Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; Sp 9(5): 736-740
Received: 28-08-2020
Accepted: 07-09-2020

Bisma Gulzar
Division of Aquatic Environmental Management, Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Rangil, Ganderbal, Jammu and Kashmir, India

Masood H Balkhi
Division of Aquatic Environmental Management, Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Rangil, Ganderbal, Jammu and Kashmir, India

Adnan Abubakr
Division of Aquatic Environmental Management, Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Rangil, Ganderbal, Jammu and Kashmir, India

Farooz A Bhat
Division of Aquatic Environmental Management, Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Rangil, Ganderbal, Jammu and Kashmir, India

Oyas Asimi
Division of Aquatic Environmental Management, Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Rangil, Ganderbal, Jammu and Kashmir, India

Bilal A Bhat
Division of Aquatic Environmental Management, Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Rangil, Ganderbal, Jammu and Kashmir, India

Corresponding Author:
Bisma Gulzar
Division of Aquatic Environmental Management, Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Rangil, Ganderbal, Jammu and Kashmir, India

Distributional pattern of algal/plankton groups in relation with water quality of Himalayan Dal lake, Kashmir, India

Bisma Gulzar, Masood H Balkhi, Adnan Abubakr, Farooz A Bhat, Oyas Asimi and Bilal A Bhat

Abstract
Present study deals with the general ecological studies on phytoplankton community in terms of species composition, abundance and distribution in the Himalayan Dal lake. Important physico-chemical parameters were also analyzed using the standard methodology. Pollution of water bodies due to human activities affects the physico-chemical characteristics of water, leading to changes in aquatic community structure and deterioration of the lake environment. A clear dominance of Bacillariophyceae followed by chlorophyceae, Cyanophyceae, Euglenophyceae and Dinophyceae was observed throughout the study period. Phytoplankton serves as an indicator of trophic status and ecological condition of the lake. Many pollution tolerant algal species were present that are indicators of organic pollution, thus, making water unfit for drinking and recreational purposes.

Keywords: Plankton, diversity, abundance, bio-indicators, physico-chemical parameters, Himalayan lake, aquatic ecology, pollution, phytoplankton diversity, Dal lake

1. Introduction
Freshwater ecosystem throughout the world is under increasing threats and pressures due to both local and global changes (Dudgeon *et al.*, 2005 [4] and Pattnaik, 2007) [21]. Besides freshwater bodies like rivers, lakes, tanks and ponds are over-strained and poisoning in various ways like industrial wastes, sewage, and agricultural runoff with chemical wastes and excess nutrients. Discharge of pollutants can degrade the quality of water, as well as affect the health of its aquatic ecosystem.

Algae are a large and diverse group of simple, typically autotrophic organisms, ranging from unicellular to multicellular forms. They are non-vascular plants which lack organs like root, stem and leaves. The various types/forms of algae play a significant role in aquatic ecology. Microscopic forms that live suspended in water column i.e. phytoplankton provide the food for most aquatic food chains. In very high density they form blooms and poison other life forms. Phytoplankton communities are sensitive to alterations in their habitats, and thereby, phytoplankton total biomass and many phytoplankton species are utilized as indicators of aquatic habitat qualifications (Chellappa *et al.*, 2009) [3]. Phytoplankton demonstrates water quality through changes in its community composition, distribution and proportion of sensitive species (Gharib *et al.*, 2011) [8].

Phytoplankton is the pioneer of an aquatic food chain. Biological production can be used as an index of trophic status and fisheries resource potential in any aquatic body (Jhingran, 1992) [15]. The productivity of an aquatic environment is directly correlated, with the density of phytoplankton (Narasimha, 2013) [26] as they play an important role as primary producers and thus can affect higher trophic levels by providing nutritional bases for zooplankton and subsequently to other invertebrates, shell fish and finfish (Emmanuel and Onyema, 2007) [7].

2. Materials and Methods
2.1. Study area and study sites
Kashmir valley is one of the divisions of Jammu and Kashmir, India, which is bestowed with number of world famous lentic water bodies and Dal Lake is one such important water body of Himalayan ecosystem. This urban lake is of fluviatile origin having been formed from the ox-bow of the River Jhelum situated towards the North-east of Srinagar, Kashmir at the foot of Zabarwan mountains. The lake lies between 34º6' N-34º10' N latitude and 74º50' E-74º54' E longitude at an altitude of about 1,584 m above mean sea level (Najar and Khan, 2012) [18]. The main source of water for this lake is rainfall (Khan *et al.*, 2012) [18]. The lake is also

mainly fed by a large perennial inflow streams called as Telbal Nallah that contributes about 80 percent of the total inflow to the lake. However, the lake bed abounds in number of natural springs. The lake is divided into four basins: Hazratbal, Bod Dal, Nagin and Gagribal which differ markedly in their area, volume, depth and shoreline development indices etc. The Nagin basin is the deepest basin (maximum depth of about 6 m), and Gagribal basin the shallowest (maximum depth 2.5 m). The total water surface area of the lake is 11.50 km², of which 4.1 km² is under floating gardens, 1.51 km² is submerged land and 2.25 km² under marsh lands respectively (Jeelani and Shah, 2006) [14].

To amplify our understanding and augment the knowledge of vast algal communities in Dal lake, the present research work was taken up for a period of one year starting from November 2018 with the following objectives to attain.

- Evaluation of pollution level in Dal lake, and
- To examine the phytoplankton community structure as an indirect assessment of the water quality of the lake.

In total, six sampling sites were selected on the basis of water depth, vegetation, biotic variables and anthropogenic stresses for carrying out the study as spotted and shown in the map given in Fig.1.

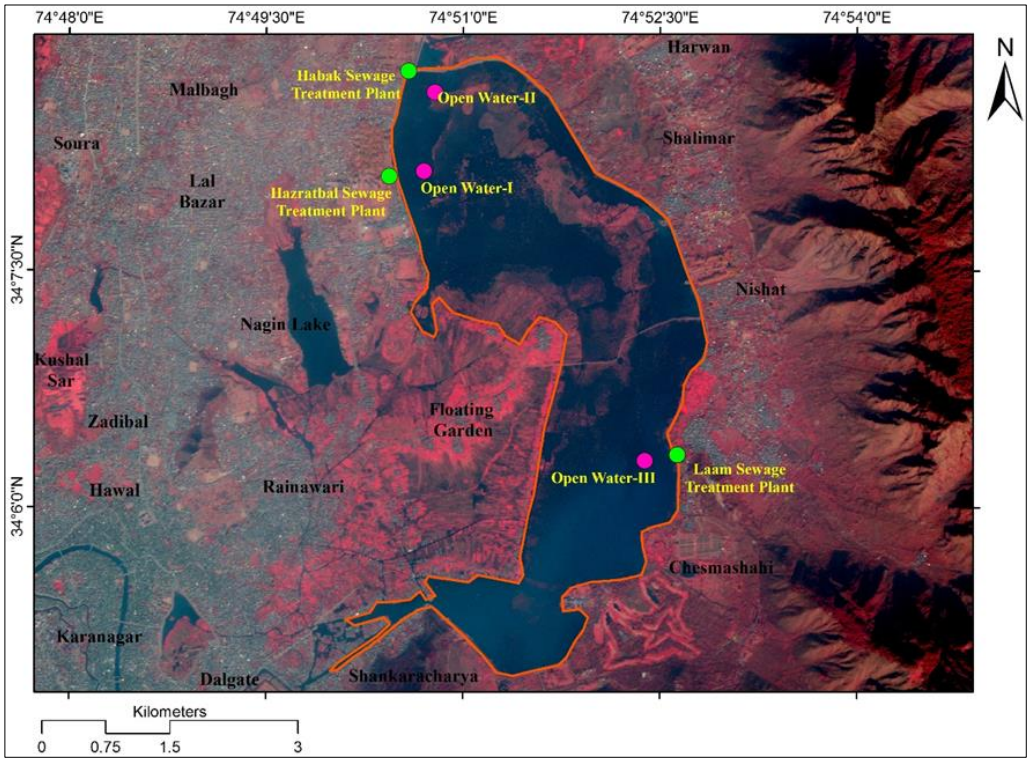

Fig 1: Map showing different study sites of the study area

3. Water analysis

Surface water samples were collected from the lake at designated sites using sampling bottles. For dissolved oxygen, D.O bottles of 125ml capacity were used and the fixation of the samples was done on spot. Air-temperature, water-temperature, Depth, Transparency and pH were determined at the sampling stations and samples for detailed analysis *viz*., Electrical conductivity, Nitrate-nitrogen, Nitrite-nitrogen, Ammoniacal-nitrogen, Total Phosphorus and Biochemical Oxygen Demand were immediately transported to the Aquatic Environmental Management Laboratory, Faculty of Fisheries, Rangil, Ganderbal, Kashmir. The water analysis was carried out using the methods outlined in Adoni (1985) [1] and APHA (2012) [2]. (Table 1.)

Table 1: Standard methodology employed for monitoring important physico-chemical parameters of Dal lake

S. No.	Parameter	Method	References
1.	Air Temperature	Celsius thermometer	APHA (2012)
2.	Water Temperature	Celsius thermometer	APHA (2012)
3.	Depth	Seechi disk	APHA (2012)
4.	Transparency	-	APHA (2012)
5.	pH	Digital pH meter	APHA (2012)
6.	Electric Conductivity	Conductivity meter	APHA (2012)
7.	Dissolved oxygen	Azide modification of Winkler's method	APHA (2012)
8.	Ammonical-Nitrogen	Phenate method	APHA (2012)
9.	Nitrate-Nitrogen	Salicylate method	APHA (2012)
10.	Nitrite-Nitrogen	Salicylate method	APHA (2012)
11.	Total Phosphorus	Stannous chloride method	APHA (2012)
12.	Biological Oxygen Demand	5-day BOD Test	APHA (2012)

3.1. Plankton analysis

Plankton analysis was carried out with the help of Sedgewick-Rafter Counting Cell of 1 ml capacity and studied under compound microscope using the standard keys given by Pennak (1978) [22]; Edmondson (1992) [5, 6] and Adoni (1985) [1].

The results obtained from the study were interpreted with the help of statistical methods using Microsoft Excel, R software and SPSS for Windows.

4. Results and Discussion

4.1. Physico-chemical characteristics of Dal Lake

Overall average value of the various physico-chemical parameters at different selected stations of the lake during study period are shown in Table 2. Temperature is one of the most important limnological parameter that plays a prominent role in regulating nearly all other physico-chemical characteristics of the water as well as biological productivity (Wetzel, 1983) [26]. The atmospheric temperature depicted a definite seasonal trend during the entire period of study and changed with the change in the seasons. The overall mean value of air temperature was 16.15 ± 0.23. The observations on water temperature registered during the present investigation showed a close relationship with the atmospheric temperature. The surface water temperature of all the study sites revealed that the seasonal temperature significantly varied with maximum temperature being exhibited during summer season. The water temperature showed an overall average value of 15.34 ± 0.27 during the study period. The temperature recorded during the summer and autumn season was optimum for the normal growth and survival of aquatic organisms as phytoplanktons recorded during our study also showed peak growth and abundance.

The annual mean values of transparency showed a value of 0.55 ± 0.10. The lake waters were usually turbid at complementary sites; the low values of transparency being attributed to silt impregnated waters from the catchment responding the growth of phytoplankton. Greater the depth of light penetration, less it can be considered as limiting the primary productivity of phytoplankton in the water column. The maximum depth was recorded during autumn season and minimum depth values were obtained in the summer season. The mean depth values recorded were at 1.32 ± 0.56. The same has been reported by (Gulzar and Abubakr, 2019) [9, 10] and ascribed it to the discharge of heavy loads of domestic sewage and agricultural runoff.

pH is the measurement of acidity or alkalinity of water solution, hence it is an important factor for water quality analysis. The overall pH recorded during the present investigation was 7.76 ± 0.13. Conductivity is a measure of the ability of water to pass an electrical current. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge). Electric conductivity (EC) depends upon the quantity of dissolved salts present in water and also nutrient loading of the lakes (Gupta *et al.*, 2008) [11]. Electric conductivity, being a thermophysical property of lake water has a strong interrelationship with pollution level. The results showed that the mean value of 421.5 ± 10.57 was observed at different sites of the lake. Shastree *et al*., (1991) [23] and Kanue *et al.*, (2013) [16] also reported that high level of conductivity reflects the pollution status as well as trophic levels of the lake and rivers.

Dissolved oxygen (DO) is an essential component which determines the water quality and trophodynamics of an aquatic system. DO dynamics are complex in nature and are affected by many physical, chemical, and biological processes. The important factors that affect DO dynamics in an aquatic environment are atmosphere-water surface exchange, photosynthesis, respiration, and mineralisation. The other processes that affect the oxygen dynamics in the water column include nitrification, sediment-water exchange. In any aquatic ecosystem, dissolved oxygen is of paramount importance because it is critical to the survival of most forms of aquatic life besides being the most reliable criterion in assessing the trophic status and the magnitude of eutrophication (Edmondson, 1966) [5, 6]. The Dissolved oxygen concentration was found to be 7.06±0.35 with low D.O. values obtained at outlet sites. Low values of dissolved oxygen implies higher trophic status thereby creating anoxic conditions in the lake (Gulzar, 2019) [9, 10]. Excess nutrient inflows, nitrification, and denitrification events are the main causes for the observed conditions.

Ammonical-nitrogen has been reported to be the preferred nitrogen for phytoplankton uptake (Wetzel, 2001) [26] and is also a product of many organic degradation processes and thus could be expected to show large variations in concentration. Overall mean NH4-N values 288.44 ± 10.33 were observed at different sites of the lake. Organically polluted waters with high levels of NH4-N show increased biological productivity due to readily available nutrients (Sheela *et al*., 2010) [24]. Average concentration of nitrate-nitrogen and nitrite-nitrogen was recorded to be 409.48 ± 12.74 and 37.91 ± 1.54 respectively. Pandit and Yousuf (2002) [20] also found that nitrate and phosphate enters the lakes through domestic wastewater, accounting for the accelerated eutrophication and their augmented concentration leads to enhanced phytoplankton productivity.

The mean value of BOD was found to be maximum 10.82 ± 0.60 during the summer season which is related to increased biological activities at higher temperatures and low dissolved oxygen available in this season. Our findings are in agreement with (Venkatesharaju *et al*., 2010) [25] who also reported the high DO and less BOD as an outcome of plentiful phytoplanktonic growth resulting in high photosynthesis.

Phosphorus is an essential element for fertility of lakes and is regarded as key nutrient in the productivity of waters. Phosphate seems to be limiting factor in nearly all fresh waters and its addition can increase the growth of algae particularly blue-green algae (*Oscillatoria* sp., *Lyngbya* sp.) and green algae (*Chaetophora* sp.). The highest phosphorus content was observed in summer season with an average value of 731.84 ± 13.28**.** Hutchinson (1957) [13] related the increased phosphorus to sewage contamination. Correll (1998) is of the opinion that the formation of algal blooms is due to high phosphorus concentration, which leads to eutrophication as a result of which several waterbodies have deteriorated to a large extent.

4.2. Species composition

During the entire study, Bacillariophyceae was found to be the most dominant class followed by chlorophyceae, Cyanophyceae, Euglenophyceae and Dinophyceae. The occurrence and abundance of phytoplankton showed a close relationship with the changes in the physico-chemical characteristics of water (Kaul *et al.*, 1978; Pandit, 1980) [20]. The pollution tolerant taxa like *Euglena*, *Scenedesmus*, *Cymbella* and *Oscillatoria* were sparse at open water sites whereas it was most abundant in nutrient enriched waters at complimentary sites due to presence of higher phosphorus and nitrate concentrations (Fig.2.).

Table 2: Overall average value of the various physico-chemical parameters at different selected stations of Dal lake

S. No.	Parameters	Mean	SD
1.	Air temp. (ºC)	16.15	0.23
2.	Water temp. (ºC)	15.34	0.27
3.	Max. depth (m)	1.32	0.56
4.	Seechi Disc Transparency (m)	0.55	0.10
5.	pH	7.76	0.13
6.	Dissolved oxygen (mgL^{-1})	7.06	0.35
9.	Nitrate-nitrogen (µg/L)	409.48	12.74
10.	Ammonical-nitrogen (µg/L)	288.44	10.33
11.	Nitrite-nitrogen (µg/L)	37.91	1.54
12.	Total phosphorus (µg/L)	731.84	13.28
13.	Biological Oxygen Demand (mgL^{-1})	10.82	0.60
14.	Electric conductivity (μScm^{-1})	421.51	10.57

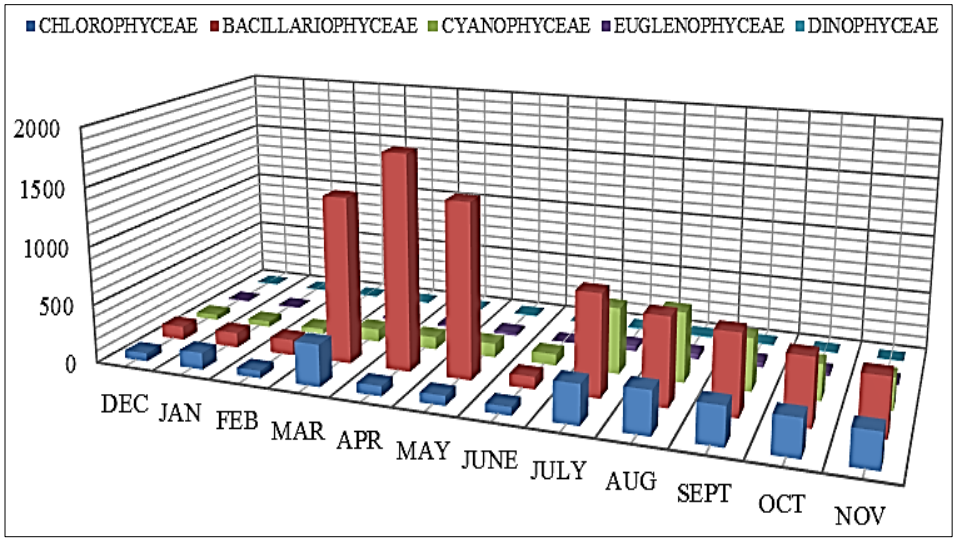

Fig 2: Monthly variations in the mean density values (ind. /mL) of phytoplanktons

Table 3: Checklist of dominant phytoplankton species reported during the study period

S. No.	Species name	Winter	Spring	Summer	Autumn
A. *Bacillariophyceae* (Diatoms)					
1.	*Achnanthes sp.*	-	+	+	-
2.	*Amphora sp.*	-	+	+	-
3.	*Cyclotella sp.*	+	+	+	+
4.	*Cymbella sp.*	-	+	+	-
5.	*Hantzchia sp.*	-	+	+	-
6.	*Melosira sp.*	+	+	+	+
7.	*Navicula sp.*	+	+	+	+
8.	*Anabaena sp.*	-	+	+	+
9.	*Nostoc sp.*	+	+	+	+
10.	*Oscillatoria sp.*	+	+	+	+
11.	*Spirulina sp.*	-	+	+	+
B. *Cyanophyceae*					
1.	*Anabaena sp.*	+	+	+	+
2.	*A. circinalis*	+	+	-	+
3.	*Anacystis sp.*	-	+	+	-
4.	*Aphanocapsa sp.*	-	+	-	-
5.	*Anabaena sp.*	+	-	+	+
C. *Cholorophyceae*					
1.	*Ankistrodesmum sp.*	+	+	+	+
2.	*A.falcatus*	+	+	+	-`
3.	*A.spiralis*	+	+	+	-
4.	*Anthrodesmus sp.*	-	+	+	-
5.	*cladophora sp.*	+	+	+	+
6.	*Chlorella sp.*	+	+	+	+
D. *Euglenophyceae*					
1.	*Euglena acus*	+	+	+	+
2.	*Euglena rubra*	+	+	+	-`
3.	*Phacus sp*	+	+	+	-

+ = Present; - = Absent

5. Conclusion

The present study indicates that the environmental condition of the Himalayan Dal Lake is deteriorating at an accelerated rate. In natural environment, many factors other than nutrient concentration contribute to the ecological condition of the lake. Temporary disturbances and irregularities such as temperature fluctuations and variable mixing intensity may cause changes in major phytoplankton functional groups and in the dynamics of intermediate states. The study provides cardinal insight into the plankton distribution and abundance of the lake which may unravel the information on the deteriorating ecosystem. Further it will serve as a useful tool for ecological assessment and monitoring of the lake ecosystem.

6. References

1. Adoni AD. Workbook in limnology. Pratibha Publisher, C-10 Gour Nagar, Sagar (M. P); c1985.
2. APHA. Standard Methods for Examination of water and wastewater. 22nd Washington. American Public Health Association; c2012. p. 1360.
3. Chellappa NT, Câmara FRA, Rocha O. Phytoplankton community: Indicator of water quality in the Armando Ribeiro Gonçalves Reservoir and Pataxó Channel, Rio Grande do Norte, Brazil. Brazilian Journal of Biology Revista Brasileira de Biologia 2009;69(2):241-251.
4. Dudgeon D, Arthington AH, Gessner MO, Kawabata ZI, Knowler DJ, Leveque C, Naiman RJ, Sulliva CA. Freshwater biodiversity: importance, threats, status and conservation challenges. Biological review 2005;81:163-182.
5. Edmondson WT. Freshwater Biology, 2nd Edn., John wiley and Sons. Inc. New York and London 1966, P1248.
6. Edmondson WT. Freshwater Biology. 2nd Edition. International Books and Periodicals Supply Service 1992, 587-656.
7. Emmanuel BE, Onyema IC. The plankton and fishes of a tropical in Creek in South Western Nigeria. Turkish Journal of Fish and Aquatic Sciences 2007;7:105-113.
8. Gharib SM, El-Sherif AZM, Abdel-Halim M, Radwan AA. Phytoplankton and environmental variables as a water quality indicator for the beaches at Matrouh, south-eastern Mediterranean sea, Egypt: An assessment. Oceanologia 2011;53(3):819-836.
9. Gulzar B, Abubakr A. Present trophic status of Anchar Lake, Kashmir: Assessment by water quality parameters. Journal of Pharmacognosy and Phytochemistry 2019;8(4):2018-2023.
10. Gulzar B, Abubakr A, Bhat FA, Balkhi MH. Trophic status of Manasbal Lake: A high altitude deep lake water body of Kashmir, India. SKUAST Journal of Research 2019;21(2):172-179.
11. Gupta SK, Tiwari NP, Alam MN. Studies on Physco-Chemical status of two ponds at Patan in relation to growth of fishes. Nature Environment and Pollution Technology 2008;7(4):729-732.
12. Hutchinson GE. A treatise on Limnology. Geography, Physics and Chemistry. John Wiley & Sons Inc, N. York 1957.
13. Jeelani G, Shah AQ. Geochemical characteristics of Water and sediment from the Dal Lake, Kashmir Himalaya: Constraints on weathering and anthropogenic activity. Environmental Geology 2006;50(1):112-123.
14. Jhingran VG. Fish and Fisheries of India. Hindustan Publishing Corporation, New Delhi, India 1992.
15. Kanue PSA, Munshi S, Zubair SM, Dutt DH. Water chemistry of Hazratbal basin of Dal lake in Kashmir. Life Sciences Leaflets 2013;(3):89-95.
16. Khan JA, Gavali RS, Shoche YS. Exploring the present status of hydrochemistry and sediment chemistry of Dal Lake, Kashmir and effect of anthropogenic disturbances on it. Indian Journal of Innovations and Development 2012;1(7).
17. Najar IA, Khan AB. Assessment of water quality and identification of pollution sources of three lakes in Kashmir, India, using multivariate analysis. Environmental Earth Sciences 2012;66:2367-2378.
18. Narasimha RK, Benarjee G. Physico-chemical factors influenced Plankton biodiversity and fish Abundance- A case study of Nagaram tank of Warangal, Andhra Pradesh 2013.
19. Zakari Abdurahman Ya'u, Emmanuel Aduojo Ekpa, Nancy Erika Michael, Oluwatosin Comfort Oluwatoyin. Studies on spread of algal species in some fish samples from three water bodies in Zaria-Kaduna state Nigeria. Int. J Adv. Biochem. Res. 2020;4(1):47-52. DOI: 10.33545/26174693.2020.v4.i1a.101
20. Pattnaik AK. Institutional Mechanism for Monitoring and evaluation. The 12th World Lake Conference 2007, P17.
21. Pennak RW. Freshwater invertebrates of United States, 2nd Edn. Wiley inter science publication. John Wiley and sons, New York 1978, P803.
22. Shastree NK, Islam MS, Pahtahak S, Afshan M. Studies on the physico-chemical dimensions of the lentic hydrosphere of Ravindra Sarowar (Gaya). In: Current Trends in Limnology-1 (N. K. Shastree, Edn). Narindra Publishing House, Delhi, India 1991, 133-152.
23. Sheela AM, Letha J, Joseph S. Environmental status of a tropical lake system. Journal of Environment Monitoring and Assessment 2010.
24. Venkatesharaju K, Ravikumar P, Somashekar RK, Prakash KL. Physico-chemical and bacteriological investigation on the River Cauvery of kollegal stretch in Karnataka. Journal of science Engineering and technology 2010;6(1):50-59.
25. Wetzel RG. Limnology. 2nd Edition, Saunders College Publishing, Philadelphia; c1983.
26. Pandit AK, Yousuf AR. Trophic status of Kashmir Himalayan lakes as depicted by water chemistry. Journal of Research and Development. 2002;2:1-12.