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Assessment of Temporal Distribution of Phytoplankton in Anicut Dam of Kangsabati River, Paschim Medinipur, West Bengal, India

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ABSTRACT

The current study examines how the anicut dam ecosystem's algae diversity varies seasonally. Standard limnological and taxonomic techniques were used to study samples that were taken throughout the pre-monsoon, monsoon, and post-monsoon seasons. Due to nutrient enrichment and sluggish water conditions, Zygnematophyceae exhibited the highest abundance, especially during the pre-monsoon period. Following the monsoon, a decrease in dominance and an increase in species evenness were noted, demonstrating the function of hydrological flushing in controlling algal communities.The greatest diversity of phytoplankton was observed in the post-monsoon season, while the least was noted in the pre-monsoon period. Seasonal differences were determined to be statistically significant ($p<0.05$) based on ANOVA analysis. Canonical Correspondence analysis (CCA) was used to analyze the temporal distribution of phytoplankton concerning environmental factors.

Keywords Seasonal change, Phytoplankton, Diversity Index, Canonical correspondence analysis (CCA).

INTRODUCTION

Dams control river flow and significantly change natural hydrologic regimes, affecting aquatic ecosystems and downstream connections, which in turn impacts aquatic life variety and availability (Grill *et al*. 2019). A lotic (flowing water) environment is frequently replaced by a lentic (standing water) system in upstream systems due to stagnant circumstances caused by reduced downstream discharge. Light penetration, thermal stratification, nutrient cycling, and general ecological functioning are all disrupted by this shift (Maavara *et al.* 2020). Seasonal changes in water level, residence duration, and thermal stratification all affect the physico-chemical and biological properties of dammed reservoirs (Shi *et al.* 2022). Plankton and other biological communities are shaped by unstable environmental conditions created by altered hydrodynamics (Stockwell *et al.* 2020). Fish, zooplankton, and higher trophic levels can all be impacted by changes in phytoplankton composition that ripple through the food chain (Ullah *et al.* 2018). The distribution and biomass of phytoplankton in reservoirs are significantly impacted by variations in important physico-chemical parameters, such as temperature, pH, dissolved oxygen, total phosphorus, and nitrates (Kumar *et al.* 2020). Phytoplankton productivity and succession are- also significantly influenced by

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hydrological parameters, including water residence duration, discharge rate, and water level variations (Li *et al.* 2023). Phytoplankton are frequently employed as bioindicators of trophic status, eutrophication, and water quality because of their sensitivity to environmental changes (Chandel *et al.* 2024). Anicut Dam, a vital freshwater resource for local wildlife and human livelihood, is situated on the Kangsabati River in Paschim Medinipur, West Bengal. However, its ecological equilibrium has changed because to anthropogenic disturbances, seasonal water changes, and increased agricultural runoff (Bera *et al.* 2021). The dynamics of phytoplankton in this reservoir system have not received much attention, despite its ecological importance. Thus, the current study assesses the phytoplankton's seasonal distribution and functional diversity in Anicut Dam during the pre-monsoon, monsoon and post-monsoon seasons. The relationship between environmental factors and phytoplankton assemblages will be clarified using multivariate analysis employing Canonical Correspondence Analysis (CCA), showcasing its value in ecological evaluation and biomonitoring (Li *et al.* 2019).

MATERIALS AND METHODS

Study area

The present investigation was done at the Anicut dam of Kangsabati River in Paschim Medinipur district to study the diversity of phytoplankton in three seasons, pre-monsoon (February, March, April, May), monsoon (June, July, August, September)

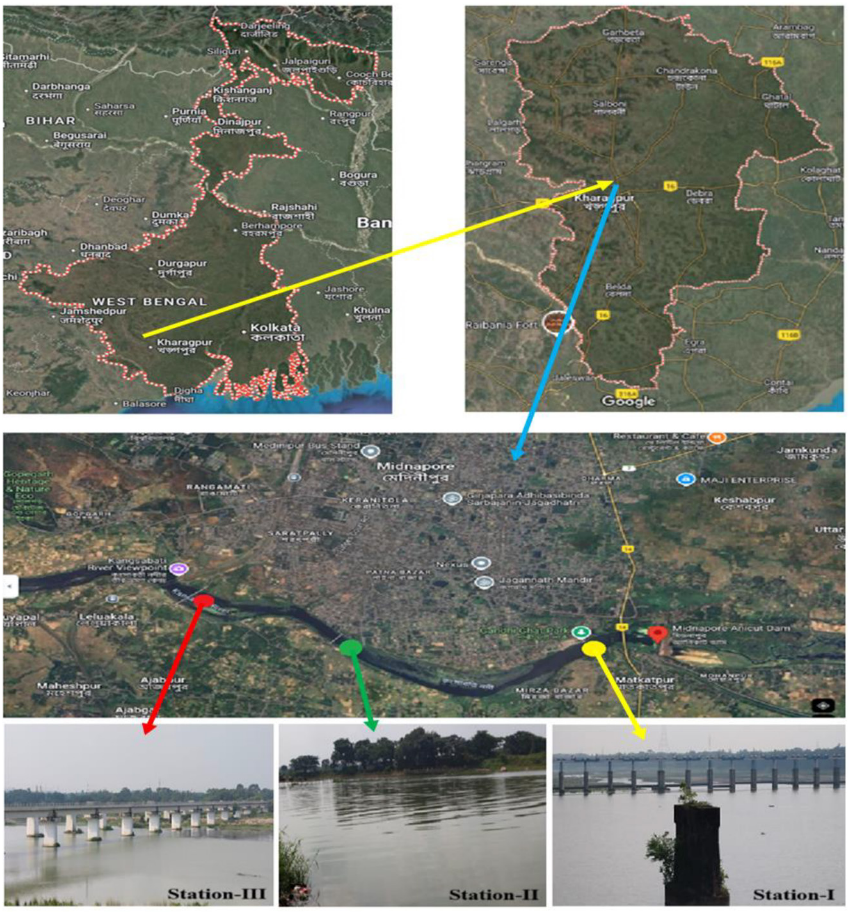

Fig. 1. Map showing three sampling stations near Anicut dam of Kangsabati River. Made with Google Map.

Table 1. Sampling zone of Anicut Dam of Kangsabati River, Paschim Medinipur.

Sl. No.	Name of the sampling station	Latitude and longitude of the sampling station	
1	Sampling station I	22.40215091°N	87.34036955°E
2	Sampling station II	22.40141989°N	87.31252333°E
3	Sampling station III	22.40986559°N	87.2961699°E

and post-monsoon (October, November, December, January).Three stations were selected (Fig. 1), the distance between stations SI (Amtala near dam) and SII (najarganj) (3000) meters and the distance between stations SII (Najarganj) and SIII (Istriganj) (2000) meters. The latitude and longitude of three sampling stations (Table 1).This dam is situated near the Midnapore town about 15 km away. It was constructed on the Kangsabati River by govt. of West Bengal on 15/01/2018 it was reconstructed& completed on 04.08.2018. This river water spread over about 300.23 km. The main purpose of this dam is to supply sufficient water to rural areas for corp. cultivation, six Block has been benefited including Kharagpur-I, Kharagpur-II, Narayangarh, Pingla, Debra, Panskura & also supply water to municipalities for industries.

Sampling

Water samples were gathered from February 2023 until January 2024. Sampling occurred from surface water in the morning (6:30 a.m.–7:30 a.m.) monthly at three locations. Over the course of four months, seasonal phytoplankton samples were taken from three sampling locations. In accordance with normal limnological protocols, 480 L of surface water were collected during each season (pooled from all sites and months). Water samples were concentrated by sedimentation after being filtered through a plankton net (mesh size according to usual procedure). The 480 L of original water sample was represented by the end amount of 12 ml, which was further lowered from the initial concentrate volume of 60 ml.

Preservation and processing of samples

To stop cell deterioration and preserve taxonomic integrity, the concentrated samples were stored right after following collection using Lugol's iodine solution (1%). Samples were carefully homogenized to provide a consistent distribution of organisms before microscopic examination (Prescott 1962).

Microscopic counting

Using a compound light microscope at 40X magnification and normal counting techniques, phytoplankton was quantitatively analyzed. A Sedgwick-Rafter counting cell was used to analyze subsamples. Only single filaments or cells were counted. To prevent overestimation, colonies and fragments were not included in the count (APHA 2012) Until a sufficient representation of the sample was obtained, counts were carried out across several microscopic areas. Standard taxonomic keys were used to identify phytoplankton up to the class level (Zygnematophyceae, Chlorophyceae, Bacillariophyceae, Cyanophyceae, Ulvophyceae and Klebsormidiophyceae).

Standardization of data and abundance expression:

The full 480 L of original water was thought to be represented by the complete number of people counted in the 12 ml concentrate. The standardized expression for phytoplankton abundance was:

People per milliliter (ind. ml^{-1}) of concentrate: Ind. mL^{-1} = Total individuals ÷ 12
People per liter (ind. L^{-1}) of initial water: Ind. L^{-1} = Total individuals ÷ 480

References to taxonomy:

Standard floras and monographs were used to identify phytoplankton and also with the help of Vidyasagar University Department of Botany.

Water samples were resolved in the laboratory for the physicochemical parameters like Ph, temperature (WT) (We have used a Centigrade Thermometer), TDS (We have used Konvioneer pen type Tds 0012 Digital TDS Meter), Hardness, Free CO_2, Phosphate, Nitrite, Alkalinity, Ammonia were calculated by Water Testing Kit (Transchem Agritech Pvt. Ltd.).

Statistical analysis

Phytoplankton community analyzed using four the degree of uniformity in the distribution of individuals among taxa in the study area is expressed using uni-

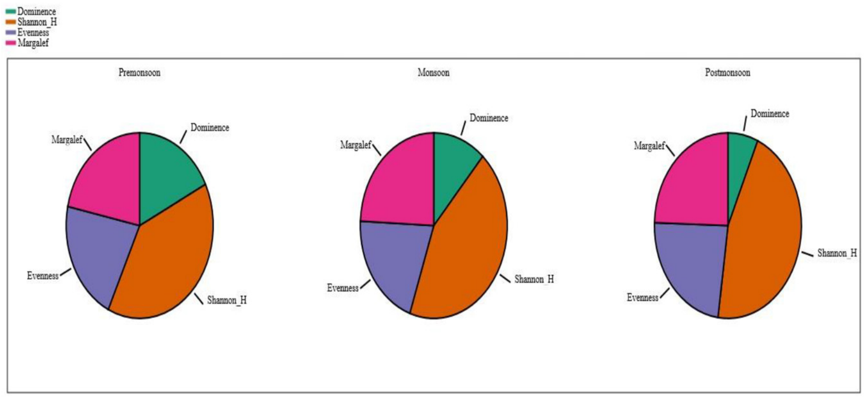

Fig. 2. Diversity index of phytoplankton in three seasons at anicut dam of kangsabati River.

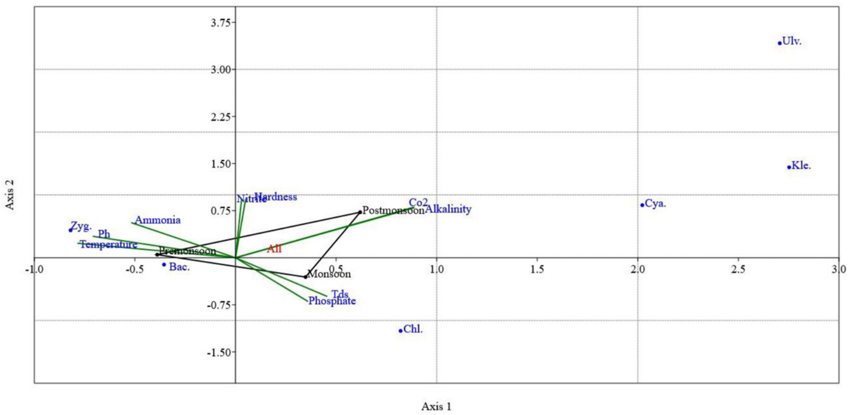

Fig. 3. Canonical correspondence analyses between environmental parameters and Genera of phytoplankton in anicut dam, Paschim Medinipur. Chl: *Chlorophyceae,* Bac: *Bacillariophyceae,* Zyg: *Zygnematophyceae,* Cya: *Cyanophyceae,* Ulv: *Ulvophyceae,* Kle: *Klebosormidiophyceae.*

variate indices (Shannon and Wiener diversity index, Pielou evenness index, Margalef species richness index and Dominance index) to establish a link between distribution of phytoplankton and water quality parameters using canonical correspondence analysis carried out using multivariate analysis PAST 4.17 package version (Paleontological Statistics) Software (Hammer *et al.* 2001) . Significance difference or not between seasons of phytoplankton genera community analyzed by SPSS Statistics 18 and water quality parameters analyzed univariate several sample test by PAST 4.17 (Paleontological Statistics).

RESULT

Phytoplankton acts as a primary producer & food source for Zooplankton and fishes and other aquatic organisms. (Fig. 2), display the importance of species variety, evenness, richness and dominance indices of phytoplankton in anicut dam, Kangsabati River, Paschim medinipur. In pre-monsoon, the Shannon-Weiner index, Pielou evenness index, Margalef richness index and Dominant index for phytoplankton were 0.99, 0.53, 0.54 and 0.44 respectively. In monsoon were 1.28, 0.60, 0.71 and 0.34 respectively. In post-monsoon were 1.58, 0.81, 0.85 and 0.23 respective values. The maximum diversity was found in the Post-monsoon and lowest found in Pre-monsoon and dominance highest in Pre-monsoon and lowest in post-monsoon. Canonical Correspondence Analysis (CCA) was executed to analyze the relationships between phytoplankton community composition

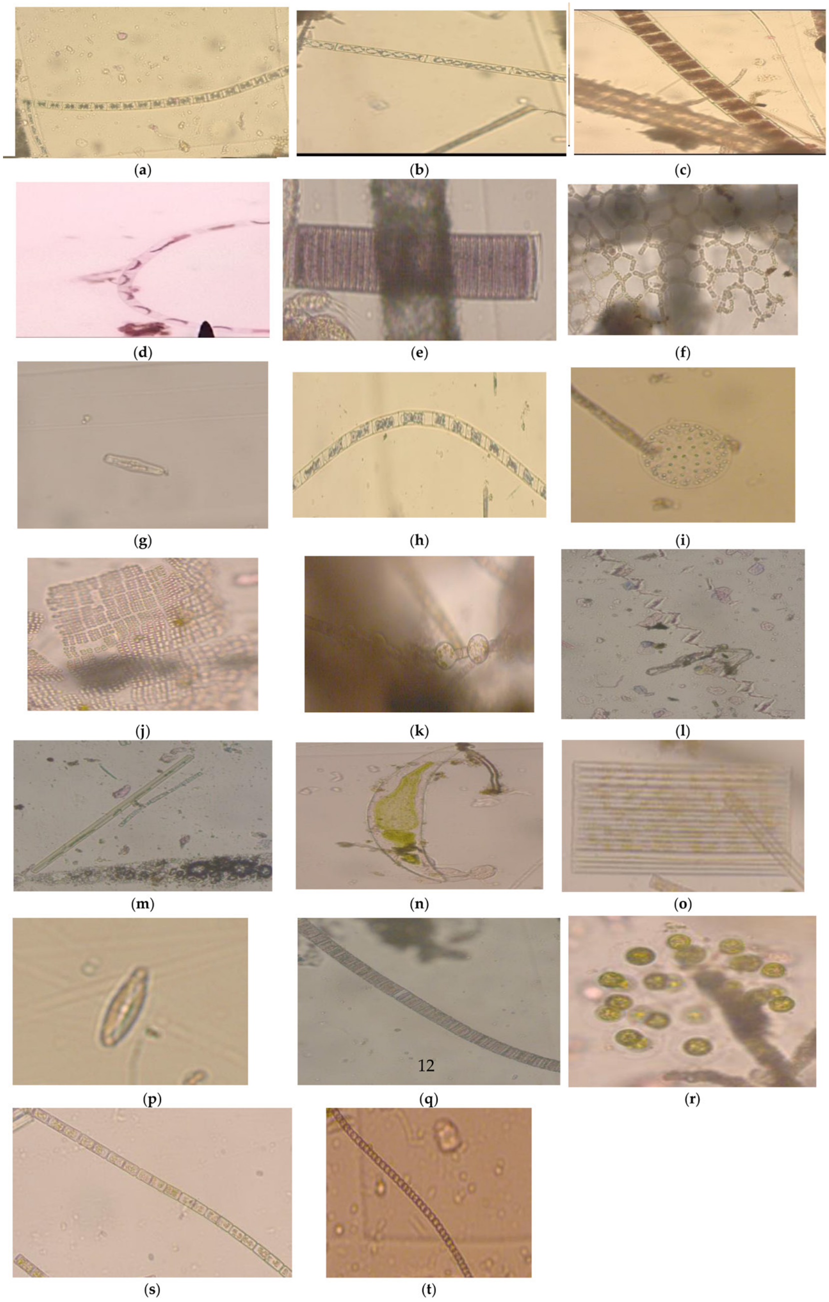

Fig. 4. a. *Mougeotia* sp. b. *Spirogyra* sp. c. *Ulothrix* sp. d. *Kelbosormidium* sp. e. *Lyngbya* sp. f. *Hydrodictyon* sp. g. *Pinnularia* sp. h. *Zygnema* sp. i. *Volvox* sp. j. *Meriamopedia* sp. k. *Oedogonium* sp. *l.Spirullina* sp. m. *Synedra* sp. n. *Closterium* sp.o. *Fragilari*a sp. p. *Diatom* sp. q. *Oscillatoria* sp. r. Eudorina sp. s. *Melosira* sp. t. *Anabaena* sp.

and environmental parameters (Fig. 3). The biplot shown demonstrates the distribution of phytoplanktonaceous taxa and the effects of the environmental variables measured. In this present survey, we found six group and 20 genera of phytoplankton (Fig. 4), that includes *Mougeotia* sp., *Spirogyra* sp., *Ulothrix*

Table 2. Number of Ind. L^{-1} (Original Water) in Anicut Dam of Kangsabati River, Paschim Medinipur from February 2023-January 2024.

Seasons	*Zygne*	*Chlor*	*Baci*	*Cyan*	*Ulvo*	*Kle*b	Total
Pre-monsoon	1.95	0.60	0.60	0.02	0.015	0	3.185
Monsoon	0.60	1.12	0.34	0.083	0.079	0.033	2.255
Post-monsoon	0.27	0.15	0.085	0.054	0.15	0.027	0.736
Total	2.82	1.87	1.03	0.16	0.24	0.06	

Chlor: chlorophyceae, Baci: Bacillariophyceae, Zygne: Zygnematophyceae, Cyan: Cyanophyceae, Ulvo: Ulvophyceae, Kleb: Klebosormidiophyceae.

Table 3. Number of Ind. mL^{-1} (Concentrate) in Anicut Dam of Kangsabati River, Paschim Medinipur from February 2023-January 2024.

Seasons	*Zygne*	*Chlor*	*Baci*	*Cyan*	*Ulvo*	*Kle*b	Total
Pre-monsoon	78.08	24.00	23.83	0.83	0.58	0.00	127.32
Monsoon	23.83	44.67	13.50	3.33	3.17	1.33	89.83
Post-monsoon	10.92	5.92	3.42	2.17	6.00	1.08	29.51
Total	112.83	74.59	40.75	6.33	9.75	2.41	

Chlor: chlorophyceae, Baci: Bacillariophyceae, Zygn: Zygnematophyceae, Cyan: Cyanophyceae, Ulvo: Ulvophyceae, Kleb: Klebosormidiophyceae.

sp., *Kelbsormidium* sp., *Lyngbya* sp. *Hydrodictyon* sp., *Pinnularia* sp., *Zygnema* sp., *Volvox* sp., *Merismopedia* sp., *Oedogonium* sp., *Spirullina* sp., *Syndra* sp., *Closterium* sp., *Fragilaria* sp., *Diatom* sp., *Oscillatoria* sp., *Eudorina* sp., Melosira sp., *Anabaena* sp.

The *Zygnematophyceae* is the dominant group followed by *Chlorophyceae* (Table 2 and Table 3).The highest population density of Phytoplankton found in Pre-monsoon seasons (Table 2 and Table 3). The highest number of individuals was found in the Pre-monsoon season 127.32 individuals /mL) and the lowest was found in Post-monsoon (29.51individuals /mL).The number of *Zygnematophyceae* (78.08 individuals /mL) group in Pre-monsoon, Monsoon was (23.83 individuals/mL) and Post-monsoon (10.92individuals/mL). The number of *Chlorophyceae* in Pre-monsoon was (24 individuals/mL), Monsoon was (44.67 individuals/mL) and Post-monsoon was (5.92 individulas/mL). The number of Bacillariophyceae in the Pre-monsoon was (23.83 individuals/mL), the Monsoon was (13.50 individuals/mL) and Post-monsoon (3.42 individuals/mL). The number of *Cyanophyceae* in the Pre-monsoon was (0.83in-

Table 4. Seasons wise mean value and standard error of physicochemical parameters from February 2023 to January 2024.

Parameters	Pre-monsoon	Monsoon	Post-monsoon
Ph	7.6 ± 0.08	7.4 ± 0.01	7.5 ± 0.04
Water temperature (°C)	30°C ± 0.11	25°C ± 0.18	27°C ± 0.06
Hardness (mg L^{-1})	83 ± 0.79	72 ± 0.01	88 ± 1.68
Alkalinity (mg L^{-1})	79 ± 2.03	83 ± 1.26	92 ± 2.09
Ammonia (mg L^{-1})	0.21 ± 0.01	0.19 ± 00	0.15 ± 00
Nitrite (mg L^{-1})	0.05 ± 0.003	0.026 ± 0.002	0.06 ± 0.007
Phosphate (mg L^{-1})	0.008 ± 0.001	0.06 ± 00	0.014 ± 0.005
TDS (ppm)	98.2 ± 0.64	112.8 ± 0.82	101.4 ± 1.46
Free CO^2 (mg L-1)	5.6 ± 0.32	9.3 ± 00	18 ± 0.34

Note: A one-way analysis of variance (ANOVA) indicated a highly significant difference between the group means ($F_{8,18}$ = 224.1, p = 2.03 × 10^{-16}). The effect size was exceptionally large (ω^2 = 0.9851), suggesting that around 98.5% of the overall variance resulted from discrepancies between groups. The intraclass correlation coefficient (ICC = 0.9867) further validated significant variability between groups. Despite Levene's test, which indicated variances were heterogeneous based on means (p = 0.0023), Welch's ANOVA ($F_{7.058}$ = 1356, p = 1.54 × 10^{-10}) further validated that the group means differed significantly. The Bayes factor (2.59 × 10^{13}) offered convincing evidence in favor of unequal means. In general, these findings show both statistically and practically meaningful differences between the groups.

*Each season-wise value is overall average ± SE (n=12, 3 sites × 4 months).

dividuals/mL), Monsoon was (3.33individuals/mL) and Post-monsoon was (2.17 individuals/mL). The number of *Ulvophyceae* in Pre-monsoon was (0.58 individuals/mL), Monsoon was (3.17 individuals/mL) and Post-monsoon was (6 individuals/mL).The number of *Klebosormidiophyceae* in the Pre-monsoon was (00 individuals/mL), monsoon was (1.33 individuals/mL) and the Post-monsoon was (1.08 individuals/mL).The maximum average water temperature (30°C±0.11), pH (7.6±0.08) and ammonia (0.21±0.01) were recorded in pre-monsoon, maximum phosphate (0.06±00) and tds (112.8±0.82) in monsoon and nitrite (0.06±0.007), alkalinity (92±2.08), hardness (88±1.68) and free carbon dioxide (18±0.34) in post-monsoon. Environmental parameters in three seasons (premonsoon, monsoon and postmonsoon) are shown in (Table 4).

DISCUSSION

Zygnematophyceae was the most prevalent group during the research, with the pre-monsoon season seeing the highest abundance. This outcome is consistent with research showing that filamentous green algae grow more in stagnant waters that has been treated with nutrients during dry seasons. Due of nutrient depletion and improved species evenness after monsoon flushing, the Shannon–Wiener diversity index peaked during the post-monsoon season (Das *et al.* 2024). In contrast to our results, Bacillariophyceae dominance was noted during the monsoon season by (Kumar and Thomas 2019), indicating that local hydrology and nutrient regimes have a significant impact on phytoplankton composition. Because of nutrient stabilization and reduced turbidity, (Naik *et al.* 2020) also found that the post-monsoon season in tropical waters had the maximum phytoplankton abundance. The Canonical Correspondence Analysis (CCA) clarified the connection between phytoplankton communities and the observed physicochemical variables during various seasons. The ordination plot indicated that the distribution of phytoplankton groups is heavily affected by environmental gradients including pH, temperature, alkalinity, hardness, CO_2, and nutrient levels (phosphate, ammonia, nitrite). The location of Ulvophyceae, Klebsormidiophyceae, and Cyanophyceae on the positive end of Axis 1 shows their strong link to alkalinity, CO_2, and hardness, implying their resilience to elevated ionic and alkaline environments, especially in the post-monsoon season. These trends align with findings that Cyanophyceae and Ulvophyceae frequently prevail in nutrient-rich and alkaline water bodies (Kausar 2024). In contrast, Zygnematophyceae and Bacillariophyceae were found on the negative end of Axis 1, associated with temperature, pH, and ammonia, conditions commonly present during the pre-monsoon period. This connection shows their inclination towards environments that are moderately nutrient-rich and slightly alkaline, as noted by (Vijaya Krishna *et al*. 2024). Chlorophyceae, located along the phosphate and TDS vectors, displayed a trend of growth during the monsoon season, indicating their ability to thrive on nutrient surges and elevated conductivity from increased runoff (Mamun *et al.* 2021). The seasonal arrangement of sampling sites (pre-monsoon, monsoon, post-monsoon) within the ordination space reinforces that hydrological and physicochemical shifts influence phytoplankton composition and distribution. The noted differentiation of taxa across environmental gradients highlights that phytoplankton communities act as responsive indicators of ecosystem health and nutrient dynamics (Dalu *et al.* 2022). The CCA clearly shows that changes in algal composition are mainly influenced by nutrient levels and water chemistry, indicative of the joint effect of seasonal contributions and human activities.

CONCLUSION

Communities of zooplankton in Anicut Dam exhibited distinct seasonal changes, with Zygnematophyceae group being the most prevalent throughout all seasons and reaching their highest numbers during the pre-monsoon period. Species–environment connections validated by CCA emphasize their significance as dependable bioindicators of water quality. Human activities and dam operations significantly impacted community composition, highlighting the necessity for sustainable management to maintain ecological equilibrium and biodiversity.

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