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# APPRAISAL OF CYCLIC DISSIMILARITY AND SEASONAL CHANGES OF THE PHYTOPLANKTON IN TUNGABHADRA RIVER NEAR HARIHAR – KARNATAKA

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**AUTHOR'S CONTRIBUTION**

The sole author designed, analysed, interpreted and prepared the manuscript.

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## ABSTRACT

The present paper deals with the study of the cyclic dissimilarity and seasonal changes in phytoplankton population in Tungabhadra River from Harihar, Karnataka. The river located in the district Davangere is located in the central part of Karnataka state (India) between latitude 14°17′ to 14°35′ N and longitude 75°50′ - 76°05′ E covering an area of 6500 sq. km at an average altitude of 540 m above Mean Sea Level (MSL). From the selected 3 stations of Tungabhadra river water, samples were collected at monthly intervals. Qualitative and quantitative analysis of phytoplankton were carried out during the year 2018 – 2019. Seventy-one (71) species of phytoplankton were found comprising Chlorophyceae 35.47%, Bacillariophyceae 18.11%, Cyanophyceae 37.48% and Euglenophyceae 8.93%. Phytoplankton communities had the highest and lowest Shannon-Weaver diversity indices in the winter and summer, respectively. The highest Evenness index occurred in both the winter and rainy seasons, whereas the minimum was in winter. Sequential seasonal phytoplankton succession in Tungabhadra river was divisions Cyanophyceae a followed by Chlorophyceae. The diversity and distribution patterns of certain species were related to water quality as evident from the present study.

**Keywords:** Phytoplankton; population; summer; quantitative; Tungabhadra river.

## 1. INTRODUCTION

Plankton word comes to us [1] from a Greek word meaning "traveller" or "drifter" first coined by the German scientist Victor Heusen (1887). Plankton can be classified into two classes phytoplankton means plants and zooplankton mean animals. Phytoplankton constitutes the very basis of the nutritional cycle in aquatic ecosystems. Phytoplankton plays a key role in freshwater ecosystems as primary producers and constitutes the major fraction of food energy transferred to the second trophic level (herbivores). It becomes quite essential to study the trends of seasonal variation in phytoplankton communities. Phytoplankton is the plants inhabiting almost all kinds of habitats. The majority of algae inhabits water bodies and is sensitive to environmental changes i.e. nutrient enrichment, human development and climate changes. They respond quickly to environmental changes. This aspect has led researchers and water managers to use algae as biological indicators of water quality Patil SK [2], Sreenivasan A [3], Munwar M [4], Nygaad G [5], Sarkar, et al. [6], Hegde GR [7], Sharma R, Sharma KC [8].

Phytoplankton of freshwater rivers have been studied extensively in India [9], Mistra and Saksena, [10], Trivedy and Khatavkar [11]. The various

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phytoplankton groups prefer to exist in different kinds of water. However, there may be certain species which resist pollution, while others may be very sensitive. Pearsall [12,13] have attempted to pinpoint what water types containing Chlorophyceae are different from diatoms and members of the myxophyceae. The density of phytoplankton has been reported to be affected by the quality of water [14].

Diversity indices are applied in water pollution research to evaluate the effects of pollution on species composition [15]. Species diversity responds to changes in particular to stresses and limiting factors, thus reflecting many interactions which may characterize communities. Changes in any environmental factor will consequently change diversity [16], as long as adaptation is either rare or nonexistent, or gene flow from non-adaptive areas is great.

The present investigation was undertaken to study the cyclic dissimilarity and seasonal changes in phytoplankton populations in the Tungabhadra River from December 2018 to November 2019 near Harihar town, Davangere Dist., Karnataka. For convenience three sampling stations $S_1$, $S_2$ and $S_3$ from the River were selected.

## 2. MATERIALS AND METHODS

### 2.1 Phytoplankton Analysis

The water samples for phytoplankton analysis were collected from the river for a period of 12 months starting from September 2018 to August 2019. One thousand ml per each sample (8 samples per date) were concentrated by the sedimentation method using 10 ml of Lugol's solution to a final volume of 10 ml and preserved with 1 ml Lugol's solution and stored in the dark, following the methods of Benson-Evan et al. [17]. Phytoplankton was identified and counted under a compound light microscope by the Drop microtransect method [17,18].

### 2.2 Diversity Analysis

Phytoplankton dynamics were examined using the Shannon-Weaver index [16]:

$$H' = -\Sigma(ni/N) \ln(ni/N)$$

*ni* is the abundance of species i, and N is the total number of individuals in the community. The maximum diversity of a phytoplankton community occurs when all species are equally abundant in numbers or contribute equally to the total number of individuals. Maximum diversity is given by:

$$H\text{max} = \ln S$$

*S* is the total number of species of a community.

The Evenness-index (*E*) of the phytoplankton communities [16] was calculated by comparing the actual diversity to the maximum diversity.

$$E = H' / H\text{max}$$

## 3. RESULTS

### 3.1 Phytoplankton Community and Seasonal Succession

The total number of phytoplankton and monthly average phytoplankton number per ml are given in Table 1, while the seasonal variation and percentage composition of plankton components are shown in Tables 2 and 3.

We found that the total number of phytoplankton at station $S_1$ was from 2513 to 5602 cells per ml, at station $S_2$ 2228 to 6842 per ml and at station $S_3$ 2343 to 5999 per ml, during the year 2018 – 2019.

***Chlorophyceae*:** Chlorophyceae was encountered as the second most significant group of phytoplankton with a contribution of 35.47% (Table 2) of the total annual population. It exhibited a maximum density during January, April and December and the least in September (Fig. 1). The group includes *Pediastrum duplex sp., Spirogyra sp., Ulothrix sp., Cosmarium sp., Scenedesmus sp., Closterium lanceolatum sp., Desmidium greviellei sp.*

***Bacillariophyceae*:** This group accounted for a contribution of 18.11% (Table 2) to the total annual phytoplankton population. Its maximum density was noticed during April, October and August and the least in February (Fig. 1). This group includes *Cymbella sp., Nitschia sp., Melosires sp., Pinnulariasp., Synendra sp., Fragilaria sp.*

***Cyanophyceae*:** This was the most significant group of phytoplankton having a contribution of 37.48% (Table 2) of the total population. They exhibited a maximum density during July, March and December and the least in September and April (Fig. 1). This group includes *Lyngbya sp., Nostoc sp., Anabaena sp., Phormidium sp., Oscillatoria sp., Microcystis sp.*

***Euglenophyceae*:** This group contributed 8.93% to the total annual phytoplankton production and was represented by *Euglena, Spirogyra sp., Euglena minuta sp., Phacus sp., Trachelomonas,*

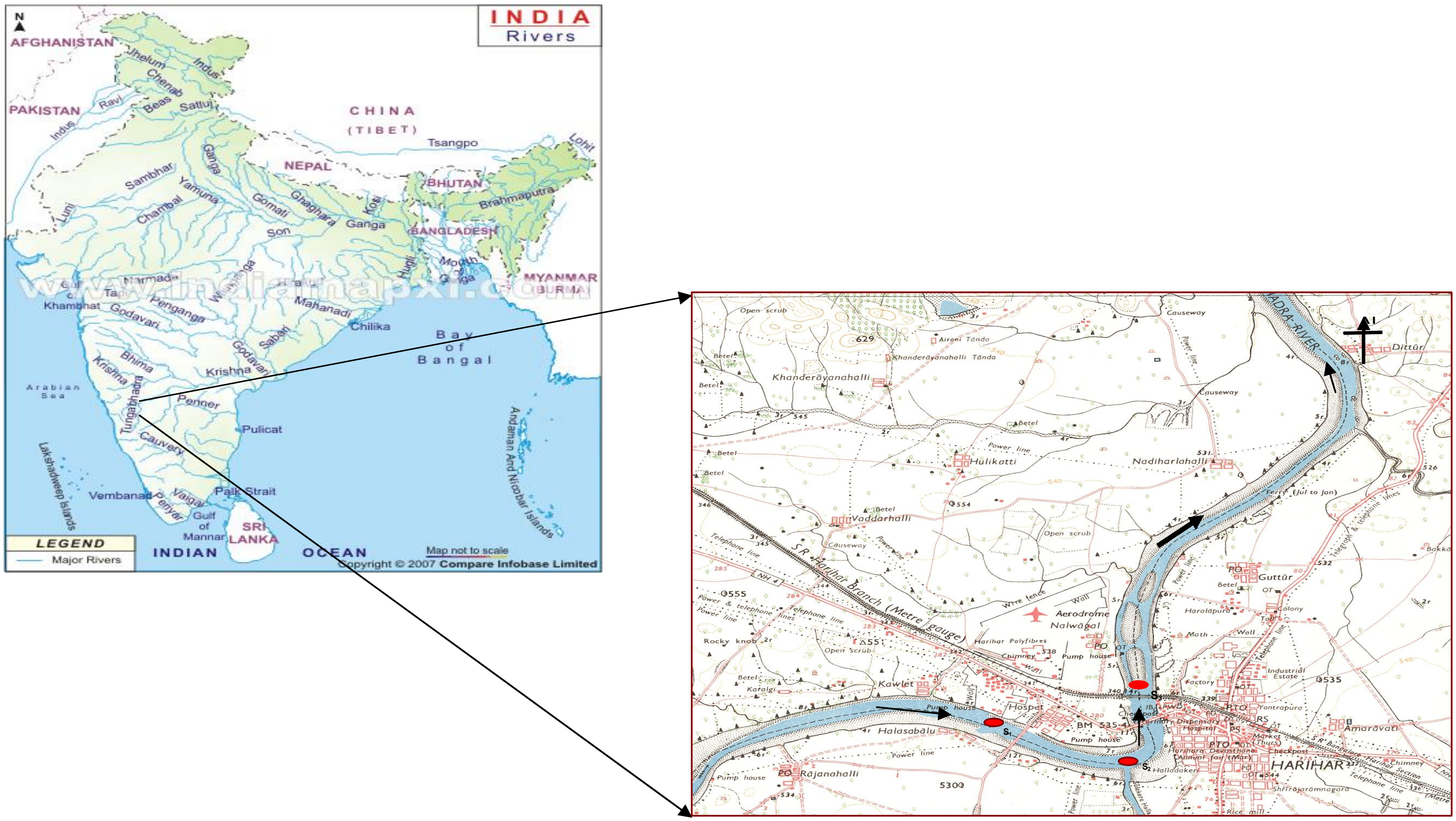


**Fig. 1. Shows study area location map of river Tungabhadra in Karnataka India**

**Table 1. Monthly variations in phytoplankton count per ml (2018 - 2019)**

| Sl. no. | Component | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Station S1** | | | | | | | | | | | | | |
| 1 | Chlorophyceae | 1686 | 2547 | 1384 | 1086 | 1868 | 1865 | 1210 | 1384 | 1068 | 765 | 1684 | 1456 | 18003 |
| 2 | Bacillariophyceae | 496 | 794 | 276 | 545 | 1658 | 725 | 754 | 674 | 920 | 654 | 986 | 898 | 9380 |
| 3 | Cyanophyceae | 2656 | 1975 | 1686 | 3164 | 778 | 1465 | 1664 | 2086 | 1346 | 674 | 1056 | 1356 | 19906 |
| 4 | Euglenophyceae | 210 | 286 | 318 | 186 | 648 | 176 | 214 | 318 | 218 | 420 | 546 | 486 | 4026 |
| | Total | 5048 | 5602 | 3664 | 4981 | 4952 | 4231 | 3842 | 4462 | 3552 | 2513 | 4272 | 4196 | 51315 |
| | **Station S2** | | | | | | | | | | | | | |
| 1 | Chlorophyceae | 1751 | 2471 | 1456 | 1815 | 1756 | 1686 | 1218 | 1456 | 954 | 656 | 1594 | 1386 | 18199 |
| 2 | Bacillariophyceae | 371 | 818 | 315 | 818 | 1464 | 814 | 664 | 764 | 418 | 758 | 875 | 866 | 8945 |
| 3 | Cyanophyceae | 2546 | 2156 | 1784 | 945 | 878 | 1345 | 1756 | 4151 | 1315 | 356 | 1246 | 1264 | 19742 |
| 4 | Euglenophyceae | 315 | 194 | 421 | 274 | 735 | 194 | 203 | 471 | 148 | 458 | 674 | 765 | 4852 |
| | Total | 4983 | 5639 | 3976 | 3852 | 4833 | 4039 | 3841 | 6842 | 2835 | 2228 | 4389 | 4281 | 51738 |
| | **Station S3** | | | | | | | | | | | | | |
| 1 | Chlorophyceae | 1698 | 2498 | 1398 | 1718 | 1818 | 1756 | 1198 | 1399 | 995 | 698 | 1644 | 1298 | 18118 |
| 2 | Bacillariophyceae | 396 | 798 | 310 | 756 | 1545 | 718 | 685 | 738 | 816 | 664 | 1015 | 975 | 9416 |
| 3 | Cyanophyceae | 2565 | 2015 | 1696 | 1064 | 718 | 1394 | 1698 | 3464 | 1295 | 465 | 1186 | 1196 | 18756 |
| 4 | Euglenophyceae | 298 | 256 | 307 | 218 | 545 | 188 | 225 | 398 | 236 | 516 | 756 | 856 | 4799 |
| | Total | 4957 | 5567 | 3711 | 3756 | 4626 | 4056 | 3806 | 5999 | 3342 | 2343 | 4601 | 4325 | 51089 |

**Table 2. Percentage of phytoplankton**

| Sl. no. | Group | No. of genera | % |
|---|---|---|---|
| 1 | Chlorophyceae | 25 | 35.47 |
| 2 | Bacillariophyceae | 13 | 18.11 |
| 3 | Cyanophyceae | 27 | 37.48 |
| 4 | Euglenophyceae | 6 | 8.93 |

**Table 3. Seasonal variations of phytoplankton groups of the river Tunga Bhadra**

| Season | Chlorophyceae | Bacillariophyceae | Cyanophyceae | Euglenophyceae | Total |
|---|---|---|---|---|---|
| Summer | 21508 | 6693 | 24252 | 3283 | 55736 |
| Winter | 18614 | 11203 | 21397 | 4315 | 55529 |
| Rainy | 14198 | 9845 | 12755 | 6079 | 42877 |

### 3.2 Phytoplankton Species Diversity

Fluctuations in the Shannon-Weaver index (*H*'), maximum diversity (Hmax) and Evenness (*E*) indices were observed throughout the year but on the whole as little variation among seasons excepting a late summer decline and early winter gain. Thus the Shannon-Weaver index ranged between about 2.3 and 3.0 except for the late summer low of 2.05 in May and early winter high of 3.57 in October. The maximum diversity remained relatively constant at around 4.4 to 4.6 in winter and summer but at late summer declined to about 3 and again at the late rainy season to the lowest value of 2.77 in August, with a peak of 4.66 in January (Fig. 4, Table 2). The species richness varied from month to month but reached a maximum in January and in October the highest number of species with an equal number of individuals in each species was found. The Evenness index (*E*) tended to track the Shannon-Weaver index in winter and summer within a range of 0.54 to 0.78. The lowest Evenness index was in December while the highest in October and August (Table 2) suggested that the phytoplankton community in these two months were at their most diverse.

## 4. DISCUSSION

Water bodies exhibit seasonal qualitative and quantitative fluctuations in planktonic populations for both temperate and tropical climates. Researchers report that the maximum development of phytoplankton occurs during summer and the minimum in winter [19,7,20]. Kumar et al. [21] estimated that the dynamics of phytoplankton is greater during summer, post-monsoon season and winter and is lowest in monsoon. In our investigation, we also observed a peak of phytoplankton during the summer followed by winter Table 3 and Fig. 3. Saha and Choudhary [22] obtained the maximum density of phytoplankton during July and minimum during January. In our study the peak of phytoplankton was observed during July, May and December while lowest levels were found in September followed by February and June Table 1 and Fig. 2.

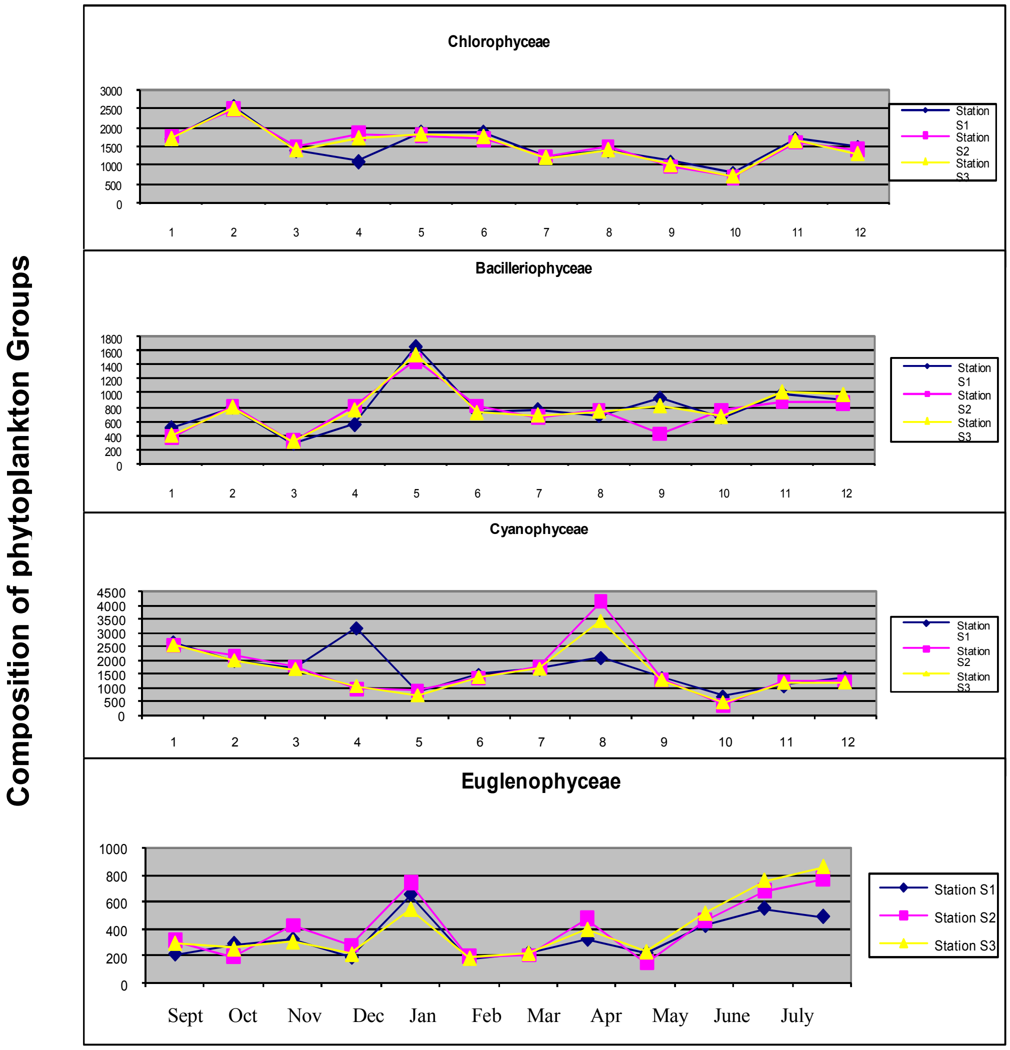


**Fig. 2. Monthly variations in the average total count of all phytoplankton populations**

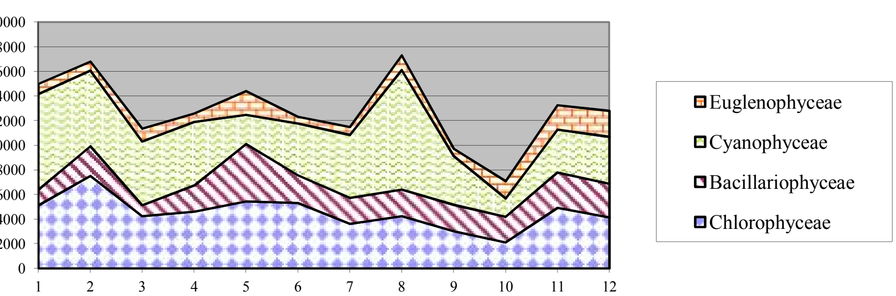


**Fig. 3. Monthwise distribution of phytoplankton**

**Table 4. List of phytoplankton species in Tungabhadra River from September 2018 to August 2019**

| Season | Season/Month | Indices | | |
|---|---|---|---|---|
| | | H' | E | $H_{max}$ |
| Winter | September | 2.41 | 3.57 | 2.55 |
| | October | 2.42 | 2.78 | 2.71 |
| | November | 2.95 | 3.23 | 2.05 |
| | December | 2.80 | 3.10 | 2.16 |
| | January | 0.60 | 0.78 | 0.57 |
| | September | 0.54 | 0.60 | 0.60 |
| Summer | February | 0.65 | 0.70 | 0.63 |
| | March | 0.72 | 0.75 | 0.78 |
| | April | 4.01 | 4.56 | 4.49 |
| | May | 4.48 | 4.66 | 4.51 |
| | February | 4.55 | 4.61 | 3.26 |
| | March | 3.87 | 4.13 | 2.77 |
| Rainy | June | 2.41 | 3.57 | 2.55 |
| | July | 2.42 | 2.78 | 2.71 |
| | August | 2.95 | 3.23 | 2.05 |

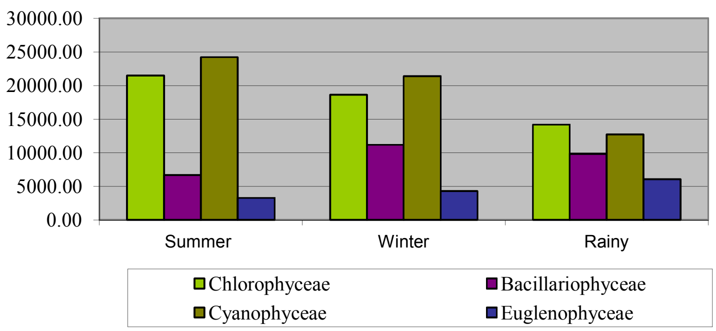


**Fig. 4. Seasonal variation of phytoplankton**

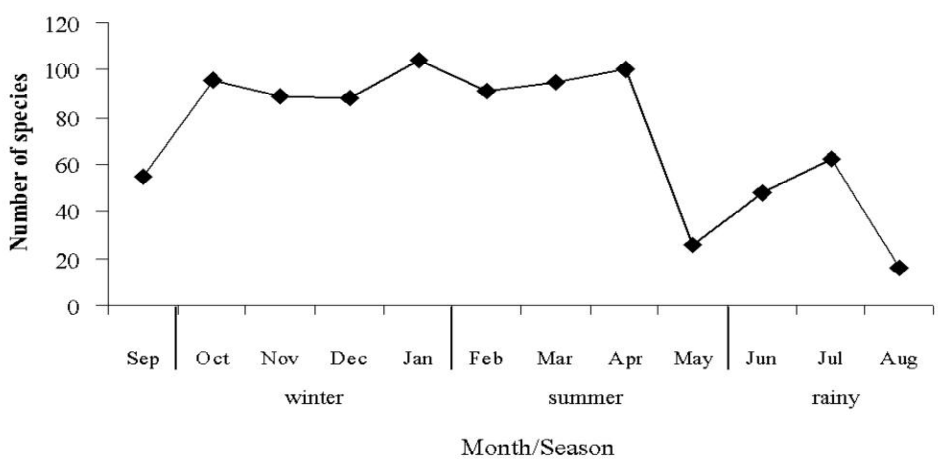


**Fig. 5. Total number of phytoplankton species recorded for each month in Tungabhadra river**

Srenivasan et al., [3] have observed that the peaks of phytoplankton occurred at different periods in different years. In our study populations of green algae and blue-green algae were abundant as compared to other groups of algae. The Cyanophyceae were dominant in summer as compared to other seasons. Overall the phytoplankton flora was greater in the summer season as compared

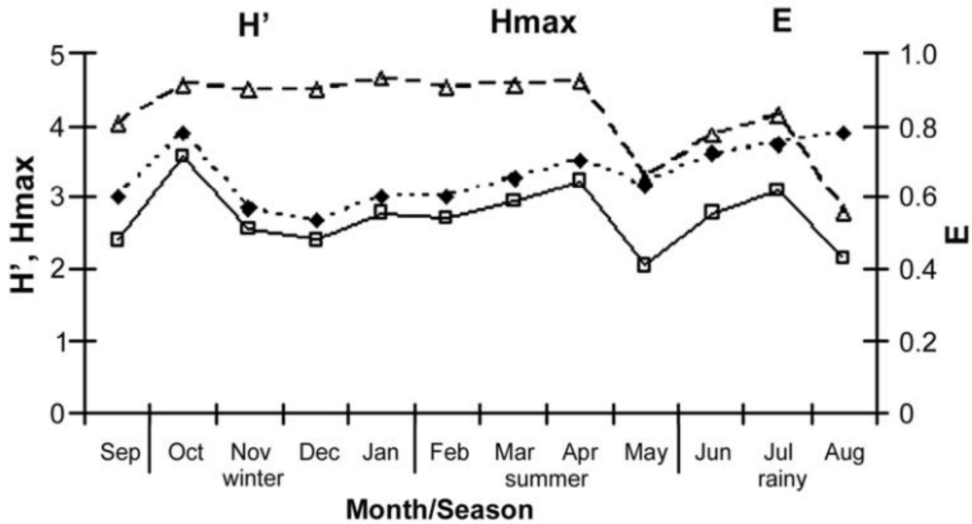


**Fig. 6. The Shannon-Weaver index (*H*'), Evenness index (*E*) and maximum diversity (Hmax) of phytoplankton communities in Tungabhadra river**

to the other seasons and this agreed with the observations of Sing [23], Nazeen [24] and Nandan and Patel [25].

Margalef [26] suggested that phytoplankton populations in the fertile waters are more diverse than those in infertile waters. Their study revealed a dominance of cyanophytes followed by chlorophytes, bacillariophytes and euglenophytes. A similar finding was reported by Padhi [27] in a polluted pond. Low phytoplankton densities recorded during the rainy season may be due to dilution by the rain waters coupled with other unfavourable environmental conditions.

The total percentage of Cyanophyceae (37.48%) Chlorophyceae (35.47%) from the Table 2 was observed greater as compared to 4 groups of algae Fig. 3 similarly total population of green algae was greater at all 3 stations as compared to those of other groups. Euglenoids were more or less uniform in population. Its percentage was much less as compared to the other groups. Thus it may be concluded that the density of phytoplankton is dependent on different abiotic factors either directly are indirect.

Across northern Thailand many research worked on phytoplankton diversity showed variation 222 species in Mae Kuang Udomtara [28], 68 species in Mae Ngat Somboonchol reservoir [29], 75 and 89 species were reported for Mae Kham and Mae Moh reservoirs around Mae Moh Power Plant, respectively [30] and 57 species in the Hui Lan reservoir [31].

Differences in phytoplankton diversity in an aquatic ecosystem are depending on the physicochemical water quality in each location [32]. In the present study, the species diversity was highest in the winter perhaps due to the clear water in this season which allows high light penetrance and thus photosynthesis for phytoplankton growth in all divisions [33].

In Tungabhadra River the Shannon-Weaver and Evenness index values of phytoplankton showed little variation among seasons, suggesting that overall phytoplankton species richness and diversity were quite stable all year round. The maximum values of both Shannon-Weaver diversity and Evenness indices were observed in October 2018, the same sequence was accepted and suggesting the strongest ecological health status of the lake for the year [16]. Shannon-Weaver index values of phytoplankton communities can be used to indicate water pollution status. Values of less than 1 are interpreted as heavily polluted, 1-3 as moderately polluted and more than 3 as clean water [34].

The present study reveals that the Shannon-Weaver index varied from 2.05 to 3.57, suggesting that the water quality should be classified as moderately polluted to clean. Tungabhadra River is flowing near the city and supplying water to the Davangere city and Harihar town province. During 2018 to 2019, water quality in Tungabhadra River highly fluctuated in different seasons, probably due to human activities like sand mining, discharge of industrial treated effluent and sewage from the cities conditions. These conditions significantly affected water quality parameters including especially the species diversity, food chain and levels of suspended solids of the river [35,36] and, therefore, likely accounts for a major part of the fluctuating phytoplankton composition observed in the River.

## 5. CONCLUSION

The authors would like to conclude that the phytoplankton communities in selected stations of the Tungabhadra River showed seasonal variation with high species number and density in winter and summer. In the rainy season, the observed number of species and density values dropped. The species diversity and Evenness indices showed only a slight variation from month to month. The pattern of seasonal succession of phytoplankton in this river was Cyanophceae dominated the winter and summer and replaced by Chlorophyceae in the rainy season and is likely to be related to the water qualities and especially species diversity. It is recommended that apart from the continuous collection of effluents for monitoring purposes, treatment process, automated measuring and monitoring equipment be installed to check discharge parameters against stipulated standards for drinking water, aquatic life and other uses. The diversity and distribution patterns of certain species were related to water quality as evident from the present study.

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## COMPETING INTERESTS

Author has declared that no competing interests exist.

## REFERENCES

1. Thurman HV. Introductory Oceanography, 8th edition Prentice Hall; 1997.
2. Patil SK. Inaugural address. Proc. Symp. Alogology. ICAR, New Delhi, India. 1960;1–3.
3. Sreenivasan A. Hydrobiological study of tropical impoundment, phavanisagar reservoir, Madras State, Indian for the year 1956 – 61, Hydrobiologia. 1964;24(4):514–539.
4. Munwar M. Limnological studies on fresh water ponds of Hydrabad. India. Hydroniol. 1974;44:13–27.
5. Nygaard G. Tavlerne tra Dansk, Plantoplankton, Gkylendendal; 1976.
6. Sarkar R, Krishnamurthy KP, Chaudhary PR, Rao AVJ. Ecological responses of freshwater periphyton community for water quality evaluation. JAWPC Tech. Annual. 1986;13: 110.
7. Hegdae GR. Comparative phytoplankton ecology of certain temple tanks of Dharwad. Adv. Appl. Phycol. 1989;2:145.
8. Sharma R, Sharma KC. Diatoms of Anasagar lake of Ajmer Rajasthan. Acta Ecol. Primary production in three upland lakes of Madras State. Curr. Sci. 1992;32:130.
9. Somashekar RK. Ecological studies on the two major rivers of Karnataka. In: Ecology and pollution of Indian rivers (Ed. Trivedy RK). Ashish Pub. House, New Delhi. 1988;39–53.
10. Mishra SR, Saksena DN. Phytoplanktonic composition of sewage polluted Morar (Kalpi) river in Gwalior, Madhya Pradesh, Environ, Ecol. 1993;11:625–629.
11. Trivedy RK, Khatavkar SD. Phytoplankton ecology of the river Krishna in Maharastra with reference to bio-indicators of pollution. In: Assessment of water pollution (Ed. Mishra SR). APH Pub. Corp., New Delhi. 1996;299–328.
12. Pearsall WH. Phytoplankton in the English lakes. Part I. The proportion in the water of some dissolved substances of biological importance. J. Ecol. 1930;18:306–320.
13. Pearsall WH. Phytoplankton in the English lakes. Part II. The composition of phytoplankton in relation to dissolved substances. J. Ecol. 1930;30:241–262.
14. Bilgrani KG, Datta Munshi JS. Ecology of river Ganges. Impact of human activities and conservation of aquatic biota (Patna to Farkka). Allied press, Bhagalpur, India; 1985.
15. Archibald REM. Diversity in some South African diatom associations and its relation to water quality. Water Research. 1972;6:1229-1238.
16. Washington HG. Diversity, biotic and similarity indices. Wat. Res. 1984;18:653-694.
17. Benson-Evan K, Williams PF, Griffiths HM, Antonie SE, Esho RT. Methods of processing biological data and expressing results. Aquatic Ecology and Pollution Bulletin. 1985; 5:6-33.

18. Traichaiyaporn S. Water quality analysis. Department of Biology, Faculty of Science, Chiang Mai University; 2000.
19. Philipose MT. Fresh water phytoplankton of inland fisheries, proc. Symp. Algology. ICAR, New delhi, India. 1960;279–291.
20. Anjana S, Gujarathi, Kanhera RR. Seasonal dynamics of phytoplankton population in relation to abiotic factors of freshwater pond at Barwani (MP). Poll. Res. 1980;17:133–136.
21. Kumar S, Dutta SPS. Studies on phytoplanktonic population dynamic in Kunjwani pond, Jammu. Hydrobiol. 1991;7: 55–59.
22. Saha LC, Choudhary RC. Phytoplankton in relation to abiotic factors of a pond, Bhaglpur. Comp. Physiol. Ecol. 1985;10: 91–100.
23. Singh VP. Phytoplankton ecology of inland waters of Uttar Pradesh, Proc. Symp. Algol. ICAR. 1960;243–271.
24. Nazneen S. Influence of hydrobiological factors of seasonal abundance of phytoplankton in Kinjhaor lake. Pakistan. Int. Revu Ges. Hysdrobiol. 1980;65(2):269–280.
25. Nandan SN, Patel RJ. Ecological studies on algal flora of Vishwmitri river, Baroda, Gujarath, Indian J. Plant Nature. 1984;1: 17– 32.
26. Margalef R. Perspective in Ecology Theory, Univ. of Chicago press, Chicago; 1968.
27. Padhi SB. Algal environment of polluted and unpolluted fresh water ponds. In: Kargupta, A. N. and Siddique, E. N. eds. Algal ecology: an overview. Pub. International book distributors, Dehradun, India. 1995;131–147.
28. Peerapornpisal Y, Sonthichai W, Somdee T, Mulsin P, Rott E. Water quality and phytoplankton in the Mae Kuang Udomtara reservoir, Chiang Mai, Thailand. Journal Science Chieng Mai University. 1999;26: 25-43.
29. Tularak P, Traichaiyaporn S, Rojanapibul A. Seasonal succession of phytoplankton in the Mae Ngat Somboonchol dam reservoir, Chiang Mai, Thailand. 7th International Phycological Congress, Thessaloniki, Greece; 2001.
30. Pinkate C, Traichaiyaporn S. Impact of caged fish culture on water quality and diversity of phytoplankton in reservoir of Mae Moh power plant (II). 30th Congress on Science and Technology of Thailand, Impact Exhibition and Convention Center, Muang Thong Thani, Bangkok; 2004.
31. Chompusri W, Peerapornpisal Y. Water quality in Hui Lan reservoir, Sankampang district Chiang Mai province in the year 2002. The second National Conference on Algae and Plankton, Holiday Garden Hotel, Chiang Mai; 2005.
32. Millman M, Cherrier C, Ramstack J. The seasonal succession of the phytoplankton community in Ada Hayden lake, North Basin, Ames, Iowa. Limnology Laboratory, Iowa State University, Ames, Iowa; 2005.
33. Guenther M, Bozelli R. Effects of inorganic tubidity on the phytoplankton of an Amazonian Lake impacted by bauxite tailings; 2004.
34. Whitton BA. River ecology. Blackwell scientific publications, London; 1975.
35. Olding DD, Hellebust JA, Douglas MSV. Phytoplankton community composition in relation to water quality and water-body morphometry in urban lakes, reservoirs, and ponds. Canadian Journal of Fishery and Aquatic Science. J. Can. Sci. Halieut. Aquat. 2000;57:2163-2174.
36. Vaulot D. Phytoplankton. Centre Nationale de la Recherche Scientifique et Université Pierre et Marie Curie, Roscoff, France; 2001.