International Journal of Ecology and Environmental Sciences
www.ecologyjournal.in
Online ISSN: 2664-7133; Print ISSN: 2664-7125; Impact Factor: RJIF 5.28
Received: 29-10-2020; Accepted: 14-11-2020; Published: 29-11-2020
Volume 2; Issue 4; 2020; Page No. 478-483

Influence of physico-chemical parameters of water on the seasonal variations in algal bloom in dora beel, Assam, India

Jayati Das[1*], Mautushi Das[2]
[1, 2] Department of Botany, University of Science and Technology, Meghalaya, Kling Road, Baridua, Ri-Bhoi, Meghalaya, India

Abstract
Algae sometimes referred to as the phytoplanktons, inhibit the upper sunlit layer of almost all freshwater ecosystems and form part of the lentic system biota. They are a highly diverse group of organisms that have important functions in aquatic habitats. The present study was conducted to assess the relationship between physico-chemical parameters and phytoplankton assemblages of Dora *beel* of Assam, India. A data set of environmental parameters and algal bloom occurrence, density and composition was analyzed seasonally (i.e., monsoon, post-monsoon, winter and pre-monsoon). Statistical treatment of data between phytoplankton species and seasons and the water parameters and seasons in a year indicate that the phytoplankton cell count, diversity and distribution of phytoplankton in the Dora *beel* is influenced both by the variabilities of season and water parameters.

Keywords: phytoplankton, bloom, *beel,* lentic, seasonal

1. Introduction

Algae have been known to human being since time immemorial. They are a ubiquitous group of predominantly aquatic photosynthetic organisms of the kingdom Protista having photosynthetic pigments. The word ‘algae’ originated from the Greek word ‘phykos’ meaning ‘seaweed’ and the study of algae is known phycology. This group of organisms form a major chunk of the aquatic ecosystems (both lentic and lotic). Lakes, ponds, pools, wetlands, puddles, tanks, reservoirs, ditches, etc. are examples of lentic ecosystems.

The term algae is now applied to a broad assemblage of organisms that can be defined both in terms of morphology and general physiology (Bellinger & Sigee, 2010) [2]. These microscopic organisms that are visible only with the aid of a microscope are typically present in almost all freshwater environments. Although they are relatively inconspicuous, but play a major role in the freshwater environment. Changes in algal population have been reported seasonally, but the dominant species may differ from year to year (Transeau, 1916) [16].

Distribution of algae is wide and varied such as aquatic algae, planktonic algae, terrestrial algae and many more. Majority of algae (about 90%) are aquatic. In freshwater ecosystems, particularly in the lentic ecosystems, they form a scum on the surface of the water. The abundance of algae of different kinds is rather closely associated with restricted seasonal periodicity, differing of course in widely separated geographical locations.

Sometimes algae burst forth into dense growths under favorable nutritional conditions. This is known as algal bloom. Algal bloom results when the numbers of planktonic algae in water bodies grow rapidly. Lentic ecosystems are more susceptible to blooms. Bloom formation depends on factors such as temperature increase, high level of inorganic nutrients like nitrogen and phosphorus and long photoperiod. Cyanobacteria play a key role in bloom formation. Algal bloom containing *Anabaena*, *Microcystis*, *Anabaenopsis*, etc. are a common sight in the tropics during late winters and summers. On the other hand, in tropical regions growth may be nearly continuous when sufficient nutrients are available (Pal and Choudhury, 2014) [18].

Phytoplankton communities are influenced by washout, i.e., the rate of replacement of the water mass. (Moss, 2018) [15]. Phytoplankton form the base of food webs and are the principal source of organic production in aquatic ecosystems (Chao *et al.*, 2016) [3]. The biomass, composition and community structure of phytoplankton can serve as indices to monitor aquatic environments (Paerl *et al*., 2003) [17]. Meanwhile, the distribution and succession of phytoplankton are the consequences of adaptation to different environmental conditions, such as temperature, discharge, nutrients, and light intensity (Margalef, 1978) [14]. They are the important primary producers of aquatic ecological system and also form the foundation of the water ecological system. Phytoplankton are sensitive aquatic organisms and their community structure could reflect the eutrophic situation in a short time (Jing *et al.*, 2014) [11].

2. Materials and Methods

2.1 Study Area

The present study has been conducted in Dora *beel,* a floodplain wetland of Kamrup (Rural) district of Assam, India. This beel is situated on the south bank of the river Brahmaputra and located nearby the Kulsi River. Its coordinates are 26º53´76´´N latitude and 91º2´99´´E longitude. The beel is very rich in biotic communities. During the monsoon season the *beel* gets connected to the Kulsi River.

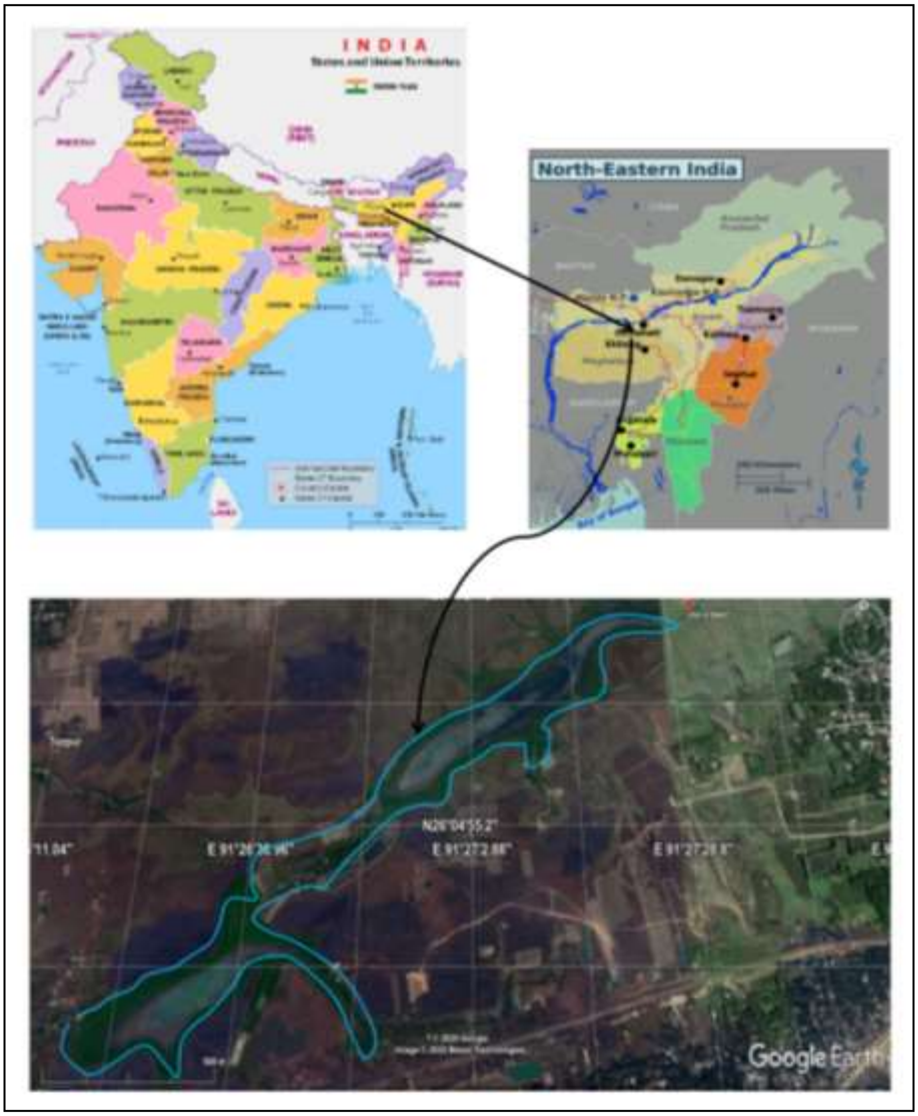

Fig 1: Location map of the study area

2.2 Water sampling and analysis of physico-chemical parameters of water

Replicates of water samples were collected from different sampling locations by point sampling method (also known as grab sampling) for studying different physico-chemical characteristics.

Water samples were collected in three replicates from five different sites and mean values of all three observations were taken into consideration. Samplings were done on a seasonal basis (monsoon, post-monsoon, winter and pre-monsoon) from selected sites and continuous monitoring for algal blooms was carried out for a period of one year (2019-2020). The selection of stations was made on the basis of the previous occurrence of algal blooms. The terms MON, POM, WIN and PRM are used to represent monsoon, post-monsoon, winter and pre-monsoon respectively.

The physico-chemical parameters such as pH, temperature, turbidity, conductivity and DO were studied in the field itself. Samples for other parameters like alkalinity, BOD, nitrogen (NO^{3-}N), phosphorus (PO_4^{3-}—P), Total Nitrogen and Total Phosphorus were brought to the laboratory for further analysis following the standard methods (Baird, *et al*., 2017) [1].

2.3 Collection of algal sample

Samples were collected in such a manner that they represent a range of habitats. Also they were collected at a particular site at approximately the same time of day each time, preferably in the morning. This is because the algae move up in the water towards the surface in the morning and tend to sink to lower regions in the afternoon.

2.4 Phytoplankton sampling and identification

Phytoplankton sampling was done at locations where a visible appearance of the bloom was reported. Sampling of the bloom was done by moving the sample bottle through the surface of the scum. They were then put in an ice box for transfer to the laboratory for further study. Identification of phytoplanktons was carried out following the monographs of Tiffany and Britton (1952) [16]; Desikachary (1959) [5]; Smith, G. (1951) [21] and Fritsch (1945) [6] etc.

2.5 Measuring of algal cell count

Algae were fixed in Lugol's iodine solution immediately after collection. It is the most widely recommended preservative. For field samples, 10 drops of Lugol's solution was added per 200 ml of sample or until the appearence of weak colour of tea. (Lugol's is made by dissolving 100 g Potassium Iodide (KI) in 1L of distilled water, then 50 g crystalline iodine (I_2) is dissolved in this solution and then100 ml of glacial acetic acid is added).

Algae enumerations are frequently used to assess and monitor the health of aquatic systems. It is a quantitative procedure and designed to provide data on algal densities (expressed as cells per ml) at a sampling site. Cell counting was done using a hemocytometer. A viable cell count was obtained from suspension cells using a hemocytometer. The formula for counting cell concentration is as follows (Kruse and Patterson, 1973) [13]:

Viable cells/ml = Average viable cell count/square x Dilution Factor x 10^4

3. Results & Discussion

3.1 The Physico-chemical parameters of water quality

The quality of a water body is dependant on its physical chemical and biological characteristics. A number of physical, chemical and biological factors act simultaneously (Davis, 1955) [4]. The water chemistry variables for Dora *beel* are presented in Table 1.

The physico-chemical parameters were determined in order to observe their influence on phytoplankton cell density (Table 2). Water temperature was found to be the maximum at (30.44^{0}C) in monsoon season and the minimum was recorded in winter season (21.32^{0}C). PH is an important parameter and has significant role in the biological process of all aquatic organisms. PH was maximum (7.16) in post monsoon season and the lowest (6.88) was recorded in monsoon season. The water was alkaline in nature. Hardness was found to be maximum in winter (128.3 mg/L) and minimum during the monsoon season (115.44mg/L). Maximum turbidity recorded in monsoon (7 NTU) is due to the rainfall and the lowest reading was observed in winter (4.64 NTU). A high value of TDS was observed in post-monsoon season (182.4 mg/L). The amount of dissolved oxygen (DO) present in water serves as one of the critical factors for the survival of the aquatic organisms (Sharma *et al*. 2017) [20]. It is an important parameter for the health of any lentic ecosysytem that supports aquatic organisms. Both in natural and waste water, DO levels depend on the physical, chemical and biological activities in the water body. DO was found to be maximum (9.744 mg/L) in winter season and minimum (6.731mg/L) during the monsoon season. Higher dissolved oxygen in winter season has also been reported by Garg *et al*. (2010, 2006a &b) [7, 8, 9]. BOD values were highest (5.138 mg/L) in winter season and lowest (3.25 mg/L) in monsoon season. Similar findings was recorded by Hoque *et al.* (2012) [10].

Table 1: Seasonal variation in physico-chemical parameters of water in Dora *beel*

Water Parameters	Code	Monsoon, 2019	Post Monsoon, 2019	Winter, 2019	Pre Monsoon, 2020
Temperature (^{0}C)	Tem	30.44	29.54	21.32	26.46
pH	pH	6.88	7.16	7.3	7.14
Alkalinity (mg/L)	Al	112.01	118.32	123.94	121.56
Hardness (mg/L)	Hd	115.44	121.11	128.3	125.5
Turbidity (NTU)	Tu	7	5.56	4.64	5.28
Conductivity (µS/cm)	Con	188.6	170.8	155.6	161
TDS (mg/L)	TDS	181.6	182.4	140.2	144.8
DO (mg/L)	DO	6.731	8.516	9.744	8.078
BOD (mg/L)	BOD	3.25	4.862	4.286	5.138
Nitrate [NO_3-N] (mg/L)	NO	0.564	0.714	0.918	0.628
Orthophosphate [PO_4^{-3}-P] (mg/L)	PO	0.016	0.046	0.058	0.048
Total Nitrogen (mg/L)	TN	0.587	0.727	0.952	0.684
Total Phosphorus (mg/L)	TP	0.014	0.156	0.062	0.058

3.2 Algal bloom analysis

The study of water chemistry parameters is important to know their impact on the different phytoplanktons present in the system and vice-versa. The biotic community of any water body is the outcome of interaction between the chemical, physical and geomorphological characteristics of a water body (Karr, *et al*., 2000 and Stevenson and Pan, 1990) [12, 22]. It is, therefore, necessary to study the different factors controlling phytoplankton growth or in other words phytoplankton ecology. A total of 10 taxa belonging to 5 different classes were recorded in the Dora *beel* (Table 2). The phytoplankton in the lake is represented by six major families Chroococcaceae (4), Oscillatoriaceae (1), Scenedesmaceae (2), Selenastraceae (1), Desmidiaceae (1) and Pinnulariaceae (1). The percentage compositions (Fig. 2) of these six families were Chroococcaceae (40%), Oscillatoriaceae (10%), Scenedesmaceae (20%), Selenastraceae (10%), Desmidiaceae (10%) and Pinnulariaceae (10%). The highest algal cell density (Table 3) was recorded as 1.02x10^4 cells/ml during the winter season. The genus *Microcystis* sp was the dominating one with a representation of 76% followed by *Ankistrodesmus* sp and *Pinnularia* sp. The lowest algal cell count was recorded as 0.72 x10^4 cells/ml in the post-monsoon season. The composition of bloom was different from the other two seasons. It was represented by *Microcystis* sp, *Scenedesmus communis* sp, *Oscillatoria* sp and *Pinnularia* sp. *Scenedesmus communis* showed a percentage occurence of 22% in post-monsoon and *Scenedesmus bijugatus* showed a percentage occurence of 8% in winter. The class Cyanophyceae was the dominant group represented by *Microcystis* sp. in all the three seasons. Occurence of algal bloom was not reported in the monsoon season.

Table 2: Composition of the bloom

Sl. No	Class	Order/Family	Name of the species
1	Cyanophyceae	Chroococcales/ Chroococcaceae	*Microcystis aeruginosa*
2			*Microcystis pseudofilamentosa*
3			*Microcystis ramose*
4			*Microcystis robusta*
5		Nostocales/ Oscillatoriaceae	*Oscillatoria acutissima*
6	Chlorophyceae	Sphaeropleales/ Scenedesmaceae	*Scenedesmus bijugatus*
7			*Scenedesmus communis (Table 2).*
8	Chlorophyceae	Sphaeropleales/Selenastraceae	*Ankistrodesmus falcatus*
9	Chlorophyceae	Conjugales/ Desmidiaceae	*Closterium gracilimum*
10	Bacillariophyceae	Naviculales/Pinnulariaceae	*Pinnularia viridis*

Phytoplanktons help in maintaining the oxygen level of the water body, i.e. dissolved oxygen or DO by their photosynthetic activity. Dissolved oxygen is produced by the phytoplankton biomass due to their photosynthetic activity. Therefore, dissolved oxygen was found to be higher in winter season where phytoplankton count was also high. Density of Cyanophyceae was found to be highest in winter season.

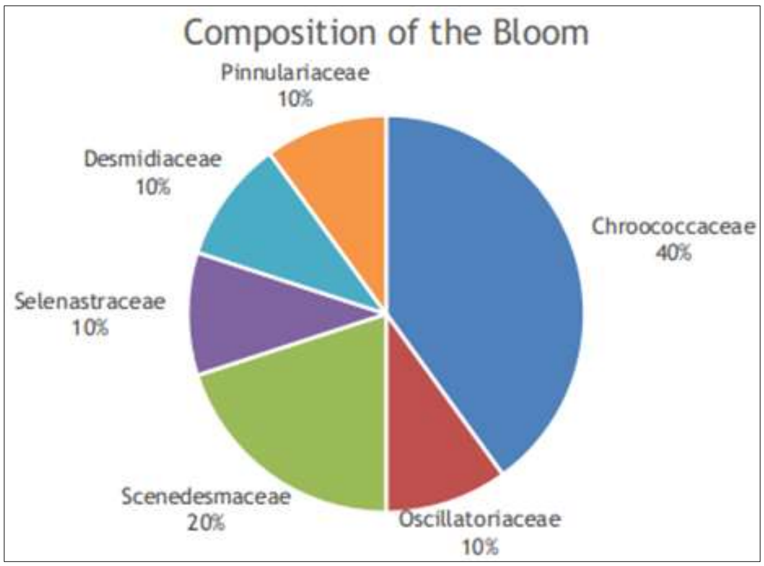

Fig 2: Percentage occurrence of bloom composition

Table 3: Seasonal variation of bloom phytoplankton in Dora *beel*

Post Monsoon, 2019		Winter, 2019		Pre Monsoon, 2020	
Total algal cell density (Cells/ml)	**Algal cell density according to genus (Cells/ml) and % in the Total Count**	**Total algal cell density (Cells/ml)**	**Algal cell density according to genus (Cells/ml) and % in the Total Count**	**Total algal cell density (Cells/ml)**	**Algal cell density according to genus (Cells/ml) and % in the Total Count**
0.72 $x10^4$ cells/ml	*Microcystis* sp 0.4896 x 10^4 cells/ml (68%)	$1.02x10^4$ cells/ml	*Microcystis* sp $0.7752x10^4$ cells/ml (76%)	$0.86x10^4$ cells/ml	*Microcystis* sp $0.6106x10^4$ cells/ml (71%)
	Scenedesmus sp 0.1584 x 10^4 cells/ml (22%)		*Ankistrodesmus* sp $0.1428x10^4$ cells/ml (14%)		*Ankistrodesmus* sp $0.172x10^4$ cells/ml (20 %)
	Oscillatoria sp 0.0576 x 10^4 cells/ml (8%)		*Scenedesmus* sp $0.0816x10^4$ cells/ml (8%)		*Oscillatoria* sp $0.0602x10^4$ cells/ml (7%)
	Pinnularia sp 0.0144 x 104 cells/ml (2%)		*Pinnularia* sp $0.0204x10^4$ cells/ml (2%)		*Closterium* sp $0.0172x10^4$ cells/ml (2%)

3.3 Statistical analysis of data

Canonical correlation analysis **(**CCA) was drawn between physico-chemical parameters and seasons in a year (Fig. 3) and between species of phytoplankton and seasons in a year (Fig. 4). The axis1 shows 86.3% correlation and axis 2 shows 9.4% correlation with the physico-chemical parameters and seasons (Fig. 3). The visualization shows that TDS, pH and hardness (Hd) are associated with the winter and pre-monsoon seasons. It is observed that TDS is on the opposite side of the map indicating that this parameter is least affected by winter as well as pre-monsoon. The TDS, pH and hardness (Hd) are strongly related with axis 1. Out of these pH and hardness (Hd) have positive correlation with winter and pre-monsoon, whereas TDS has negative correlation with these two seasons. Turbidity and conductivity are negatively related to both axis1 and axis 2.

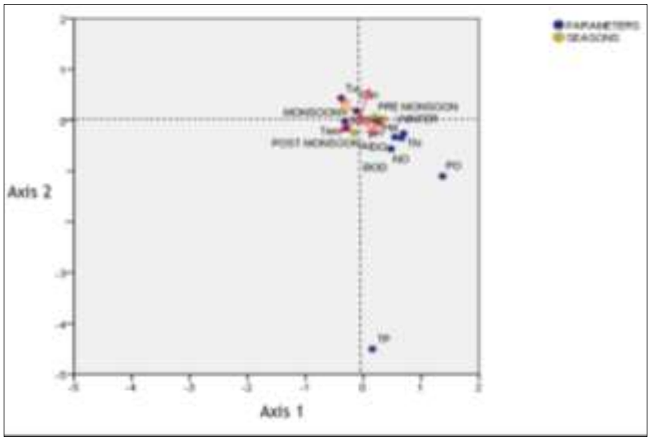

Fig 3: CCA biplot between physico-chemical parameters and seasons in a year

[*Temperature (Tem), pH, Alkalinity (Al), Hardness (Hd), Turbidity (Tu), Conductivity (Con), TDS, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Nitrate (NO), Orthophosphate (PO), Total Nitrogen (TN), Total Phosphorus (TP)*]

The axis 1 shows 68.3% correlation and axis 2 shows 31.7% correlation with the seasons and dominant phytoplankton species (Fig. 4). The visualization shows that species *Microcystis robusta* (Mro) and *Scenedesmus bijugatus* (Sb) is positively associated with the winter season and *Microcystis aeruginosa* (Ma) is negatively associated with pre-monsoon season. It is evident that *Closterium gracilimum* (Cg) and *Microcystis pseudofilamentosa* (Mp) are least affected by winter and post-monsoon, but negatively affected by the pre-monsoon. *Ankistrodesmus falcatus* (Af) is positively associated with pre-monsoon season and negatively related with axis 2. The species *Microcystis aeruginosa (*Ma) is strongly related with axis 1.

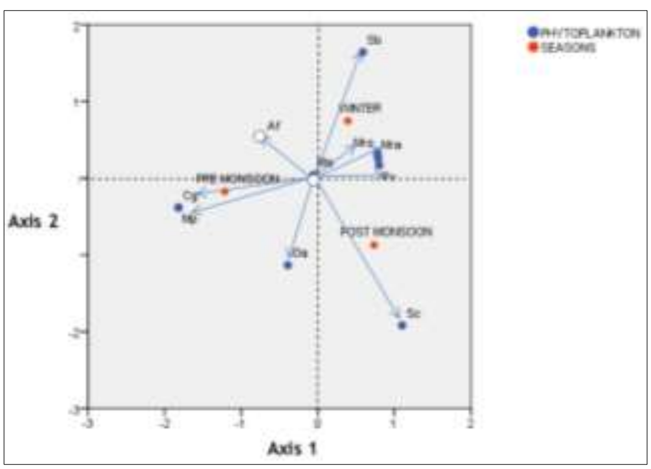

Fig 4: CCA biplot between species of phytoplankton and seasons in a year

[*Microcystis aeruginosa* (Ma), *Microcystis pseudofilamentosa* (Mp), *Microcystis ramose* (Mra), *Microcystis robusta* (Mro), *Oscillatoria acutissima* (Oa), *Scenedesmus bijugatus* (Sb), *Scenedesmus communis* (Sc), *Ankistrodesmus falcatus* (Af), *Closterium gracilimum* (Cg), *Pinnularia viridis* (Pv)]

4. Conclusions

The above study highlights the fact that the environmental variables i.e. the physico-chemical parameters of water has an impact on the seasonal occurrence of the phytoplankton bloom. The density or cell count has also been found to vary season wise. The composition of the algal bloom also differs from season to season. It can be summarized from the above study that the seasonal variations of physico-chemical parameters influences the phytoplankton community of the lentic ecosystem of Dora beel.

5. References

1. Baird RB, Eton AD, Rice EW. Standard Methods for the Examination of Water and Wastewater (23rd ed.). American Public Health Association (APHA), American Water Works Association (AWWA) and Water Environment Federation (WEF), Washington, 2017.
2. Bellinger EG, Sigee DC. Freshwater Algae: Identification and Use as Bioindicators. Wiley-Blackwell, 2010, 1-243.
3. Chai Chao, Jiang Tao, Cen Jingyi, Ge Wei and Lu Songhui. Phytoplankton pigments and functional community structure in relation to environmental factors in the Pearl River Estuary. Oceanologia. 2016; 58(3):201-211.
4. Davis C. Charles. The Marine and fresh water plankton, Michigan state University press, 1955, 1-562.
5. Desikachary TV. Cyanophyta. New Delhi: Indian Council of Agricultural Research, 1959.
6. Fritsch FE. The structure and reproduction of the algae. (Vol 2). New York Cambridge University Press, 1945.
7. Garg RK, Rao RJ, Uchchariya D, Shukla G, Saksena DN. Seasonal variations in water quality and major threats to Ramsagar reservoir, India. African Journal of Environmental Science and Technology. 2010; 4(2):61-76.
8. Garg RK, Saksena DN and Rao RJ. Assessment of physico-chemical water quality of Harsi reservoir, district Gwalior, Madhya Pradesh. Journal of Ecophysiology Occupation and Health. 2006 a; 6:33-40.
9. Garg RK, Rao RJ, Saksena DN. Nutrients and trophic status of Ramsagar reservoir, Datia, Madhya Pradesh. Journal of Nature Environment and Pollution Technology. 2006 b; 5:545-551.
10. Hoque MMM, Roy S, Hoque MN, Islam MZ. Assessment of Some Water Quality Parameters of Bansi River in Monsoon and Winter Seasons Journal of Environmental Science & Natural Resources. 2012; 5(2):53-57.
11. Jing M, Li JY, Liu MY. Canonical Correspondence Analysis between Phytoplankton Community and Environmental Factors in Yangcheng Lake. Environmental Science and Management. 2014; 39(11):145.
12. Karr JR, Allen JD, Benke AC. River conservation in the United States and Canada. In: Boon PJ, Davies BR, editors. Global perspectives on River conservation, Science, Policy, and Practice. Wiley, New York, 2000, 3-39.
13. Kruse Paul F Jr, Patterson MK Jr. (Eds), Tissue Culture: Methods and Applications, Chapter 1 - Hemocytometer Counting, Academic Press, 1973, 395-397.
14. Margalef R. Life forms of phytoplankton as survival alternatives in an unstable environment. Oceanol. Acta. 1978; 1(4):493-509.

15. Moss Brian. Ecology of Freshwaters: Earth's Bloodstream. John Wiley & Sons Ltd, UK, 2018.
16. Tiffany LH, Britton ME. The Algae of Illinois. Chicago: Univ. of Chicago Press, 1952.
17. Transeau EN. The periodicity of freshwater algae. American Journal of Botany. 1916; 3:121-133.
18. Paerl HW, Valdes LM, Pinckney JL, Piehler MF, Dyble J, Moisander PH, *et al*. Phytoplankton photopigments as indicators of estuarine and coastal eutrophication. Bio Science. 2003; 53(10):953-964.
19. Pal Ruma, Choudhury AK. An Introduction to Phytoplanktons: Diversity and Ecology, Springer India, 2014. ISBN 978-81-322-1837-1.
20. Sharma I, Dhanze R, Rana P. Physico-chemical parameters of lentic water bodies from Mid- Himalayan region (H.P.), India. International Journal of Fisheries and Aquatic Studies. 2017; 5(2):674-678.
21. Smith GM. Manual of Phycology - An introduction to the algae and their biology. New York. NY. Ronald Press, 1951.
22. Stevenson RJ, Pan Y. Assessing environmental conditions in Rivers and streams using diatoms. In EF Stoermer and JP Smol, (Ed.). The diatoms, Applications for the environmental and earth sciences. Cambridge University Press, Cambridge, 1990, 11-40.