Study of Phytoplankton Diversity And Seasonal Variation of Kotwal Reservoir, Morena District (M. P.) India

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Abstract- *the study of phytoplankton diversity, density and distribution in different seasons and their correlation with physico-chemical parameters during study period of two years, June 2016 to May 2018.A total 36 species, 22 families and 23 genera of different groups of Phytoplankton were recognized, in which 10 species belonging to class Cyanophyceae, 8 Zygnematophyceae,7Bacillariophyceae, 5 Chlorophyceae, 4 Euglenophyceae, 1 species to each Chrysophyceae and Trebouxiophycea. The percentage composition of phytoplankton groups belonging toCyanophyceae with (27.7%)occupied dominant positionfollowed byZygnematophyceae(22.2%), Bacillariophyceae(19.4%), Chlorophyceae(13.8%), Euglenophyceae(11.1%), Chrysophyceae and Trebouxiophycea(2.7%).All groups of phytoplankton were maximumin summer season, minimum in rainy season and intermediate in winter season.*

Keywords- Planktonic diversity, summer, rainy and winter season, kotwal reservoir.

I. INTRODUCTION

Phytoplankton are microscopic plants that make up an important part of primary productions in every part of aquatic ecosystems and plays a vital role in the food web and productivity. They liberate oxygen during photosynthesis and aid in energy exchange process Khan (2003) and they are providing food for all other organisms ranging from benthic invertebrates to fish.

The distribution and dynamics of algal species varies depending upon the physico-chemical parameters like temperature, light intensity, biological oxygen demand, dissolved oxygen, alkalinity and concentrations of micro and macro elements, (Tiwari *et al*., 2004). Phytoplankton monitoring provides essential information on the consequences of eutrophication and climate change Suikkanen*et al*. (2007). The water quality parameters have a direct influence upon distribution and ecology of phytoplankton. They are the bio-indicators of water pollution. Its appearance, disappearance, density and pattern of distribution depend on biotic and abiotic factors Escaravage*et al*. (1999) and LeQuere*et al*. (2005). The Phytoplankton studies on various water bodies have been made by Hosmani (2002), Ramakrishnan (2003), Kumawat and Jawale (2004), Tiwari and Chauhan (2006) Guru (2007), Patil (2011), Chaudhary and Pillai (2013), Sivalingam (2018), Prajapati *et al*. (2019) and Bharti *et al*. (2020).The presentstudy was conducted to examine the interaction ofphytoplankton community withphysico-chemical Parameters.

Study area:

The Kotwal reservoir has been constructed on Asan River in the year 1914, a tributary of Chambal River.Geographically the reservoir lies between 780 03' 16" to 78007'41" E longitude and 26029'25" to 26030'35" N latitude. It is situated near Kotwal village in Morena district of Madhya Pradesh, India. The Reservoir has been named on the name of Kotwal village as Kotwal reservoir. It is 21 km away from Morena city towards east at an altitude of 246m from mean sea level. Morena is one the districts that forms a part of the Chambal riverine system. The district is bordered by Rajasthan state on its north east. The rest of the sides are bordered by the districts of Madhya Pradesh (Fig. 1).

Fig. 1 Actual view of the study area Kotwal Reservoir

II. MATERIAL AND METHODS

Phytoplankton samples were collected from different stations every month in iodine treated polyethylene bottle of 500 ml capacity. The samples were preserved by adding 5 ml of Lugol's iodine solution. The preserved samples will be brought to the laboratory and a sub sample of 10 ml was realized by decanting and centrifugation for qualitative analysis. one drop of concentrated sample was transferred on a slide and the sample was observed under inverted microscope. The phytoplanktonwere identified at generic level and species level with the help of standard books like Edmondson (1959) and Needhanm and Needham (1962).

The quantitative studies were done by using a Sedgwick rafter cell1.0 ml of concentrated sample was transferred to Sedgwick rafter cell on the rafter cell for differential count of phytoplankton species. The counting was repeated 10 times and an average of 10 counting was taken. The number of total phytoplanktonin a sample was calculated by following the formula:

$$\text{Phytoplankton organisms (L-1)} = \frac{n \times V1 \times V\,2}{V}$$

Where,

n = The average numbers of phytoplankton in a counting cell
V1 = The volume of the concentration sample in ml
V2 = The volume of one drop sample ml
V = The volume of original water samples in lt

III. RESULT AND DISCUSSION

A total 36 species, 22 families and 23 genera of different groups of Phytoplankton were recognized throughout study period of two years, in which 10 species belonging to class Cyanophyceae (*Oscillatoria princeps, Oscillatoria sp, O. subbrevis, Raphidiopsis sp., Pseudanabaena sp., Microcytis aeruginosa, Synechocystispevalekii, Aphanocapsa grevillea, Spirulina laxissima* and*A nabenanaviculoides*),8 species belonging to class Zygnematophyceae(*Spirogyra sp., Spirogyra elongate, Closterium dianae, C. Parvulum, Staurastrum sp., S. chaetoceras, Arthrodesmus sp.* And *Actinastrumsp,*) 7 species belonging to class Bacillariophyceae*(Melosira sp., GyrosigmaKutzingii, Amphora minutissima, Gomphonema sp., G. lanceolatum, G. intricatum*and*Naviculasubrhyncocephala*), 5 species belonging to class Chlorophyceae(*Coelastrummicroporum, Oedogonium sp., Pediastrum duplex reticulatum, P. simplex* and *P. duplex gracillimum*), 4 species belonging to Euglenophyceae (*Euglinaelastica, E. gracilis, E. acus*and *E. ignobilis),* 1 speciesbelonging to class Chrysophyceae (*Dinobryoncylindricum*)and Trebouxiophycea (*Actinastrum sp.*).Cyanophyceae was dominated group over rest of the phytoplankton population. The species diversity of phytoplankton has been given infigures (2 to 37).

The numerical abundance of Phytoplankton (org./l) during various season

In the present study, group wise seasonal variation of phytoplankton in various seasonan average value ofphytoplanktonic density of under different groups in summer seasonthat were 735 org./l with (23.6%) Cyanophyceae, 730 org./l (23.4%) Zygnematophyaceae, 626 org./l (20.1%) Bacillariophyaceae, 533 org./l (17.1%) Chlorophyceae, 360 org./l (11.5%) Euglenophyceae, 82 org./l (2.6%) Chrysophyceae and 40 org./l (1.2%) Trebouxiophyceae.
In rainy seasonthat was 457 org./l with (26.0%) Cyanophyceae, 256 org./l (14.6%) Zygnematophyaceae, 446 (25.4%) Bacillariophyaceae, 360 org./l (20.5%) Chlorophyceae, 178 org./l (10.1%) Euglenophyceae, 35 org./l (1.9%) Chrysophyceae and 18 org./l (1.0%) Trebouxiophyceae.
In winter season that was 642 org./l with (23.9%) Cyanophyceae, 513 org./l (19.1%) Zygnematophyaceae, 591 (22.0%) Bacillariophyaceae, 502 org./l (18.6%) Chlorophyceae, 342 org./l (12.7%) Euglenophyceae, 69 org./l (2.5%) Chrysophyceae and 22 org./l (0.8%) Trebouxiophyceae. These results given in (table 1) and figure (38 to 41)

The percentage composition of phytoplankton groups belonging toCyanophyceae with 27.7%occupied dominant positionfollowed byZygnematophyceae with 22.2%, Bacillariophyceaewith19.4%, Chlorophyceaewith 13.8%, Euglenophyceae with 11.1%, Chrysophyceae and Trebouxiophycea with 2.7%.The similar findings were also reported by Perumalasamy and Thangamani (2004) recorded 43 species of phytoplankton, of these 11 species belonging to Bacillariophyceae, 18 species to Chlorophyceae, 11 to Cyanophyceae and 3 species to Charophyceae. Sakhare (2006) 30 species of phytoplankton belonging 14 to chlorophyceae, 9 to bacillariophyceae and 7 to myxophyceae in Jawalgaon reservoir, Laskar and Gupta (2009) reported 34 species of phytoplankton belonging tocyanophyceae, chlorophyceae, bacillariophyceae and euglenophyceae in Chatla floodplain lake, Assam, Sharma *et al*., (2011) 58 species in Pichhola lake, Udaipur, Lone *et al*. (2013) obtained 67 species of phytoplankton belonging to Chlorophyceae (25), Bacillariophyceae (24), Cyanophyceae (17) and Euglenophyceae (1) in some crenic habitats of district

Anantnag, Kashmir, Ferdoushi*et al.,* (2015) 21 species inRamsagar lake, Dinajpur. Sasikala*et al.* (2017) 15 species of phytoplankton belonging 10 species of Chlorophyceae, 2 species of Bacillariophyceae and 3 species of Cyanophyceae were found in Varaha reservoir,Rawat and Trivedi (2018) 30 species of phytoplankton belonging 11 to Chlorophyceae, 10 to Bacillariophyceae, 7 to Cyanophyceae, 1 to Dinophyceae and Euglenophyceae in Dholawad Dam, Anbalagan and Sivakami (2019) obtained 28 species of phytoplankton belonging to Cynophyceae (8), Chlorophyceae (11), Bacillariophyceae (4), Euglenophyceae (3) and Dinophyceae (1) in Mayanur Dam, Tamil Nadu, Patel and Dubey (2020) 32 species belonging to Chlorophyceae (13), Bacillariophyceae (11), Cyanophyceae (6) and Euglenophyceae (2) in Govindgarh Lake in Rewa. Sheikh and Slathia (2021) identified 92 species belonging to Chlorophyceae (57), Bacillariophyceae (20), Cyanophyceae (11), Dinophyceae (2) and Euglenophyceae (2) in Mansar lake.

The present study revealed the Cyanophyceae was found to be rich and dominated in the Kotwal Reservoir. These findings are similar to those of Goyal (2001) in Bhicherli pond, Rajasthan, Harsha and Malammanver (2004) in Gopalaswamy pond at Chitradurga, Karnataka, Affan*et al*., (2005) in four aquaculture ponds of Bangladesh, Kavita (2006) in fresh water agriculture system, Tamilnadu, Hujare (2008) in freshwater tank of Talsande, Maharashtra. Kumari and Guru (2013) in Ranchilake, Kadam *et al*., (2014) in Masooli and Yeldari reservoirs in Parbhani district, Singh *et al*. (2015) in two Pond of Kanyakumari, Joseph (2017) in artificial pond, Kumari *et al*., (2018) in Matia Lake.

In the present investigation, the phytoplankton fluctuates seasonally. The maximum abundance of phytoplankton during summer season while minimum during the rainy season and intermediate in the winter season. Similar study was made by Chakrabarty *et al*., (1959), Carter *et al*., (1980), Bhowmick and Singh (1985), Kumar and Bohra (2005), Devika *et al*., *(*2006), Wojciechowska*et al. (*2007) Chellappa*et al.,* (2008),, Gupta *et al*. (2009) Hasan *et al*., (2010), Tarakeshwar*et al.,* (2011), Khan (2012) Malik and Panwar (2014), Kaparapu and Geddada (2015) Sharma (2017) and Seeta and Reddy (2020) Devika *et al*., (2006) who recorded high population density of Phytoplankton during summer suggested that this might be due to physical rather than chemical conditions among which water temperature and high transparency speed up the photosynthetic activity of phytoplankton. Low density during the monsoon season is attributed to heavy flood and fresh water inflow (Krishnamoorthy *et al.,* 2007).

In the present investigation, Cyanophyceae were found to be in abundance in summer months in reservoirs. Similar observation also reported by Singh (1981), Jayanthi (1994), Tiwari and Chauhan (2005), Zacharias and Roy (2007), Thiruganamoorthi and Selvaraju (2009), Ganai*et al*., (2010), Joseph (2012), Bhatnagar and Bhardwaj (2013), Sirajunisa (2014), Singh *et al*. (2015),Rosinska*et al*. (2017),Anbalagan and Sivakami (2019) and Rajawat and Sharma (2020) Generally, it is found that due to high temperature, organic matter and low dissolved oxygen are favourable to the growth of blue-green algae Kumar *et al*., (2005). Ganapati *et al.* (1943) suggested that Cyanophyceae reached the peak while temperature, pH, alkalinity silicates and phosphates were high. The dominance of Cyanophyceae is the indication of eutrophic environment which is due to high concentrations of nutrient especially phosphate and nitrate (Neelam *et al*., 2009).

Singh (1981) and Haque *et al*. (1990), Jeelani*et al*. (2005) and Shinde *et al*., (2012) obtained Euglenophyceae to occur in high numbers during the summer season as was noticed in the present study. According to Kumar *et al*., (1974) it was due to high temperature and organic matter and low dissolved oxygen. Kant and Kachroo (1977), Kundanagar and Zutshi (1985), Sakhre and Joshi (2003) Rajagopal *et al.* (2010)**,** Summarwar (2012), Wang *et al*. (2013)and Pandiammal*et al*.(2017) reported Chlorophyceae were found to be maximum during summer seasondue to high light intensity (Chukwu, 2007). This result also agreement with the present findings. Round (1957), Rao *et al.* (1978), Prasad and Singh (1982) and Anago *et al*. (2013) found that sewage contamination accelerate the growth of Chlorophyceae.

The maximum abundance of Bacillariophyceae during summer season recorded by Abbas (1984), Kastooribai (1991), Nandan and Magar (2007), Sharma (2009), Agale (2013) and Jyotsna *et al*. (2014). This result also agreement with the present findings. Water temperature also plays an important role in the periodicity of green algae (Munawar 1970). The presence of phosphate, nitrate, silicate and total hardness promoted the growth of diatoms Ansari *et al*. (2015).

The percent wise phytoplanktonic density among all groups was, Cyanophyceae constituted from 11% to 66% in various fresh water bodies (Hegde and Bharathi, 1985; Singh, 1990; Jayanthi, 1994; Sivakami, 1996). In fresh water Tank Talsande, Maharashtra the percentage composition of each group of phytoplankton that Cyanophyceae (35.77%) formed largest group followed by Bacillariophyceae (34%), Chlorophyceae (27.4%) and Euglenophyceae (2.24%). In Ranchi Pond, Jharkhand the percentage composition of various groups was, Cyanophyceae (61%) followed by

Chlorophyceae (33%), Bacillariophyceae (3%), Euglenophyceae (2%), and Dinophyceae (1%) Kumari and Das (2017). In artificial Pond, Cyanophyceae (39%) formed the dominant group, followed by Chlorophyceae (34%) Bacillariophyceae (23%) and Euglenophyceae (4%) joseph (2017).Anbalagan and Sivakami (2019) found up to 28.6% Cyanophyceae, 39.3%, Chlorophyceae, 17.8%, Bacillariophyceae, 10.7% Euglenophyceae and 3.6% Dinophyceae in Mayanur Dam.In Rudrasagar Lake, Tripura the percentage composition of various group was Chlorophyceae (39.89%) contributed, followedby Cyanophyceae (30.31%), Bacillariophyceae (27.22%) andEuglenophyceae (2.58%) Bharti *et al*. (2020). These findings similar to the present study of Kotwal reservoir, Cyanophyceae with 27.7%, Zygnematophyceae with 22.2%, Bacillariophyceaewith19.4%, Chlorophyceaewith 13.8%, Euglenophyceae with 11.1%, Chrysophyceae and Trebouxiophycea with 2.7%.

Inter relationship of phytoplankton among various physico-chemical parameters have been computed. Pandy *et al*. (1995) showed a positive correlation between pH, dissolved oxygen, bicarbonate, phosphate and transparency. Kumar and Bohra (2005) observed a significant positive correlation between Phytoplankton and pH in Raja Dighi Pond. Hulyal and Kaliwal (2008) have shown a positive relationship between cyanophyceae with dissolved oxygen, nitrate, phosphate and negative correlation with chloride. Lashkar and Gupta (2009) observed a highly significant positive correlation between phytoplankton density and transparency. Mustapha (2009) have shown positive correlation of phytoplankton with pH dissolved oxygen, nitrate and phosphate. Bacillariophyceae and Euglenophyceae showed negative correlation with water temperature Ganai (2010). Malik and Bharti (2012) shown positive correlation with dissolved oxygen and negative correlation with magnesium, sodium, potassium, chloride and temperature in Sahastradhara stream. Sharma and Singh (2013) observed positive correlation of phytoplankton with pH and phosphate in Tighra Reservoir. In temple Pond, Bacillariophyceae and Chlorophyceae positively correlate with pH and dissolved oxygen while, negative correlate with air and water temperature Devi and Antal (2013). In Polachira wetland, cyanophyceae, Bacillariophyceae and Euglenophyceae have shown positive correlation with pH, dissolved oxygen, phosphate and nitrate Geethu and Balamurali (2015). In Meghadrigedda Reservoir, the phytoplankton showed positive correlation with transparency and pH Kaparapu and Geddada (2015). In Nachiketa Tal, abundance of Bacillariophyceae, Chlorophyceae, Dinophyceae is negatively correlated with water temperature however, Bacillariophyceae Chlorophyceae and Dinophyceae was positively correlated with Dissolved Oxygen Sharma and Tiwari (2018). Above observation also similar to the present investigation on Kotwal reservoir, all Phytoplankton groups showed positive correlation with pH, dissolved oxygen, transparency, nitrate and phosphate while, negative correlation with magnesium, sodium, potassium, chloride and temperature.

PHYTOPLANKTONIC DIVERSITY OF KOTWAL RESERVOIR

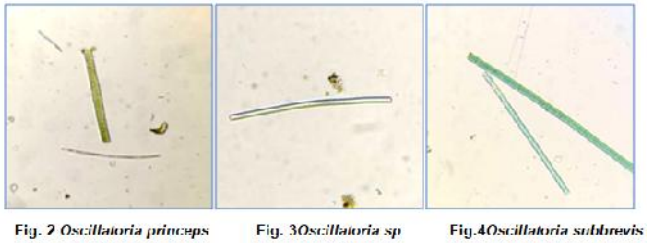
Fig. 2 *Oscillatoria princeps* Fig. 3*Oscillatoria sp* Fig.4*Oscillatoria subbrevis*

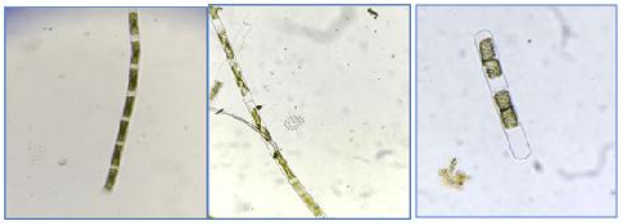
Fig. 5*Melosirasp* Fig. 6*Spirogyra sp.* Fig.7 *Spirogyra longata*

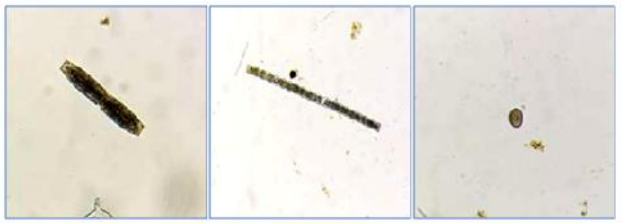
Fig. 8*Rhabdionsisso* Fig. 9*Pseudanabaenasp* Fig.10*Coelastrummicroporum*


Fig. 11*Oedogonium sp* Fig. 12*Gyrosigmakutzingii* Fig. 13*Amphora minutissima*

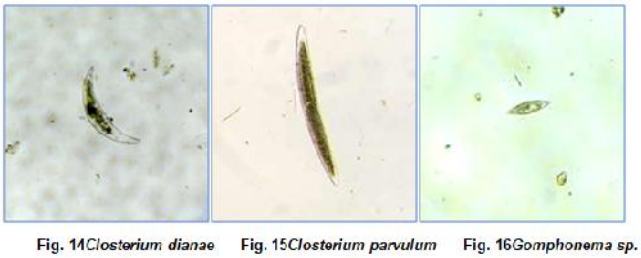
Fig. 14*Closterium dianae* Fig. 15*Closterium parvulum* Fig. 16*Gomphonema sp.*

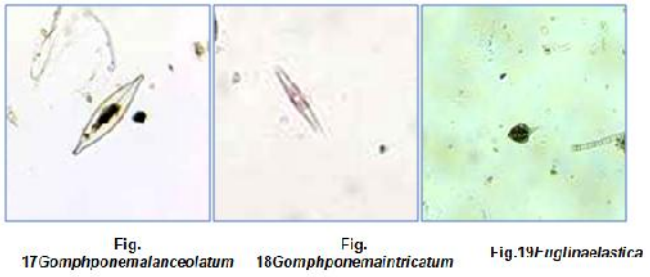

Fig. 17Gomphphonemalanceolatum Fig. 18Gomphphonemaintricatum Fig.19Euglinaelastica

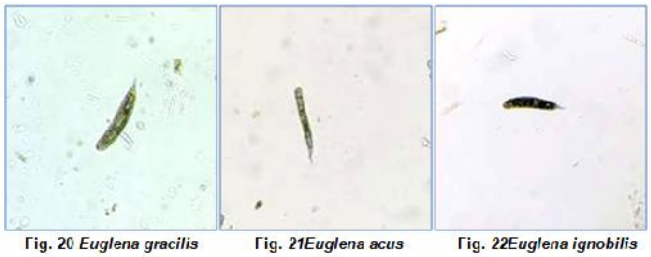

Fig. 20 Euglena gracilis Fig. 21Euglena acus Fig. 22Euglena ignobilis

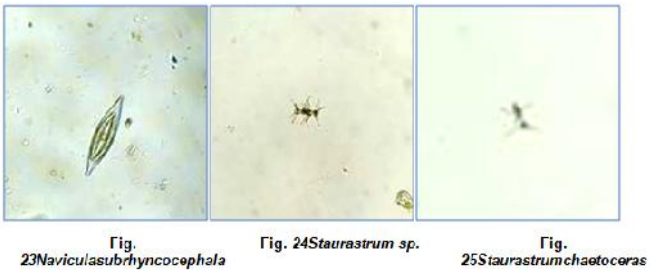

Fig. 23Naviculasubrhyncocephala Fig. 24Staurastrum sp. Fig. 25Staurastrumchaetoceras

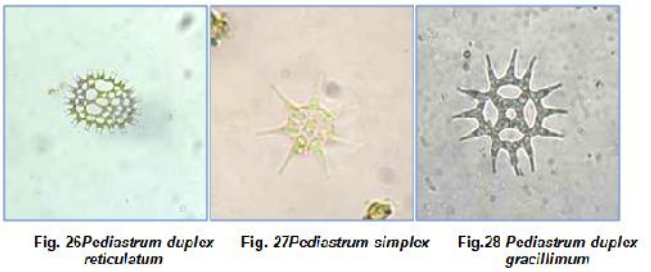

Fig. 26Pediastrum duplex reticulatum Fig. 27Pediastrum simplex Fig.28 Pediastrum duplex gracillimum

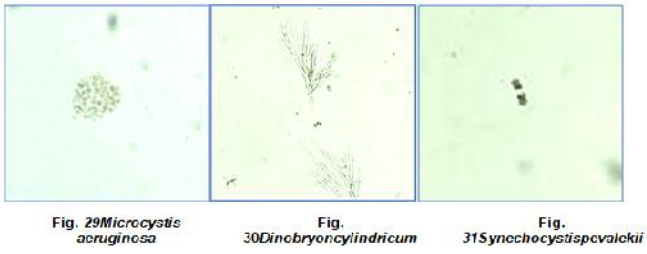

Fig. 29Microcystis aeruginosa Fig. 30Dinobryoncylindricum Fig. 31Synechocystispevalekii

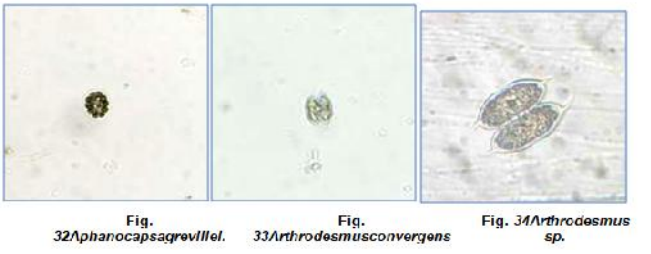

Fig. 32Aphanocapsagrevillei. Fig. 33Arthrodesmusconvergens Fig. 34Arthrodesmus sp.

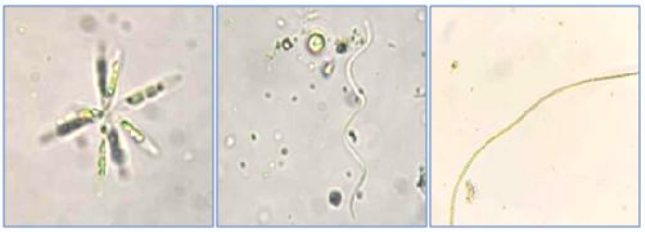

Fig. 35Actinastrumsp Fig.36Spirulina laxissima Fig.37 Anabaena naviculoides

Table 1. showing group wise average value of phytoplankton organism/l during both year of study Period

S.No.	Groups	Summer	Rainy	Winter
1	Cynophyceae	735 (23.6%)	457 (26.0%)	642 (23.9%)
2	Zygnematophyaceae	730 (23.4%)	256 (14.6%)	513 (19.1%)
3	Bacillariophyaceae	626 (20.1%)	446 (25.4%)	591 (22.0%)
4	Chlorophyceae	533 (17.1%)	360 (20.5%)	502 (18.6%)
5	Euglenophyceae	360 (11.5%)	178 (10.1%)	342 (12.7%)
6	Chrysophyceae	82 (2.6%)	35 (1.9%)	69 (2.5%)
7	Trebouxiophyceae	40 (1.2%)	18 (1.0%)	22 (0.8%)

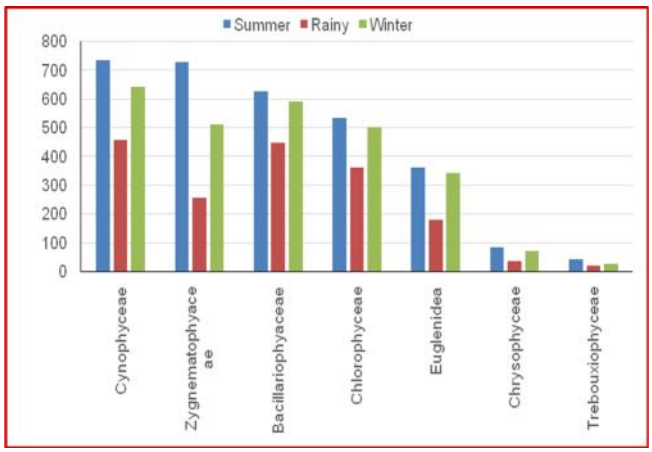

Fig. 38 Showing the seasonal abundance of various phytoplankton groups during both the years of study

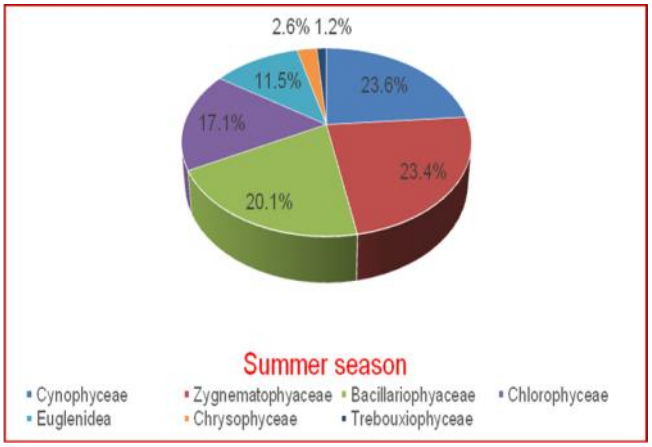

Fig. 39 Showing Percentage composition of different groups of phytoplankton during summer season average value of both the years of study period

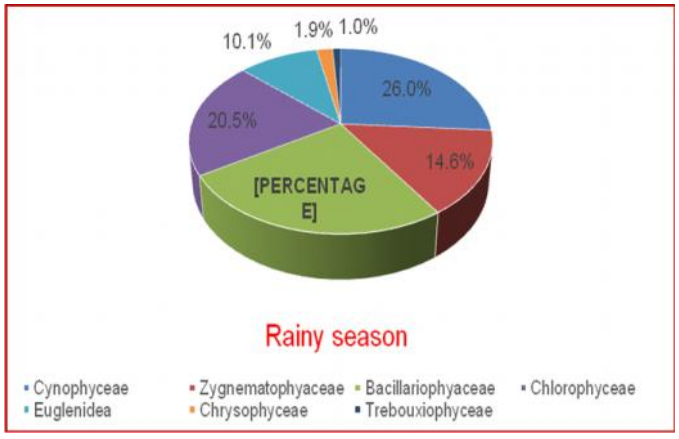

Fig.40 Showing Percentage composition of different groups of phytoplankton during rainy season average value of both the years of study period

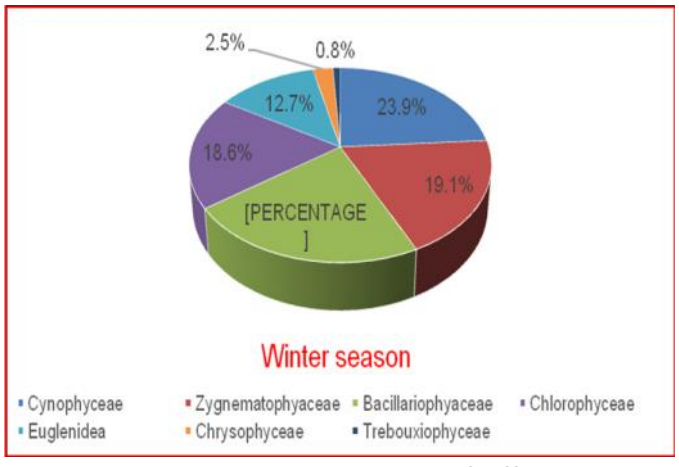

Fig. 41Showing Percentage composition of different groups of phytoplankton during winterseason average value of both the years of study period

IV. CONCLUSIONS

The study confirmed that 10 species belonging to class Cyanophyceae, 8 species belonging to class Zygnematophyceae, 7 species belonging to class Bacillariophyceae, 5 species belonging to class Chlorophyceae, 4 species belonging to Euglenophyceae, 1 species belonging to class both Chrysophyceae andTrebouxiophycea.Among theseCyanophyceae was the most dominant class in the phytoplankton followed byclass Zygnematophyceae, Bacillariophyceae, Chlorophyceae,Euglenophyceae, Chrysophyceae andTrebouxiophycea. All groups of phytoplankton were maximum in summer season, minimum in rainy season and intermediate in winter season.

REFERENCES

[1] Agale, M. C., Patil, J. V. and Patel, N.G. (2013). Study of seasonal variations of Phytoplankton and their correlation with physicochemical parameters of Budaki Medium Irrigation Tank, Shirpur. Dist. Dhule (M.S.) India. *European Journal of Zoological Research*, 2 (3) :8-16.

[2] Affan, A., Jewel, A.S., Haque, M., Khan, S. and Lee, J.B. (2005). Seasonal Cycle of Phytoplankton in Aquaculture Ponds in Bangladesh. *Algae*., 20(1): 43-52.

[3] Anago, I.J., Esenova, I.K. and Ugwumba, A.A.A. (2013). The Physico-chemical and Plankton Diversity of Awba Reservoir University of Ibadan, Ibadan. Nigeria Research. *Journal of Environment and Earth Science*., 5(1) :638-644.

[4] Ansari, E., Mohini, G. and Ujjania, N.C. (2015). Phytoplankton diversity and water quality assessment of Ongc pond, Hazira. *I.J.RES.* 1(1): 1-15

[5] Bhatnagar, M. and Bhardwaj, N. (2013). Algal Biodiversity status in Chambal River at Kota Barrage, Rajasthan. *Journal of Experimental Biology and AgriculturalSciences.*,1 (2S): 132-138.

[6] Bhowmick,B.N. and Singh, A.K. (1985). Phytoplankton population in relation to physico-chemical factors of riverGanga at Patna. *Indian J. Ecol*., 12 (2) :360-364.

[7] Bharati, H., Deshmukhe, G., Das, S.K., Kandpal, B.K., Sahoo, L., Bhusan, S. and Singh, Y.J. (2020). Phytoplankton Communities in Rudrasagar Lake, Tripura (North-East India) – A Ramsar Site. *Int. J of Bio-resource and Stress Management.*, 11(1): 001-007.

[8] Chaudhary, R. and Pillai, R.S. (2013). Diversity and density of zooplanktons of Kolar reservoir of Bhopal, M.P., India. *Int. J of Development and Sustainability.*, 2(3): 1931-1936.

[9] Chellappa, N.T.,Borba, J.M. and Rao, O.(2008). Phytoplankton community and physico-chemical characteristics of water in the public reservoir of Cruzeta, RN, Brazil. *Braz. J Biol.*,68:477-494

[10] Chukwu, G.O. (2007). Land suitability classification of Southeastern Nigeria wetlands for azolla. *Scientific Research and Essays*., 2(12) :512-515.

[11] Devika, R., Rajendran, A. andSelvapathy, P.(2006). Variation studies on the physico-chemical and biological characteristics at different depths in model waste stabilsation tank. *Pollut. Res*. 24: 771-774.

[12] Devi, A. and Antal, N. (2013). Variation in Phytoplankton Diversity and Its Relationship with Abiotic Environment of a Temple Pond in Birpur (J&K) India. *Universal Journal of Environmental Research and Technology*., 3(2) :181-189.

[13] Escaravage, V. and Prins, T.C. (2002). Silicate availability, vertical mixing and grazing control of phytoplankton blooms inmesocosms. *Hydrobiol*. 484: 33-48

[14] Ferdoushi, Z., Chowdhury, R.H., Fatema, K. and Islam, A. (2015). A study on limnological aspects of Ramsagar lake in Dinajpur district. *J.Bangladesh Agril.Univ.*,13(1): 145-152.

[15] Ganai, A. H., Parveen, S., Khan, A.A. and Maryam, H. (2010). Phytoplankton diversity at Watlab Ghat in Wular Lake, Kashmir. *Journal of Ecology and the Natural Environment*., 2(8) :140-146.

[16] Ganapati, S. V. (1943). The ecological study of a garden pond containing abundant zooplankton. *Proc. Acad. Sci*., 17: 41-58.

[17] Goyal, S. (2001). Pollution and Trophic indicator species of Bicherli Pond, Beawar Rajasthan. *Journal of Environmental Science and technology*., 4(2): 35-47.

[18] Gupta, A. K. (2009).Sustainable strategies for restoration of degraded VarunaRiver corridor. *J. of Envir. and Poll.* 7(1): 43-46.

[19] Guru, S. D. (2007). Effect of Xenobiotic pollution on the algal (Chlorophyceae) population of somefreshwater lakes of Jharkhand. *Biospectra* 2 (1):143-147.

[20] Harsha, T.S. and Malammanver, S.G. (2004). Assessment of phytoplankton density in relation to environmental variableson Gopalaswamy pond at Chitradurga, Karnataka. *J. Environ. Biol*. 25(1): 113-116

[21] Hegde, G. R. and Bharati, S. G. (1985). Comparative phytoplankton ecology of fresh water ponds and lakes of Dharwad, Karnataka State, India. Proceedings of the National Symposium on Pure and Applied Limnology (ed. Adoni, A.D.). *Bull. Bot. Soc. Sagar,* 32: 24-29.

[22] Hosmani, S.P. (2004). Biodiversity of freshwater algal blooms. In *Biodiversity and Environment.* Ed. Arvind Kumar. A P H A Pub. Corp. New Delhi. Pp. 17-26.

[23] Hulyal, S.B. and Kaliwal, B.B. (2008). Dynamics of phytoplankton on relation to physico-chemical factors ofAlmathi reservoir of Bijapur District, Karnataka state. *Environ. Monit. Assess.*,153 (1-4):45-59.

[24] Hujare Milind, S. (2008). Seasonal variation of phytoplankton in the freshwater tank of Talsande, Maharastra.*Nat. Envir. And Pollu. Tech*. 7(1):147-150.

[25] Hasan, F.M., Taylor, W.D., Mayson, M. S., Al-Taee. and Hassan, J.J. (2010). Phytoplankton composition of Euphrates River in Al-Hindiya barrage and Kifil city regionof Iraq. *J. Environ Biol*., 31: 343-350.

[26] Jayanthi, M. (1994). A comprehensive study of three contrasting lentic systems in the context of aquaculture. Ph.D. Thesis, Bharathidasan University, Tiruchirappalli, India.

[27] Jeelani, M., Kaur, H., and Sarwar, S.G.(2005) Distribution and ecology of phytoplanktons in the Dal Lake Kashmir (India).In : Ecology of Planktons. Ed. ArvindKumar.Daya Publishing House, Delhi pp.41-54.

[28] Joseph, J. (2017). Diversity and distribution of phytoplankton in an artificial pond. *Int. J. Adv. Res. Biol. Sci*., 4(5):114-122.

[29] Joseph, J., (2012). Studies on the cyanobacterial diversity from selected freshwater environment and its application in biotechnology. Ph.D. Thesis. Submitted to M.S. University, Tirunelveli

[30] Jyotsna, N., Rangaiah, G.S., Narasimha, M. and Rao, G. (2014). A contribution to the seasonal distribution and biodiversity of fresh water phytoplankton of Karagam Lake, Srikakulam, Andhra Pradesh, India. *International J. of Environ*., 4(1) :82-100.

[31] Kadam, S.U., Kadam, S.S. and Babar, M.D. (2014). Phytoplankton diversity of reservoirs in Parbhani District, Maharashtra, India. *Int.J.Curr.Microbiol.App.Sci*., 3(8) :459-466.

[32] Kant, S. andKachroo, P. (1977). Limnological studies on Kashmir lakes I. Hydrological features, composition and periodicity of phytoplankton in Dal and Nagin lakes. *Phykos.* 16: 77-97.

[33] Kaparapu, J. and Geddada, M.N. (2015). Seasonal dynamics of phytoplankton and its relationship with the environmental factors in Meghadrigedda Reservoir of Visakhapatnam, Andhra Pradesh, India. *J. Algal Biomass Utln*., 6 (4) :60- 67.

[34] Kastooribai, R. S. (1991). A comparative study of two tropical lentic systems in the context of aquaculture. Ph.D. Thesis, University of Madras, India.

[35] Kavitha, A. (2006). Ecotechnological application of Cyanobacteria for microproductivity enhancement in freshwater agricultural system. Ph.D. Thesis, ManonmaniamSundaranar University, Tirunelveli, Tamilnadu.

[36] Khan, T. A. (2003). Limnology of four saline lakes in Western Victoria, Australia. *Limnologica*, 33: 327-339.

[37] Krishnamoorthy, G., Rajalakshmi, S. and Sakthivel, D. (2007). Diversity of plankton in mangrove areas of Puducherry, India. *J. Aqua. Biol*.,22:45-48.

[38] Kumawat, D.A. and Jawale, A.K. (2004). An ecologicalstudy of Chlorococcales in the inland fishery. *J. Phytol. Res*., 17 (1):43-46.

[39] Kumari, S. and Guru, S.D. (2017). Diversity and Seasonal Variation of Phytoplankton Community in the Ranchi Lake, Jharkhand. *An Int. J. of Plant Research*., 51-55.

[40] Kumar, A. and Bohra, C. (2005) Dynamics of phytoplankton productivity of certain Lentic Ecosystem ofJharkhand, India. Ecology of plankton (Ed. Arvind Kumar) Daya Publishing House, Delhi pp. 1-14.

[41] Kumar, V., Majagi, S., Jadesh, M. and Kumar, B. (2005). Pollution status of Bheem River at Gulbarg. *Eco environment and Conservation*., 11 :467-469.

[42] Kumar, H.D., Bisaria, G.P., Bhandari, L.M., Rana, B.C. and Sharma, V. (1974). Ecological studies on algae isolated from the effluents of an oil refinery. A fertilizers factory and brewery. *Indian J. of environmental Health*., 16 :247-255.

[43] Kumari, S., Khan, J.A. and Thakur, M.S. (2018). Study on Phytoplankton, Zooplankton and Ichthyo Fauna of Motia Lake. *Journal of Zoological Sciences*., 6(2): 26-49.

[44] Kundanagar, M. R. and Zutshi, D. P. (1985). Environmental features and plankton communities of two Himalayan rural Lakes. Proc. Nat. Symp. pure and Applied Limnology. Adoni A.D. (ed.), *Butt. Bot. Soc.* Sagar, 32: 40-47.

[45] Laskar, H.S. and Gupta, S. (2009). Phytoplankton diversity and dynamics of Chatla floodplain lake, Barak Valley, Assam, North East India - A seasonal study. *Journal of Environmental Biology*., 30(6) :1007-1012.

[46] LeQuere, C., Harrison, S.P., Prentice, I.C., Buitenhuis, E.T., Aumont, O., Bopp, L. and Clauster, H. (2005). Ecosystemdynamics based on plankton functional type for Globalocean,biogeochemistry models. *Glob. Change Biol*. 11: 2016-2040.

[47] Lone, S.A., Pandit, A.K. and Bhat, S.U. (2013). Species composition and diversity of phytoplankton in some crenic habitats of district Anantnag, Kashmir. *Acad. J. Biolog. Sci*., 4(2): 19- 26

[48] Malik, D.S. and Bharti, U. (2012). Status of plankton diversity and biological productivity of Sahastradhara stream at Uttarakhand, India. *Journal of Applied and Natural Science.*, 4 (1): 96-103.

[49] Malik, D.S. and Panwar, S. (2014). Effect of climate changing pattern on phytoplankton biomass in Bhimtal lake of Kumaun Himalaya. *International Journal of Advanced Research* 2(7) :880-894.

[50] Mustapha, M. K. (2009). Phytoplankton assemblage of a small, shallow, tropical African reservoir. *Rev. Biol. Trop*., 57 (4):1009-1025.

[51] Nandan, S. N. and Magar, U. R. 2007. *Seaweed Res. Utiln*., 29(1-2): 279-285.

[52] Neelam, V., Avinash, B., and Dwivedi, S.N., (2009). Planktonic Biodiversity of Bhoj. Wetland, Bhopal, India. *J.Appl. Sci. Environ. Manage.*, 13(4):103-111.

[53] Pandey, B.N., Mishra, A.K., Das, P.K.L. andJha, A.K. (1995). Studies on hydrological conditions of river Saura inrelation to its impact on Biological health. In: Recent Research in aquatic environment. Ed. V.B. AshutoshGoutam and N.K. Aggarwal.Daya Publishing House, Delhi pp. 57-65

[54] Patel, K. and Dubey, S. (2020). Assessment of aquatic Phytoplanktons and water quality of Govindgarh Lake in Rewa district, Madhya Pradesh, India. *International Journal of Applied Research*., 6(11): 231-235.

[55] Patil, J.V. (2011). Study of selected faunal biodiversity of Toranmal area, Toranmal reserve forest, Ph.D. ThesisSubmitted To, The Maharaja Sayajirao University of Baroda, Vadodara, Gujrat (India).

[56] Perumalsamy, K. and Thangamani, A. (2004). Species diversity in indices of phytoplankton richness and evenness and pollution indicators in Perennial ponds in Tamil Nadu. *J. Aqu. Biol.*,19(2): 23-27.

[57] Prasad, B.N. and Singh, Y. (1982). On diatom as indicator of water pollution. *Journal of Botanical Society*., 61 :326-336.

[58] Rajagopal, T., Thangamani, A. and Archunan, G. (2010). Comparison of physico-chemical parameters and phytoplankton species diversity of two perennial ponds in Sattur area, Tamil Nadu. J. *Environ. Biol*., 31:784-794.

[59] Rajawat, J. and Vijendra K. Sharma. (2020). physicochemical and phytoplankton status of Rani Sagar Pond in Ranthambhore Fort, Rajasthan, India. *International Journal of Recent Scientific Research*., 11 (04) :38116-38121.

[60] Ramkrishnan, N. (2003). Biomonitoring approaches for water quality assessment in two water bodies at Tiruvannamalai, Tamil Nadu. India. In *Proceeding of the Third International Conference on Environment andhealth*". Chennai. India. 3-14.

[61] Rao, S.V., Singh, V.P. and Mall, L.P. (1978). Pollution studies of River Khan (Indore) India. *Inter. Biol. Asse. of pollution water res.*,12 :555-559.

[62] Rawat, R. and Trivedi, S. (2018). Seasonal Diversity of Phytoplankton in Relation to Seasonal Changes in physicochemical Parameters of Khedi Kalan Station of Dholawad Dam of Ratlam District M. P. *Int. J. Pure App. Biosci.*, 6 (2): 448-454.

[63] Round, F.E. (1957). The diatom community of some Bryophyta growing on sand stones. *Botanical J. of the Linnean Society*., 55 :657-661.

[64] Rosińska, J., Kozak, A. and Renata, D. (2017). Water Quality Response to Sustainable Restoration Measures– Case Study Of Urban Swarzędzkie Lake. E*cological Indicators*. 84:437–449.

[65] Sasikala, T., Manjulatha C. and Raju D.V.S.N. (2017). Freshwater phytoplankton communities in Varaha reservoir,Vishakhapatnam. *Adv.Crop Sci. Tech*. 5(2):262-263.

[66] Sakhare, V.B. (2006). Ecology of Jawalgaon Reservoir in Solapur District, Maharashtra. Ecology of Lakes and Reservoir Ed. V.B. Sakhare, Daya publishing House, Delhi. pp.16-35.

[67] Sakhre, V.B. and Joshi, P. k. (2003). Limnology of Papnas. A minor wetland Tulja Pure Town, Maharashtra. *J. of aquatic biology*. 18 :93-95.

[68] Seeta Y and Reddy PM. Algal diversity and water quality in the Rivers of Telangana. *Int. J. Recent Sci. Res*., 11(3):37702-37704.

[69] Singh, R. K. (1990). On the seasonal abundance of phytoplankton in relation to ecological conditions of Undasa tank. Comp. *Physiol. Ecol*.,15:91-95.

[70] Singh, S. R. (1981). Studies on seasonal composition and horizontal distribution of phytoplankton in Suraha Lake. *Phykos*. 20: 34-43.

[71] Singh, B. S. Jeeva.and Vincy, W. (2015). species composition of phytoplankton in the two migratory birds visited ponds of Kanyakumari district. *International Journal of Botany and Research*., 5(5) :1-8.

[72] Sirajunisa, V. (2014). Limnochemical and Biological Diversity of Aathivayal Lake, Kottaipattinam, Pudukkottai District, with Special Reference to Bioremediation of Heavy Metals. Ph.D. Thesis, Bharathidasan University, Tiruchirappalli, Tamil Nadu.

[73] Sivakami, R. (1996). Limnological profile of two contrasting lentic systems and their aquaculture Potential. Ph.D. Thesis, Bharathidasan University, Tiruchirappalli, India.

[74] Sivalingam P. (2018). Physico-Chemical Parameters and Plankton Diversity of Manchiryal Town Lake Adilabad District, Andra Pradesh, India. *Journal of Biotechnology & Bioresearch*., 1(2) :1-4.

[75] Sharma, R. C. and Tiwari, V. (2018). Phytoplankton diversity in relation to physicochemical environmental variables of Nachiketa Tal, Garhwal Himalaya. *Biodiversity Int. J.*, 2(2) :102-110.

[76] Sharma, P. and Bhardwaj, N. (2017). Algal biodiversity in some water bodies of Kota, Rajasthan, India. *Int. Res. J. Biological Sci.*, 6(9): 7-14.

[77] Sharma, D.K. and Singh, R. P. (2013). correlation between physicochemical parameters and Phytoplankton of the Tighra reservoir, Gwalior, Madhya Pradesh. *Int J. Sci. and Nature*., 4(1): 90-95.

[78] Sheikh, A. and Slathia, D. (2021). Biomonitoring the Health of Lake Mansar (Jammu), Using Phytoplankton. *J. Mountain Res*., 16(1) :111-118.

[79] Shinde, S.E., Pathan, T.S and Sonawane, D.L. (2012). Seasonal variations and biodiversity of Phytoplankton in Harsool. Savangidam, Aurangabad, India. *J. Envi. Bio.*, 33: 643-647.

[80] Showkat Ahmad Lone, Ashok K. Pandit and Sami Ullah Bhat. (2013). Species composition and diversity of phytoplankton in some crenic habitats of district Anantnag, Kashmir. *Acad. J. Biolog. Sci*., 4(2): 19- 26.

[81] Suikkanen, S., Laamanen, M. and Huttunen, M. 2007: Long-term changes in summer phytoplankton communities of the open northern Baltic Sea. – Estuarine, Coastal and Shelf Science 71:580-592.

[82] Summarwar, S. (2012). Studies on Plankton diversity in Bilaspur reservoir. *Int. J. LifeSci. Bt& Pharm. Res., 1(4) :66-72*.

[83] Tarakeshwar, S, G. Subhabrata,M. and Tirthankar. (2011). Variation in phytoplankton diversity and its relation with physic chemical parameters of a semi lentic water body of Golapbag,Westbengal, India. *Int J of Current Research*.,3(7):53-55

[84] Thiruganamoorthi, K. and Selvaraju, M. (2009). Phytoplankton diversity in relation to Physico-chemical parameters of Gnanaprekasam temple pond of Chidambaram in Tamilnadu, India. *Rece, Res. In Sc. And Tech.,* 1 (5):235-238.

[85] Tiwari, A. and Chauhan, S.V.S. (2006). Seasonal phytoplanktonic diversity of Kitham lake, Agra. *J. Env. Biol*., 27(1): 35-38.

[86] Tiwari, S., Dixit, S. and Gupta, S.K. (2004). An evaluation of physico-chemical parameters in surface waters ofShahpura lake, Bhopal. *Poll. Res*. 25: 829-832.

[87] Wang, X., Wang, Yu., Lusan, Liu. and Juan, Zhou. (2013). Phytoplankton and Eutrophication Degree Assessment of Baiyangdian Lake Wetland, China. *The Scientific World Journal*., 1(4) :2-8.

[88] Wojciechowska, W.,Pasztaleniec, A andSolis, M. (2007). Diversity and dynamics of phytoplankton in floodplain lakes (BuBug river, Eastem Poland). *Int. J. Oceangr.Hydrobiol XXXVI,* 199-208.

[89] Zacharias, R. and Joy, C.M.(2007). Algal biodiversity and succession in Periyar river at Aluva, Kerala. *Indian Hydrobiol*., 10: 121-133.