ISSN: 2994-872X

Review Article

International Journal of Botany and Horticulture Research

Seasonal Dynamics of Benthic Algal Diversity and Physicochemical Characteristics in Lotic and Lentic Freshwater Ecosystems of Rampur District, India

Vidushi Verma[1*], Dr. Ajima Begum[2], Dr. Archana Tiwari[3] and Aadil Hussain[1]

[1]*Undergraduate Student, Department of Botany, Kirori Mal College, University of Delhi, India*

[2]*Assistant Professor, Department of Botany, Kirori Mal College, University of Delhi, India*

[3]*Diatom Research Laboratory, Amity Institute of Biotechnology, Amity University, Noida, Uttar Pradesh, India.*

[*]Corresponding Author
Vidushi Verma, Undergraduate Student, Department of Botany, Kirori Mal College, University of Delhi, India.

Submitted: 2026, Jun 08; **Accepted:** 2026, Jul 13; **Published:** 2026, Jul 21

Citation: Verma, V., Begum, A., Tiwari, A., Hussain, A. (2026). Seasonal Dynamics of Benthic Algal Diversity and Physicochemical Characteristics in Lotic and Lentic Freshwater Ecosystems of Rampur District, India. *Int J Bot Hor Res, 4*(1), 01-06.

Abstract

The present study investigated seasonal variation in benthic algal diversity and physicochemical characteristics, a total of three seasonal sampling periods and two freshwater habitats were analyzed to evaluate ecological differences of lotic (river) and lentic (pond) freshwater ecosystems in Rampur District, Uttar Pradesh, India. The site station 1 is Kosi River, a Ramganga tributary that streches about 35 km through district and site station 2 is water chestnut pond opposite to CRPF campus NH24. Seasonal sampling was conducted during post-monsoon, winter, and pre-monsoon periods, October 2025 to March 2026. Algal samples were collected by scrapping 3x3 cm area of submerged substratum (stone) at the location site to the depth of 48.5 cm. Physicochemical parameters including pH, conductivity, total dissolved solids (TDS), chemical oxygen demand (COD), ammoniacal nitrogen, orthophosphate, and silicate were analyzed using standard methods. Algal diversity was assessed using Shannon and Simpson diversity indices along with Pearson correlation analysis. Navicula spp. Dominated the river ecosystem whereas Spirogyra, Zygnema, and Spirulina were comparatively abundant in the pond ecosystem.

The results showed noticeable seasonal variation in water quality and algal diversity between river and pond ecosystems. Conductivity showed a strong positive correlation with TDS (r = 0.996), while Shannon diversity exhibited negative correlation with conductivity and TDS. The pond ecosystem consistently exhibited higher Shannon and Simpson diversity indices than the river ecosystem across all seasons. The findings indicate that physicochemical characteristics strongly influence benthic algal diversity and provide baseline ecological information for freshwater ecosystem monitoring in Rampur District.

Keywords: Benthic Algae, Freshwater Ecosystems, Seasonal Variation, Physicochemical Parameters, Diversity Indices

1. Introduction

One of the more important photosynthetic microorganisms in freshwater systems is benthic algae, algae that grow on a submerged substrate, such as rocks or sediment. Benthic algae play a vital role in primary productivity, nutrient cycling, energy flow in the aquatic food web, and ecosystem functioning and have been considered a good bioindicator of freshwater quality and ecosystem status, due to their rapid response to environmental alteration [1].

The differences in algal diversity in river and pond is likely because of the much greater water flow and hydrological disturbances in lotic versus lentic environments. This means that the composition and structure of freshwater habitats is strongly affected by seasonal changes in light, rainfall, water flow and nutrient levels. Therefore, benthic algae requirements also include other physicochemical parameters such as temperature, pH, conductivity, dissolved oxygen, total dissolved solids and nutrients [2].

Numerous research works have been carried out on freshwater algal diversities and water quality studies in different parts of our country. Benthic algae have widely been used as ecological indicators because they respond rapidly to nutrient enrichment, organic pollution and hydrological alterations in freshwater ecosystems [3]. Seasonal changes in nutrient concentration and water flow significantly influence algal composition and community structure [4].

Information on seasonal fluctuation on benthic algae at Rampur District, Uttar Pradesh were very rare. Therefore, in present work, seasonal distribution of benthic algae and physicochemical variables were studied at river and pond environments and analyzed their correlation between physicochemical environment and algal diversity indices.

2. Materials and Methodology

The present study was undertaken in some lotic and lentic fresh water systems of Rampur District of Uttar Pradesh, India. Kosi river (28.786° N latitude and 79.045° E longitude) represented the lotic system whereas water chestnut pond located opposite to CRPF campus Rampur NH24, was used as the lentic system.

Seasonal sampling was carried out during post-monsoon (October 2025), winter (January 2026) and pre-monsoon (March 2026). Water samples and benthic algae were collected in triplicates at each location. Benthic algal samples were collected by gentle scrapping 3x3 cm area of submerged stones and sediment surfaces to a depth of 48.5 cm and preserved in lugol's reagent.

The following physicochemical parameters: pH, conductivity, total dissolved solids (TDS), salinity, oxidation reduction potential (ORP), chemical oxygen demand (COD), alkalinity, ammoniacal nitrogen, orthophosphate, silicate, free CO_2, total CO_2 and calcium hardness were studied according to standard methods of APHA (2017) [5].

Identification of benthic algae was done up to genus level by using a light microscope with the help of standard taxonomic keys. Photomicrographs were captured using a light microscope under 40x magnification. Algal diversity was determined using Shannon & Wiener diversity index [6]. Species dominan and diversity were assessed using Simpson's diversity index [7]. The relationships between physicochemical factors and diversity indices were assessed by calculating Pearson correlation. Statistical analyses were performed using Microsoft Excel 2019.

Figure 1 : Geographic location images of Site Station 1 and Site Station 2, Site Station 1 : Kosi River , Lotic Ecosystem, Site Station 2 : Water Chestnut pond, Lentic Ecosystem

3. Results

3.1. Physicochemical Characteristics

Seasonal variation in physicochemical parameters was observed in both freshwater ecosystems (Table 1). The river ecosystem showed comparatively higher conductivity and TDS values, whereas the pond ecosystem exhibited higher COD and nutrient concentrations.

Parameters	River Sample(Mean±SD)	Pond Sample(Mean±SD)
pH	8.69±0.42	8.43±0.32
Atmospheric temperature(^{0}C)	24.33±5.33	24.33±5.53
Water Surface Temperature (^{0}C)	22.33±6.11	22.33±6.11
Conductivity(µS/cm)	707.67±73.60	577.76±56.20
Total Dissolved Solids(ppm)	351.11±40.50	282.67±32.60
Salinity(ppm)	283.33±28.90	250.00±50.00
ORP(mV)	162.67±18.20	155.00±20.90
COD(mg/L)	4.98±2.28	9.71±7.36
Methyl Orange Alkalinity (mg/L)	3.57±2.91	4.18±2.31
Total Alkalinity(mg/L)	3.98±2.83	4.20±2.53
Bicarbonate Alkalinity(mg/L)	3.57±2.91	4.18±2.31
Ammoniacal Nitrogen (mg/L)	0.67±0.76	1.09±1.09
Free CO_2 (mg/L)	15.32±19.14	10.71±8.43
Total CO_2 (mg/L)	20.11±21.18	15.79±10.79
Calcium Hardness (mg/L)	34.45±32.62	44.77±38.03
Orthophosphate (mg/L)	0.66±0.63	0.75±0.66
Silicate (µg/L)	0.074±0.016	0.065±0.038

Table 1: Seasonal variation in physicochemical parameters of river and pond ecosystems (Mean ± SD, n = 3).

Seasonal fluctuations in conductivity, TDS and nutrient concentration indicated differences in hydrological conditions and nutrient retention capacity between lotic and lentic ecosystems.

Conductivity showed a strong positive correlation with TDS (r = 0.996). Shannon diversity index exhibited significant negative correlation with conductivity (r = −0.758) and TDS (r = −0.751). The negative relationship between conductivity and Shannon diversity suggested that elevated dissolved ionic content may reduce algal diversity.

3.2. Benthic Algal Composition

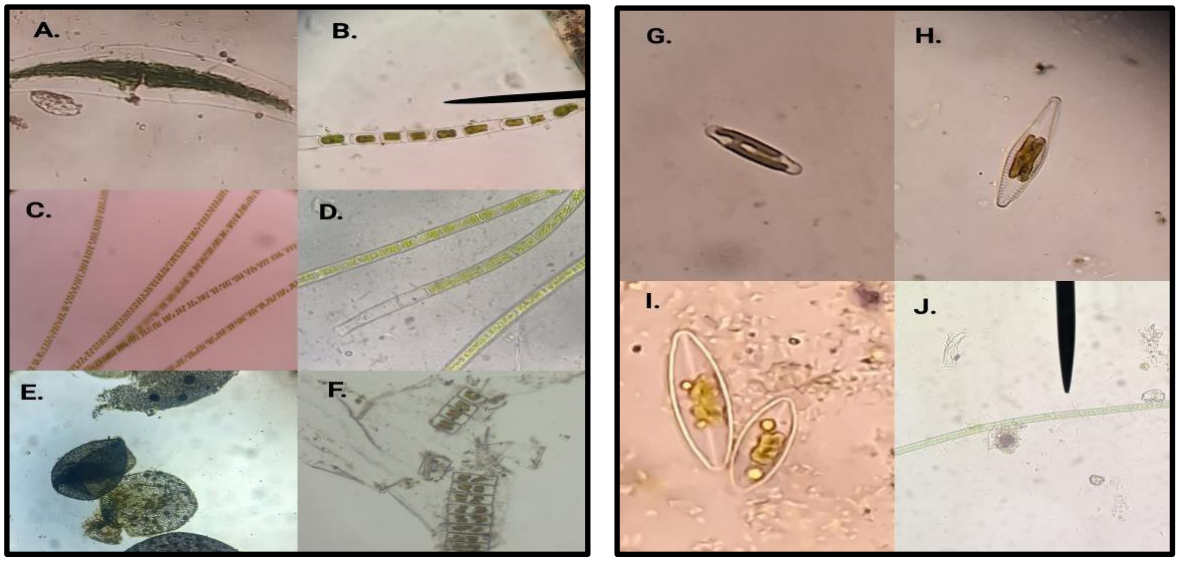

Figure 2: Representative benthic algal genera identified in Lentic and Lotic freshwater ecosystem under light microscopy (40x magnification). A to F represent the lentic genera. (A) *Closterium sp*., (B) *Oedogonium sp*., (C) *Spirogyra sp*., (D) *Spirulina sp*., (E) *Volvox sp*., (F) *Zygnema sp*., and lotic genera are (G to I) *Navicula spp*. and (J) *Phormidium spp*.

3.3. Seasonal Abundance of Algae

Genus	Lotic Post-monsoon	Lotic Winter	Lotic Pre-monsoon	Lentic Post-monsoon	Lentic Winter	Lentic Pre-monsoon
Navicula sp.	21.4±2.3	18.2±2.0	20.6±2.2	17.5±2.0	15.8±1.9	16.9±2.1
Spirulina sp.	9.2±1.4	7.5±1.2	8.4±1.3	15.6±2.2	13.4±1.8	14.8±2.0
Phormidium sp.	8.6±1.5	7.2±1.1	7.9±1.2	13.2±1.8	11.6±1.6	12.5±1.7
Volvox sp.	5.1±0.9	4.2±0.8	4.8±0.9	11.2±1.6	10.3±1.5	10.8±1.5
Spirogyra sp.	6.4±1.2	5.8±1.1	6.2±1.2	13.6±1.9	12.7±1.7	13.0±1.8
Zygnema sp.	5.9±1.0	5.4±1.0	5.7±1.1	14.8±2.1	13.2±1.9	14.1±2.0
Oedogonium sp.	4.8±0.9	4.3±0.8	4.6±0.9	10.4±1.5	9.6±1.3	10.1±1.4
Closterium sp.	3.9±0.7	3.4±0.6	3.7±0.7	9.5±1.4	8.7±1.2	9.1±1.3
Navicula spp. showed dominance in the river ecosystem, whereas filamentous green algae such as Spirogyra and *Zygnema* were comparatively abundant in the pond ecosystem.						

Table 2 : Seasonal Microscopic Abundance of Benthic Algae in Lotic and Lentic Freshwater Ecosystems (Mean cells/FOV, n = 10)

3.4 Diversity Indices

Ecosystem	Season	Shannon Index	Simpson Index
River	Post	1.88	0.82
River	Winter	1.84	0.81
River	Pre	1.86	0.82
Pond	Post	2.03	0.87
Pond	Winter	2.00	0.86
Pond	Pre	2.02	0.87

Table 3 : Diversity Indices across three seasons.

Diversity indices were consistently higher in the pond ecosystem across all seasons. Higher diversity in the pond ecosystem may be associated with greater nutrient retention and relatively stable hydrological conditions.

3.5 Pearson Correlation Analysis

Pearson correlation analysis revealed significant ecological relationships among environmental variables and diversity indices.

Variables	Correlation Coefficient (r)
Conductivity vs TDS	0.996
TDS vs COD	-0.624
COD vs Shannon	0.557
Conductivity vs Shannon	-0.758

Table 4: Pearson Correlation

Strong positive correlation between conductivity and TDS indicated a close relationship between ionic concentration and dissolved solids. Shannon diversity index exhibited strong negative association with conductivity and TDS. These findings suggest that increasing dissolved ionic concentration may negatively influence benthic algal diversity

4. Discussion

4.1. Seasonal variation in physicochemical characteristics

Noticeable seasonal variation was observed in the physicochemical characteristics between lotic (Kosi river) and lentic (water-chestnut pond) ecosystems during the present study. Conductivity and Total dissolved solids (TDS) values were higher in river habitat while higher concentration of COD, ammoniacal nitrogen, orthophosphate, calcium hardness values were found in pond ecosystem. This might be attributed to differences in hydrological

regime of these habitats where flowing water in river transports dissolved ions constantly. This would allow accumulation and nutrient retention in the stagnant pond ecosystem. This type of seasonal variation was previously found in various freshwater habitats in which change in the environmental conditions like hydrology, nutrient load, other physical parameters are responsible in quality characteristic of water [2].

Alkaline nature of the water in both habitats (pH values) is a good condition for the growth of freshwater algal communities. Change in seasonality might be the factor for the fluctuation of biological productivity, nutrient cycle by change in temperature , alkalinity, nutrient and carbon di oxide concentration of water bodies. Similar change in physicochemical character of Kosi River were found and stated that season has direct effect on the physicochemical character of freshwater habitat [8].

4.2. Seasonality in benthic algal communities

Distinction in benthic algal composition was found between the river and pond ecosystems. In river ecosystem Navicula spp was consistently abundant while in pond *Spirogyra, Zygnema*, *Spirulina* and other green algal taxa were comparatively abundant during the study period. This pattern in the river habitat might be due to adaptation of *Navicula* species for flowing water. *Navicula* species might also contribute for colonisation of submerged substrates under unstable flowing conditions. Increase in the concentration of filamentous green algal species in pond habitat might be attributed to better nutrients level in lentic system and reduced water turbulence as compared to river habitat.

Seasonality in algal abundance was found in both habitats and the numbers of algae was comparatively lesser during winter and much higher during post monsoon and pre-monsoon season of the year. This pattern is typically reported for fresh water ecosystems and attributed to variation in physical parameters like temperature, nutrient availability, light availability and hydrological conditions of the habitat [4]. This may suggest that environmental variability played a key role in controlling benthic algal composition of both lotic and lentic habitat.

4.3. Relationship between physicochemical parameters and algal diversity

The correlation analysis revealed a positive correlation between conductivity and TDS, indicating that increase in the value of the former increase in the same way as the value of TDS and that is due to dissolved ionic substance. As opposite to this Shannon diversity was negatively correlated to both conductivity and TDS and shows that the value of both parameters limits the development of the diverse community of benthic algae. Same respond of the benthic algae community composition was seen in different fresh water habitats where the response of the algal communities to environmental fluctuation is relatively faster and higher for disturbed habitats [3].

The diversity indices (Shannon and Simpson) were generally higher in lentic system as compared to lotic system, this might be due to the relatively steady environment conditions and better capacity of nutrients retain by lentic systems and hence develop more algal diversity. The presence of more algal diversity in lentic system might be attributed to longer residence time of nutrients in the lotic system. The finding of the present study showed that seasonality greatly affects physicochemical variables, which is directly or indirectly responsible in the algal diversity and structure of benthic algal communities of fresh water habitats of Rampur District

5. Conclusion

The present investigation demonstrated that seasonal variation in physicochemical characteristics significantly influences benthic algal diversity in freshwater ecosystems.

Strong positive correlation between conductivity, TDS indicated close association between dissolved ionic concentration and total dissolved solids whereas diversity indices exhibited a negative relationship with elevated dissolved solids. Moderate positive association between COD and Shannon diversity suggested possible nutrient enrichment effects on algal assemblages.

The pond ecosystem exhibited comparatively higher algal diversity than the river ecosystem. The findings emphasize the importance of monitoring physicochemical parameters and algal diversity for ecological assessment and freshwater ecosystem management.

Acknowledgments

The authors are grateful to the Department of Botany, Kirori Mal College, University of Delhi, for providing laboratory facilities and academic support for carrying out this study. The authors also thank the local authorities and residents of Rampur District, Uttar Pradesh, for facilitating field sampling activities. Special appreciation is extended to all individuals who assisted during sample collection, laboratory analysis, and data compilation.

Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Authors Contribution

- **Vidushi Verma:** Conceptualization, field sampling, laboratory analysis, data collection, statistical analysis, interpretation of results, and manuscript writing.
- **Dr. Ajima Begum:** Study supervision, methodology development, data interpretation, manuscript review, and editing.
- **Aadil Hussain:** Laboratory work, data validation, and manuscript review. All authors read and approved the final manuscript.

References

1. John, B., & Kumar, R. S. (2021). Species composition, substrate specificity, and seasonal abundance of periphytic algae in a tropical riverine system-Periyar, India. *Aquatic*

Research, 4(2), 129-144.
2. Rath, A. R., Mitbavkar, S., & Anil, A. C. (2021). Response of the phytoplankton community to seasonal and spatial environmental conditions in the Haldia port ecosystem located in the tropical Hooghly River estuary. *Environmental monitoring and assessment, 193*(9), 548.
3. Stancheva, R., & Sheath, R. G. (2016). Benthic soft-bodied algae as bioindicators of stream water quality. *Knowledge and Management of Aquatic Ecosystems, 417*, 15.
4. Gaikwad KU, Gaikwad KN. (2023) Effect of seasonal variation on the diversity of algae in Kadwa dam in Igatpuri Tehsil of Nashik district of Maharashtra. Res. *Jr. Agril. Sci. 14*(2), 505-508.
5. APHA. (2017). Standard Methods for the Examination of Water and Wastewater (23rd ed.).
6. Weaver, W., & Shannon, C. E. (1949). The mathematical theory of communication. University of Illinois. *Urbana, 13*, 1-138.
7. Simpson, E. H. (1949). Measurement of diversity. *nature, 163*(4148), 688-688.
8. Yadav, S. S., & Kumar, R. (2011). Monitoring water quality of Kosi river in Rampur district, Uttar Pradesh, India. *Advances in Applied Science Research, 2*(2), 197-201.