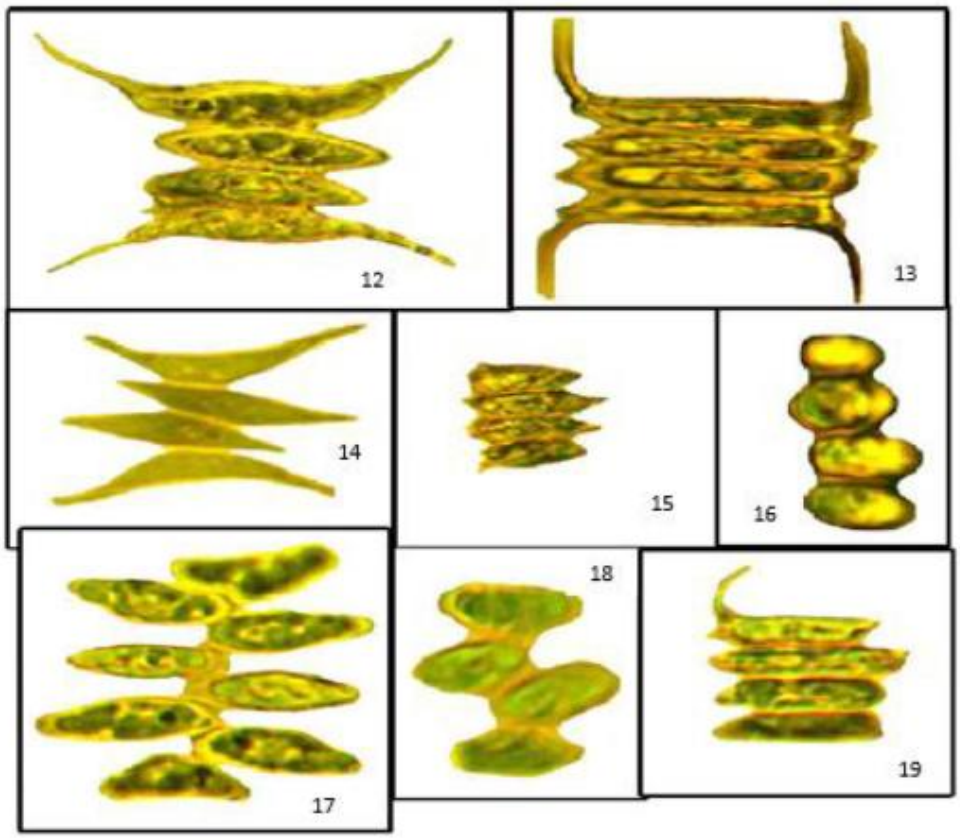

Figure.3: *12) Scenedesmus carinatus 13) Scenedesmus quadricauda* (Turp.) Breb 14) *S. acutus* Meyen 15) *S. longus* (Meyen) *var. naegelii* (Breb) *16) S. muzzanensis* Hubberpest *17) S.Bijuga* (Turp.) *Langerheim Var.alternans 18) S.bijugatus* (Turp) Kuetz 19) *S. bicaudatus* (Hansqirg)

IV. Conclusions

The present investigation elevated the distribution and diversity of Chlorophyceae in Saroornagar Lake. The water of Saroornagar Lake is highly polluted as the physico-chemical parameters such as chlorides, total hardness, calcium, magnesium, phosphates, sulphates, BOD, total solids and total dissolved solids were higher than permissible limits and dissolved oxygen is in very low concentration when compared with the standards stipulated by WHO (1971), ISI (1982), BIS (1998) and Rawal's (1978). The evaluated physico-chemical parameters considerably influenced the growth of algae.

Chloroccocales were represented by diversified species.The species of *Ankistrodesmusfalcatus*, *Chlorella vulgaris* and *Scenedesmus sp., Pandorinamorum, Actinastrumhantzchii, Pyrobotrys incurve* and *Micractiniumpusillum*, confirm eutrophic condition of the lake and act as indicators of organic pollution and represent pollution tolerant species. *Chlorella vulgaris, Scenedesmus sp., Actinastrumhantzchii*and *Micractiniumpusillum*are bio indicators of eutrophic lakes. The existence of Chloroccocales as bio indicators, pollution tolerant species and species representing nutrient rich medium proves polysaprobic and eutrophic condition of the lake.

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