Original Research

Anthropogenic Impact on Water Quality and Phytoplankton Diversity in Pong Reservoir, Himachal Pradesh

Deeksha Thakur, Akshay Kumar, Chakshu Thakur, Rakesh Kumar Daroch, Rakesh Kumar and Amit Kumar Sharma*

Department of Animal Sciences, Faculty of Life Science, Central University of Himachal Pradesh, Shahpur, Kangra 176206, India
* Corresponding author: dr.amitgkv@gmail.com

Article History
Received: 19 March 2026
Revised: 19 April 2026
Accepted: 23 April 2026
Published: 15 August 2026

Keywords
Anthropogenic activities
Biodiversity
Phytoplankton
Pong reservoir
Water quality

Abstract
Habitat ecological parameters play a pivotal part in evaluating the richness and abundance of phytoplankton diversity in freshwater ecosystems. Due to a rapid increase in anthropogenic activities, water quality in the riverine system is deteriorating due to numerous natural and anthropogenic factors, such as population growth, urbanization, and industrialization. The main focus of current research was to guesstimate the anthropogenic impact of habitat ecological parameters on phytoplankton diversity in Pong reservoir. The habitat ecological parameters and phytoplankton diversity of Pong reservoir were studied between February 2025 and April 2025 in two sampling zones. Some water quality parameters, i.e., turbidity, total dissolved solids, and biological oxygen demand, showed a small increase in April. Twenty-six genera of phytoplankton were documented, belonging to five groups: eleven genera of Bacillariophyceae, followed by ten genera of Chlorophyceae, three genera of Myxophyceae, one genus of Euglenophyceae, and one genus of Xanthophyceae. Multivariate statistical analysis was applied between habitat ecological parameters and phytoplankton species. Dissolved oxygen showed a positive correlation with phytoplankton diversity and a direct impact on phytoplankton distribution. Lastly, it can be determined that human actions like stream bed mining, development of dams and barrages across the river, etc., negatively influence water quality and the phytoplankton community in the riverine ecosystem. Still, these types of anthropogenic actions can be checked frequently and controlled.

Citation of this article: Thakur, D., Kumar, A., Thakur, C., Daroch, R. K., Kumar, R., & Sharma, A. K. (2026). Anthropogenic Impact on Water Quality and Phytoplankton Diversity in Pong Reservoir, Himachal Pradesh. *Journal of Biological Research Communication*, *1*(1), 11–22. https://doi.org/10.0000/xxxx

Statement of Sustainability: The current study provides an integrated assessment linking anthropogenic stressors with shifts in water quality and phytoplankton diversity in a Pong reservoir system. It combines ecological indicators with pollution gradients to understand ecosystem responses in fragile mountain landscapes. The findings support Clean Water and Sanitation and Life Below Water by classifying bioindicators for early detection of degradation and informing strategies for maintaining reservoir sustainability.

1. Introduction

Water is the most important natural resource and a necessary component of life. It is the most prevalent component of living creatures and is crucial to metabolism. Water covers almost the whole surface of the globe, with freshwater accounting for around 2.8 percent and saltwater accounting for the rest (Wetzel, 1983). As a result, freshwater habitats are extremely beneficial to human civilization in their daily lives. Riverine resources are the most important component of the aquatic ecosystem and the most dynamic natural water resource, on which various developmental activities depend (Obaidy *et al.*, 2015; Malik *et al.*, 2022).

Phytoplankton are free-floating, unicellular organisms that produce photo-autotrophically in aquatic ecosystems. Any freshwater ecosystem's primary production and overall nutrient cycles depend heavily on phytoplankton (Malik *et al.*, 2018; Kamboj *et al.*, 2020). Since phytoplankton are quick to adapt to changes in their environment and are sensitive to disturbances induced by such changes, they are also regarded as bioindicators of the water quality (Malik *et al.*, 2020). The management of the ecosystem's production depends heavily on the phytoplankton population. Numerous species make up the normally highly diversified phytoplankton ecosystems. Like terrestrial plants, they take in carbon dioxide, use solar energy to make carbohydrates, and exhale oxygen. Where enough sunlight can reach them to enable them to grow, phytoplankton prefer to reside close to the surface.

In both lotic and lentic water ecosystems, phytoplankton serve as the main source of food for fish and other aquatic species. They are used to assess a water body's trophic state and capacity for proliferating in large numbers in a favorable environment (Dhembare, 2011). Key factors controlling phytoplankton population status and structure in aquatic ecosystems include water quality parameters (Kumar *et al.*, 2018). Freshwater ecosystems, in which riverine systems play a main role for both terrestrial and aquatic ecosystems, are the most substantial life-supporting structures in nature (Kamboj *et al.*, 2017; Kumar *et al.*, 2026).

Water quality changes may affect the distribution, richness, and diversity of phytoplankton (Xiong *et al.*, 2016). Freshwater ecosystems are among the most globally vulnerable habitats due to the cumulative escalation in anthropogenic activity (Sharma *et al.*, 2022; Shekhar *et al.*, 2024). When many water quality measures are combined, it is difficult to interpret the results, especially when different anthropogenic stressors affect specific parameters and can mimic water quality across categories (Popovic *et al.*, 2016). Ongoing changes and instability in freshwater ecosystems strongly affect the diversity and population dynamics of phytoplankton. Cyclical fluctuations directly influence distribution, quantity, richness, and quantitative and qualitative indicators in the water quality characteristics.

Any freshwater body's water quality characteristics and phytoplankton are connected and routinely affected by the environment, such as by ongoing fluctuations in land usage, land cover patterns, etc. (Chang, 2008). The diversity and richness, as well as the quantitative and qualitative composition, of phytoplankton are all significantly influenced by nutrient dynamics (Malik *et al.*, 2020). Unscientific sand mining, dam construction, and barrage construction have been shown to have severe environmental effects on aquatic ecosystems, with the biggest threat to aquatic biota (Sharma *et al.*, 2018; Adekunbi *et al.*, 2018). The goal of the current study was to evaluate the phytoplankton diversity and habitat ecology of the Pong reservoir.

2. Materials and methods

2.1. Study area

The Pong Dam was constructed to span the Beas River in 1975. It is sometimes referred to as the Pong Reservoir or Maharana Pratap Sagar. The Himachal Pradesh government named the whole reservoir a wildlife sanctuary in 1983. It was designated a "wetland of national importance" in 1994. In November 2002, Pong Dam was designated as a Ramsar site. The Beas River and its several perennial tributaries, including Neogal, Binwa, Baner, and Uhlgaj, provide water for the lake. The lake's acceptable water level makes it a great place to participate in water sports. The sanctuary is home to about 220 bird species from 54 different bird groups. Two sampling zones were selected during the current study (Table 1 and Figure 1).

2.2. Sample collection and analyses

From February 2025 to April 2025, monthly water samples were taken from the Pong reservoir. Using a water sampler, water samples were collected, preserved in sterile polyethylene bottles, kept in an ice box, and transported to the lab for further examination. Standard techniques were used for the analysis of physico-chemical parameters, including turbidity measurement by transportable digital meters (IONIX C-600), pH measurement by a digital pH meter (IONIX C-600), DO and BOD determination by the Winkler method, and nitrate determination by spectrophotometry. Flame Photometry determined calcium, magnesium, phosphorus, and chloride. A plankton net constructed of silk with a mesh size of around 20μm was used to filter 100 liters of water for phytoplankton examination. After filtering, the water was immediately kept in plastic bottles containing a 4-5% formaldehyde solution for laboratory analysis. Physico-chemical characteristics and phytoplankton genera were correlated using PAST software to get the correlation coefficient. Paleontological Statistics (PAST, Version 3.06) software was used to conduct a Canonical Correspondence Analysis (CCA) between the dominating phytoplankton genera and habitat ecological parameters.

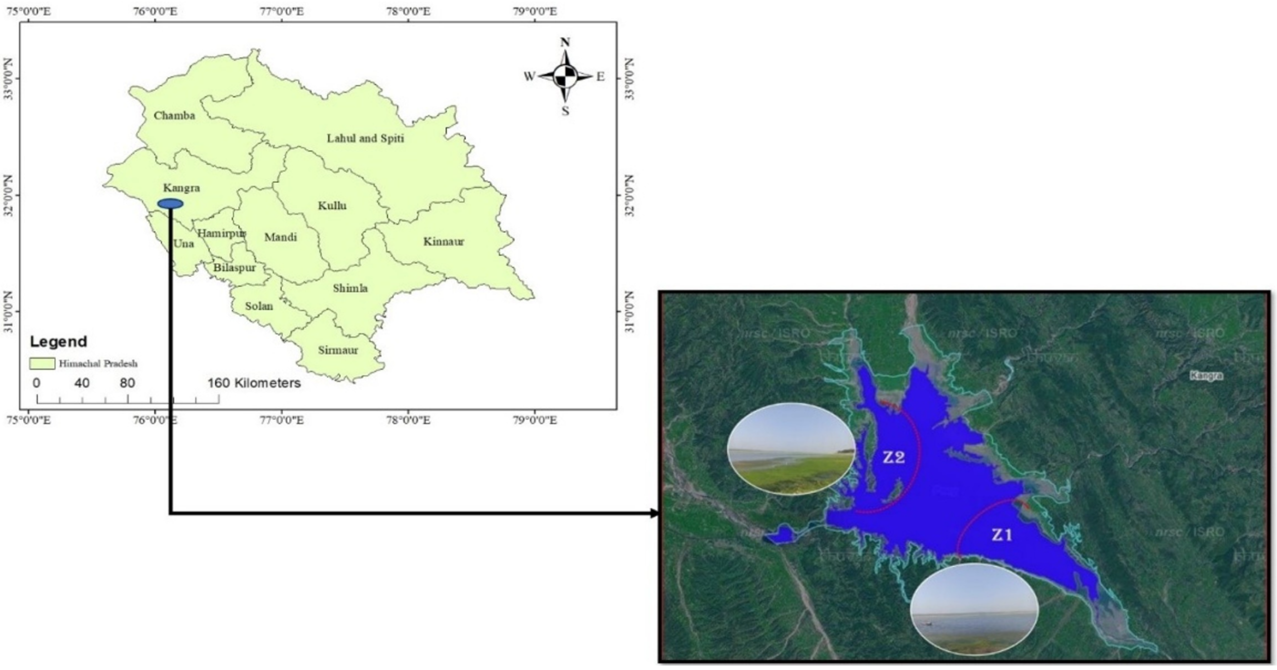

Figure 1. Satellite imagery of selected sampling zones along the catchment basin of Pong reservoir.

Table 1. Geo-coordinates of selected sampling zones.

Sampling Zone	Name	Geo-coordinates		Elevation
		Latitude	Longitude	
Zone 1	Baglahar	32°08′28.65″N	75°98′33.08″E	407 Msl
Zone 2	Kathiyar	32°08′44.02″N	78°23′2.76″E	405 Msl

Calculation for phytoplankton:

$$No.\ of\ plankton\ /\ ml = \frac{No.\ of\ organism\ counted}{No.\ of\ replicates\ taken} \tag{1}$$

$$(Plankton/l)\ = \frac{(a\ \times 1000)\,c}{L} \tag{2}$$

Where, n= no. of plankton/litre of water; a= Average number of plankton in one small counting chamber of S-R cell; c= ml of plankton concentrate; I=volume of original water filtered in litres

2.3. Identification of phytoplankton species

The phytoplankton permanent mount was made from the concentrated samples. The identification of these permanent mounts was carried out using 10X, 20X, 40X, and 100X resolution while they were examined under a digital microscope. Using a digital camera, photos of the phytoplankton species were taken. Later, (Edmondson, 1959) and other researchers identified the phytoplankton (Needham & Needham, 1978). Diversity indices were calculated using PAST software.

3. Results and discussion

Habitat ecological parameters play a vital role in determining the quality of the aquatic ecosystem. The observations were made during February, March, and April 2025 at Pong reservoir for the following parameters. The observations of habitat ecological parameters are presented in tabular form (Tables 2 and 3), Nutrient parameters (Table 4), and biological parameters (Table 4).

3.1. Hydrological parameters

Air temperature showed monthly variation among the two zones. At Zone 1, the maximum (13.5±1.5°C) was observed during April and the minimum (12.2±1.5°C) during February. At Zone 2, the maximum (13.8±1.6°C) air temperature was observed during April and the minimum (12.7±1.2 °C) during February. The average value was recorded (12.83 °C) at Zone 1 and (13.2±0.45 °C) at Zone 2. A similar observation was made by Sharma et al. (2022) in the Upper Ganga basin and its major tributaries. Water velocity showed monthly variation among the two zones. At Zone 1, the maximum (1.5±0.5m/s) was during April and the minimum (0.9±0.2 m/s) during February. At Zone 2, the maximum (0.7±0.2m/s) water velocity was observed during April and the minimum (0.4±0.1m/s) during February. The average value was recorded (1.27) at zone 1 and (0.54±0.12m/s) at zone 2. Depth showed monthly variation among the two zones. At Zone 1, the maximum (7.6±2.1ft) was observed during April and the minimum (5.1±1.1ft) during February. In Zone 2, the maximum (9.6±2.0 ft) was observed during April, and the minimum (9.1±1.9 ft) during February. The average value was recorded (6.57 ft) at zone 1 and (9.4±1.9 ft) at zone 2. Light intensity showed monthly variation among the two zones. At Zone 1, the maximum (1405±256) was observed during April and the minimum (1023±212) during February. In Zone 2, the maximum light intensity (1465±299) was observed during April, and the minimum (1095±245) during February. The average value was recorded (1233.33) at zone 1 and (1288.33±151.55) at zone 2 (Table 2). A similar trend was observed by (Sharma et al., 2022b; Kumar et al., 2018) in the Upper Ganga basin and its major tributaries.

Table 2. Monthly variation in hydrological parameters at selected sampling zones in Pong reservoir.

Parameters	February		March		April	
	Z1	Z2	Z1	Z2	Z1	Z2
AT (°C)	12.2±1.5	12.7±1.2	12.8±1.4	13.1±1.2	13.5±1.5	13.8±1.6
WV (ft/sec)	0.9±0.2	0.4±0.1	1.4±0.2	0.5±0.1	1.5±0.5	0.7±0.2
D (Ft)	5.1±1.1	9.1±1.9	7.0±1.4	9.5±1.5	7.6±2.1	9.6±2.0
LI (lux)	1023±212	1095±245	1272±305	1305±377	1405±256	1465±299

AT: Air temperature, WV: Water velocity, D: Depth, LI: Light intensity.

3.2. Physico-chemical parameters

Several physical and chemical factors primarily influence the water quality of freshwater ecosystems. The habitat ecological characteristics indicate the water quality status of any freshwater body. Water temperature showed monthly variation among the two zones. At Zone 1, the maximum (12.8±0.45 °C) and minimum (10.1±0.02 °C) temperatures were observed during February. At Zone 2, the maximum (12.7±0.32 °C) temperature was observed during April, and the minimum (10.8±0.26 °C) during February. The average value was recorded (11.8±0.82 °C) at zone 1 and (11.50±0.85 °C) at zone 2. A similar trend was observed by Sharma *et al.* (2022) in the Upper Ganga basin and its major tributaries. pH showed monthly variation among the two zones. At Zone 1, the maximum pH (8.0±0.12) and minimum (7.9±0.25) were observed during February. At Zone 2, the maximum (8.0±0.21) pH was observed during February and the minimum (7.7±0.10) during April. The average value was recorded as (7.95±0.04) at Zone 1 and (7.80±0.14) at Zone 2. Khanna et al. (2012) reported that the water quality in the Ganga is alkaline in nature at Haridwar. According to Seiyaboh et al. (2013), mining in riverbeds and other forms of development activities cause lower pH values in freshwater bodies. Freshwater aquatic life is particularly sensitive to pH levels and can cause high mortality below 5 pH 5. The EC at zone 1 was observed to be maximum (139.5±0.12 μS/cm) in April and minimum (112.3±0.25 μS/cm) in February. At zone 2, the maximum (137.8±0.62μS/cm) was in April, and the minimum (117.1±0.14μS/cm) was in February. The average value of the EC was observed as 128.36±9.09 at zone 1 and 126.03±8.86 at zone 2. The total dissolved solids at zone 1 were observed to be highest (90.3±2.16mg/l) in April and lowest (65±2.31 mg/l) in February. At zone 2, the highest (91.5±2.16mg/l) was observed in April and the lowest (67.5±2.14mg/l) in February. The average value of the total dissolved solids was observed (83.75±5.35mg/l) at zone 1 and (78.33±9.94mg/l) at zone 2. A similar trend of EC and TDS was observed by (Kumar et al., 2018; Sharma et al., 2022) in the Ganga River. A similar observation was made by (Jindal et al., 2010) in Hillstream Nogli, a tributary of the Sutlej River. The most important ecological factor for maintaining a healthy ecosystem and ensuring the existence of aquatic life in both the lentic and lotic ecosystems is dissolved oxygen. According to Bhatti and Latif (2021), DO is a crucial indicator of water quality since it helps to sustain the variety of biological life forms in the water. It also determines how effectively human activities in each water body will turn out. Despite the high concentrations of DO in the upper Ganga's catchment basin, most DO levels were below permissible thresholds at every sampling location (Sharma et al., 2022). An increase in nutrients can decrease the amount of oxygen in the water, fluctuations in water flow, high water temperatures, and the build-up of various pollutants. The total dissolved oxygen at zone 1 was observed to be highest (9.0±0.58 mg/l) in February and lowest (8.8±1.3 mg/l) in April. At zone 2, the highest (8.9±0.42 mg/l) was observed in February and the lowest (8.4±0.22mg/l) in April. The average value of dissolved oxygen was observed at zone 1 (8.9±0.08 mg/l) and at zone 2 (8.73±0.24 mg/l). A DO level > 5 mg/L is essential for freshwater ecological diversity, as well as for supporting a diversified aquatic ecological community and good fish production (Sharma et al., 2019). For metabolic processes in aquatic ecosystems, aquatic species require biological oxygen demand in large quantities. BOD rises when the amount of biodegradable organic matter in a load increases. Accordingly, the BOD is regarded as a crucial water quality metric for determining the freshwater ecosystem's state of health, according to Bhatti and Latif (2011) and Malik et al. 2020). The Biological oxygen demand at zone1 was observed to be highest (1.5±0.35 mg/l) in April and lowest (1.2±0.26 mg/l) in February. At zone 2, the highest (1.7±0.21mg/l) was observed in April and the lowest (1.3±0.33 mg/l) in February. The average value of the biological oxygen demand was observed (1.45±0.04 mg/l) at zone 1 and (1.43±0.19 mg/l) at zone 2. A similar trend of BOD in the Upper Ganga basin was reported by Kamboj et al. (2020). BOD level directly indicates the load of pollution in the riverine system (Nwankwo et al., 2014; Malik et al., 2018). The Free CO_2 at zone we were observed to be highest (1.6±0.32mg/l) in February and lowest (1.5±0.47mg/l) in April. At zone 2, the highest (1.8±0.40 mg/l) value was observed in February and the lowest (1.7±0.14 mg/l) in April. The average value of the Free CO_2 was observed (1.55±0.04mg/l) at zone 1 and (1.77±0.05 mg/l) at zone 2. Whether it be rivers, streams, or lakes, the turbidity of the water is crucial in describing the photic state of the body of water. Turbidity, which limits the quantity of light that can penetrate any water body's water column, can be caused by any suspended material, including mud, clay, sand, microscopic creatures, organic materials, and inorganic materials (Effendi et al., 2015). Turbidity at zone 1 was highest (77.5±0.25 NTU) in April and lowest (53±0.3 NTU) in February. At zone 2, the highest (76.2±0.15NTU) was observed in April and the lowest (57.9±0.7 NTU) in February. The average value of the turbidity was observed (68.55±7.31 NTU) at zone 1, (64.53±8.28 NTU) at zone 2 (Table 3). A similar trend in turbidity in the Ganga River was observed by (Kamboj *et al.*, 2020; Malik *et al.*, 2024). According to Kale (2016), rising turbidity levels have an immediate effect on aquatic life.

Table 3. Monthly variation in physico-chemical parameters at selected sampling zones in Pong reservoir.

Parameters	**February**		**March**		**April**	
	Z1	**Z2**	**Z1**	**Z2**	**Z1**	**Z2**
WT (°C)	10.1±0.02	11.0±0.22	10.8±0.45	10.8±0.26	12.8±0.45	12.7±0.32
pH	7.9±0.25	7.7±0.13	8.0±0.12	8.0±0.21	7.9±0.45	7.7±0.10
TDS (mg/L)	65.1±2.31	67.5±2.14	77.2±3.14	76±1.90	90.3±2.16	91.5±2.16
EC (μS/cm)	112.3±0.25	117.1±0.14	117.23±0.35	123.2±1.50	139.5±0.12	137.8±0.62
T (NTU)	53±0.3	57.9±0.7	59.6±0.12	59.5±0.35	77.5±0.25	76.2±0.15
DO (mg/L)	8.9±0.41	8.4±0.22	9.0±0.58	8.9±0.42	8.8±1.3	8.9±1.2
BOD (mg/L)	1.3±0.24	1.3±0.42	1.2±0.26	1.3±0.33	1.5±0.35	1.7±0.21
FC (mg/L)	1.6±0.32	1.8±0.12	1.5±0.47	1.8±0.40	1.6±0.25	1.7±0.14

WT: Water Temperature, TDS: Total Dissolved Solids, EC: Electrical Conductivity, T: Turbidity, DO: Dissolved Oxygen, BOD: Biological Oxygen Demand, FC: Free CO_2.

3.3. Nutrient parameters

The calcium at zone 1 was observed to be highest (13.5±1.2 mg/l) in April and lowest (11.7±1.5 mg/l) in February. At zone 2, the highest (13.9±1.3 mg/l) was observed in April and the lowest (11.9±1.2 mg/l) in February. The average calcium value was observed at zone 1 (38.4±0.79 mg/l) and at zone 2 (12.90±0.81 mg/l). Magnesium at zone 1 was observed to be highest

(62±1.1 mg/l) in April and lowest (36±1.2 mg/l) in February. At zone 2, the highest (60±4.1mg/l) was observed in April and the lowest (39±1.3 mg/l) in February. The average value of magnesium was observed (146±10.62mg/l) at zone 1 and (48.67±8.65 mg/l) at zone 2. The phosphorus at zone 1 was observed to be highest (0.3±0.2 mg/l) in February and lowest (0.12±0.2 mg/l) in February. At zone 2, highest (0.2±0.0 mg/l) in February and lowest 0.09±0.1 mg/l) in February. The average value of phosphorus was observed (0.57±0.08 mg/l) at zone 1 and (0.14±0.2 mg/l) at zone 2. The chloride at zone 1 was observed to be highest (3.3±0.1 mg/l) in February and lowest (3.24±0.6 mg/l) in February. At zone 2, the highest (3.66±0.5mg/l) was observed in February, and the lowest (3.28±0.6mg/l) was observed in February. The average value of chloride was observed (9.8±0.02 mg/l) at zone 1 and (3.45±0.14 mg/l) at zone 2 (Table 4). The analysis revealed low levels of all major cations, including calcium (Ca), magnesium (Mg), phosphorus (P), and chloride (Cl), and all cations were within acceptable constraints. The research area's geology could be the cause of the lower cation values. The Bhagirathi River similarly has poor values, according to Sharma *et al.* (2019).

Table 4. Monthly variation in nutrient parameters at selected sampling zones in Pong reservoir.

Parameters	February		March		April	
	Z1	Z2	Z1	Z2	Z1	Z2
C (mg/l)	11.7±1.5	11.9±1.2	13.2±0.1	12.9±1.1	13.5±1.2	13.9±1.3
M (mg/l)	36±1.2	39±1.3	48±1.1	47±2.3	62±1.1	60±4.1
P (mg/l)	0.12±0.2	0.09±0.1	0.3±0.2	0.2±0.0	0.15±0.5	0.14±0.2
C (mg/l)	3.24±0.6	3.28±0.6	3.3±0.1	3.66±0.5	3.26±0.6	3.41±0.11

3.4. Phytoplankton

Phytoplankton are an important component in any aquatic ecosystem. The phytoplankton community in Pong Dam and its tributaries comprised Bacillariophyceae, Chlorophyceae, Myxophyceae, Euglenophyceae, and Xanthophyceae. A total of 26 phytoplankton species were observed during the current study, including 11 species of Bacillariophyceae, 10 species of Chlorophyceae, 3 species of Myxophyceae, and 1 species of Euglenophyceae (Table 5).

Table 5. Temporal and spatial species abundance and distribution of Phytoplankton at selected sampling zones.

Code	Species	No.	%	Z1	Z 2	Feb	March	April
	Bacillariophyceae							
P1	*Achananthes sp.*	307	22.56	135	172	97	100	110
P2	*Amphora sp.*	177	13.01	97	80	69	60	48
P3	*Cytotella sp.*	169	12.42	91	78	65	59	45
P4	*Cymbella sp.*	111	8.16	61	50	45	38	28
P5	*Denticula sp.*	99	7.27	60	39	40	35	24
P6	*Diatoma sp.*	75	5.51	45	30	30	26	19
P7	*Fragilaris sp.*	103	7.57	39	64	28	22	23
P8	*Tabellaria sp.*	72	5.29	43	29	31	20	21
P9	*Syendra sp.*	116	8.52	71	45	46	39	31
P10	*Navicula sp.*	74	5.44	41	33	32	25	17
P11	*Nitzchia sp.*	58	4.26	33	25	22	19	17
	Total	**307**	**36.68**	**716**	**645**	**550**	**477**	**408**
	Chlorophyceae							
P12	*Chlorella sp.*	52	12.75	20	32	20	18	14
P13	*Cledophora sp.*	59	14.46	36	23	22	20	17
P14	*Desmidium sp.*	55	13.48	30	25	20	19	16
P15	*Gonatozygon sp.*	40	9.80	22	18	15	14	11
P16	*Hydrodictyon sp.*	26	6.37	16	10	13	7	6
P17	*Microspora sp.*	28	6.86	15	13	11	9	8
P18	*Ulothrix sp.*	25	6.13	16	9	9	8	8

Continued on next page...

Table 5. continued…

P19	*Zygnema sp.*	18	4.41	12	6	9	5	4
P20	*Closterium sp.*	44	10.78	24	20	18	15	11
P21	*Spirogyra sp.*	61	14.95	35	26	24	20	17
	Total	**408**	**48.75**	**226**	**182**	**161**	**135**	**112**
	Myxophyceae							
P22	*Anabaena sp.*	54	48.21	33	21	20	19	15
P23	*Oscillatoria sp.*	34	30.36	21	13	13	10	11
P24	*Phorimidium sp.*	24	21.43	11	13	12	7	5
	Total	**112**	**13.38**	**82**	**132**	**57**	**43**	**35**
	Euglenophyceae							
P25	*Euglena sp.*	5	0.60	2	3	2	1	2
	Xanthophyceae							
P26	*Vaucheria sp.*	5	0.60	1	4	0	3	2
Total		**837**	**100**	**1027**	**966**	**770**	**659**	**559**

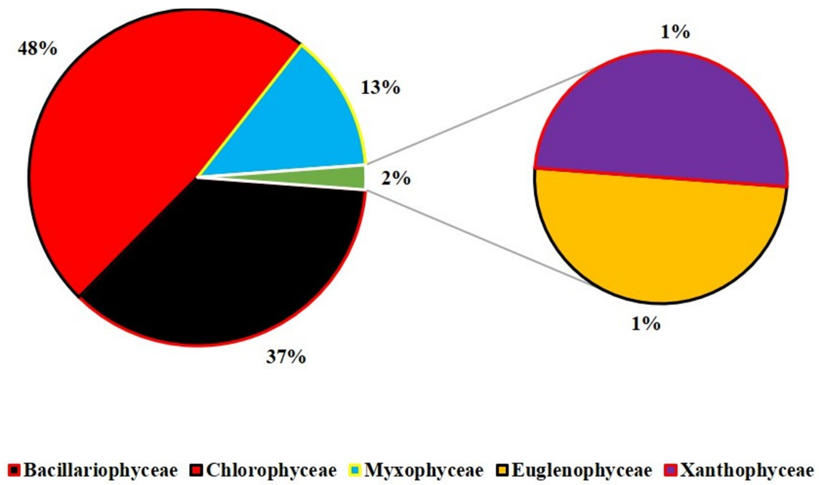

Figure 2. Percentage of phytoplankton groups at Pong reservoir.

Phytoplankton groups in different months followed the order of: Chlorophyceae > Bacillariophyceae >Myxophyceae >Euglenopyceae> Xanthophyceae (Figure 2). The maximum (307 individuals) was counted for Achananthes sp., and the minimum (58 individuals) for *Nitzchia sp.* Bacillariophyceae, which make up 22.56% and 4.26% of all individuals, respectively, are a group of organisms. Throughout the study period, zone 2 had the highest (172) population count, whilst zone 1 had the lowest (1) population count. In all sampling zones, there was a considerable monthly variation in abundance (individuals). The highest number of individuals (110) was observed in April. During the current research, the monthly abundance for each sampling zone increased significantly. The most abundant species observed were *Achananthes sp., Amphora sp., Cytotella sp., Cymbella sp., Syendra sp., and Fragilaris sp., while Achananthes species was the most dominant due to higher nutrient levels and* suitable temperature. In the river Bhagirathi in the Garhwal Himalayas, Malik *et al.* (2018) described a significant abundance of phytoplankton throughout the winter. In the Ganga River and its major tributaries, *Achananthes sp.* was the dominant species (Malik *et al.*, 2018; Sharma *et al.*, 2019; Sharma *et al.*, 2020). Sharma *et al.* (2020) detected 31 phytoplankton species in the Tehri reservoir and noted a minimal effect of the dam on the Bhagirathi River downstream. Sharma *et al.* (2026) reported a similar trend of plankton diversity and water quality in three freshwater lakes of Jammu & Kashmir. Ecologically, Chlorophyceae can be categorized as the most important component of the phytoplankton community. Chlorophyceae was found at a higher rate in water bodies and consisted of 10 species of different genera in Pong reservoir and its tributaries. The most abundant species observed were *Spirogyra sp, Cledophora sp., Desmidium sp., and Chorella sp., while Spirogyra sp.* was the most dominant in the Chlorophyceae group. The most abundant species observed were *Anabaena sp., Oscillatoria sp., and Phoridium sp.*, while *Anabaena sp.* was the most dominant in the Myxophyceae group. The most abundant species observed was *Euglena sp.* in the Euglenophyceae group. The most abundant species observed was *Vaucheria sp.* in the Xanthophyceae group. During the study period, the maximum number (716 unit/l) of Bacillariophyceae was found at zone 1. Maximum numbers (550 unit/l) of Bacillariophyceae were found in February, and the minimum number (408 unit/l) was found in April. Bacillariophyceae fluctuated between (550-408unit/l), the minimum peak was observed in April, and the maximum peak was observed in February. Chlorophyceae ranged from (112-161 unit/l); the minimum (112 unit/l) numbers of Chlorophyceae were observed in April, and the maximum (161 unit/l) numbers were observed in February. Maximum numbers (226 unit/l) of Chlorophyceae were found at zone1. Myxophyceae ranged 35-57unit/l, the minimum (35 unit/l) was observed in April, and the maximum (57 unit/l) was observed in February. Maximum numbers (132 unit/l) of Myxophyceae were found at zone 2. Euglenophyceae ranged (0-2unit/l), the minimum (0 unit/l) was observed in February, and the maximum (2 unit/l) was observed in April. Maximum numbers (3unit/l) of Euglenophyceae were found at zone 2. Bacillariophyceae was recorded between (4.26-22.56%), Chlorophyceae was recorded between (6.13-14.95%), Myxophyceae ranged between (21.43-48.21%), and Cyanophyceae ranged between (18.72-50.27%) during the study period (Table 5). According to Kumar *et al.* (2018), the construction of dams and barrages had an impact on physico-chemical parameters, which in turn had a direct and indirect impact on the distribution of phytoplankton. Additionally, Kamboj & Kamboj (2020) noted that a variety of human activities, such as riverbed mining, affect aquatic creatures. The abundance and biomass of phytoplankton, their temporal and spatial distribution, and their genus composition all play a role in the ecological health of a given environment (Khattak *et al.*, 2005). The maximum number of habitat ecological parameters showed a positive correlation with phytoplankton species (Figure 3).

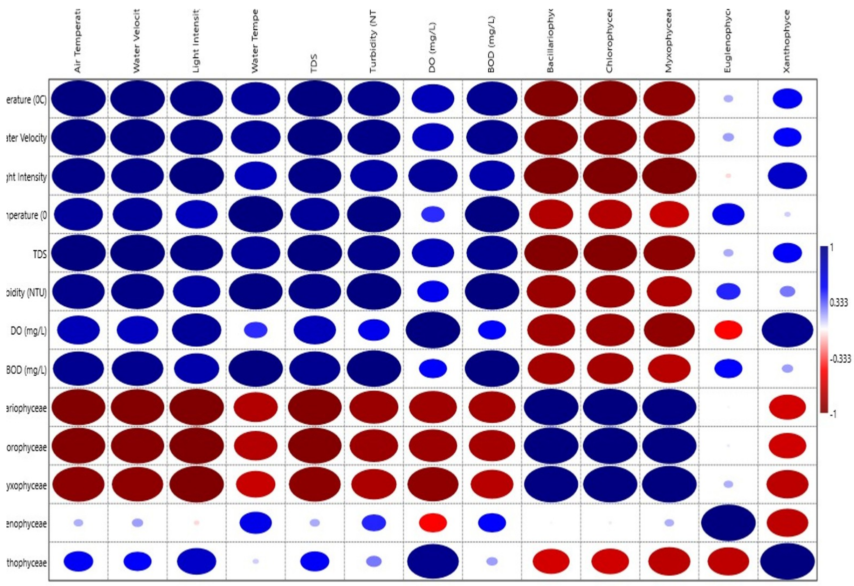

Figure 3. Correlation between habitat ecological parameters and phytoplankton groups.

3.5. Phytoplankton diversity indices

Diversity index values were computed based on stations and months (Table 6). Zone 2 has the highest dominance index (D) (0.092). In April, the dominance index (D) (0.096) values were higher than in February (0.074). Zone 1 has the highest Simpson index (1-D) (0.926). Simpson index (1-D) readings were higher in February (0.926) and lower in April (0.905). Zone 1 has the highest Shannon index (H) (2.728). In February, higher Shannon index (H) values (2.784) were discovered, whereas April had low values (2.675). Zone 1 has the highest evenness value (0.808). The highest evenness value (0.810) and lowest value (0.726) were discovered in February and April, respectively. Zone 1 had the highest Brillouin index (2.727). Brillouin index values were higher (2.711) in February and lower (2.585) in April. Zone 2 has the highest Menhinick's index (0.707). Menhinick's index readings were higher (0.915) in April compared to low (0.789) in February. Zone 2 has the highest Margalef index (2.842). Higher Margalef index readings (3.080) were observed in April, compared to low readings (2.939) in February. Zone 1 had the highest Equitability index (J) (0.929) and the lowest (0.894). In April, the Equitability Index (J) (0.893) values were higher than in February (0.912), when they were lower. Zone 2 has the highest Fisher alpha index (3.720), whereas zone 1 had the lowest (3.618). When low (3.918) values of the Fisher alpha index were reported in February, higher values (4.221) were found in April. Zone 2 has the highest Berger-Parker index (0.215). In April, the Berger-Parker index was higher (0.230), whereas in February, it was lower (0.151). Between the months and the sites, there was no discernible change in the mean value of the diversity indices (Table 6).

Table 6. Temporal and spatial diversity indices of phytoplankton at selected sampling zones.

Individuals	**Z1**	**Z 2**	**Feb**	**March**	**April**
No.	907	801	642	558	478
Dominance_D	0.074	0.092	0.074	0.082	0.096
Simpson_1-D	0.926	0.908	0.926	0.918	0.905
Shannon_H	2.782	2.679	2.784	2.731	2.675
Evenness_e^H/S	0.808	0.729	0.810	0.768	0.726
Brillouin	2.727	2.619	2.711	2.651	2.585
Menhinick	0.664	0.707	0.789	0.847	0.915
Margalef	2.790	2.842	2.939	3.004	3.080
Equitability_J	0.929	0.894	0.930	0.912	0.893
Fisher_alpha	3.618	3.720	3.918	4.056	4.221
Berger-Parker	0.149	0.215	0.151	0.179	0.230

3.6. CCA calculation between phytoplankton genus and habitat-ecological parameters

The outcomes from the initial two axes were plotted in Figure 4. The length of a particular variable's vector in a CCA analysis reveals how important that variable is, and the longest vector for water temperature demonstrated a strong link with zones 1 and 2. BOD's vector length demonstrated a substantial relationship with zones 1 and 2, whereas DO demonstrated a significant relationship with zones 1 and 2. *Microspora* sp., *Nitzchia* sp., *Ulothrix* sp., and *Fragilaris* sp. are all linked to high water temperature values. 77.74% of the association between water quality indicators and phytoplankton community was explained by the Eigen value of axis 1 (0.009874). In contrast, during the current analysis, the Eigen value of axis 2 (0.002827) explained 22.26% of the association (Table 7).

Table 7. CCA biplot scores of habitat ecological parameters and phytoplankton species at selected sampling zones of Pong reservoir.

Parameter	**Axis 1**	**Axis 2**	**Parameter**	**Axis 1**	**Axis 2**
P1	1.74189	0.53227	P21	-0.20327	0.13632
P2	-0.25153	-0.3168	P22	0.070922	-0.7811
P3	-0.24789	-0.72218	P23	0.489528	1.5995
P4	-0.67883	-0.51961	P24	-2.39341	1.23776
P5	-0.78371	-0.98493	P25	1.21866	5.48779
P6	-0.59856	-0.68011	P26	6.16787	-9.75338
P7	0.369741	1.28974	February	-0.1106	0.032586
P8	-0.50167	2.09621	March	0.011988	-0.07514
P9	-0.38357	-0.22661	April	0.134812	0.043777
P10	-1.29229	-0.43696	Air Temperature	0.987914	0.239154
P11	0.150194	0.204042	Water Velocity	0.982084	0.271973
P12	-0.21123	-0.59776	Light Intensity	0.996927	0.007455
P13	0.168188	-0.24984	Water Temperature	0.814471	0.647917
P14	0.31694	-0.48546	TDS	0.986207	0.249483
P15	-0.02078	-0.72151	Turbidity	0.903026	0.505448
P16	-2.11543	2.18128	DO	0.865751	-0.42438
P17	-0.10897	0.409472	BOD	0.8663	0.571979
P18	0.722372	0.599365	Eigenvalue	0.009874	0.002827
P19	-2.22133	1.82184	%	77.74	22.26
P20	-0.75234	-0.4739			

4. Conclusion

The Pong Reservoir's water quality is suitable for supporting a wide range of aquatic life. As a result of the current study, it can be said that both sample zones' habitat ecology and phytoplankton diversity were satisfactory. However, a few

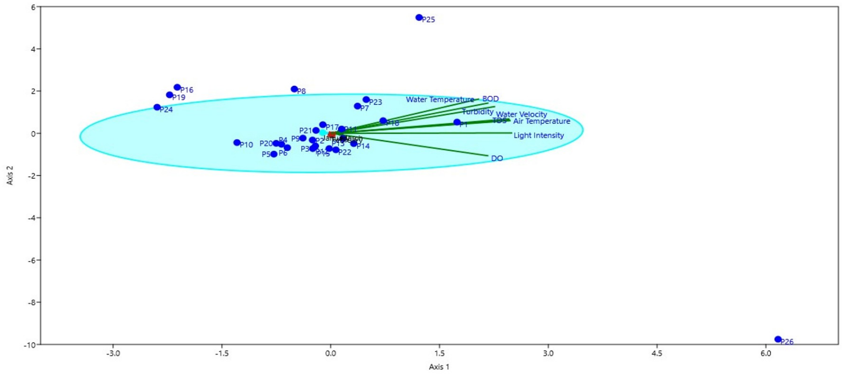

Figure 4. CCA biplot of habitat ecological parameters and phytoplankton species.

parameters in each zone were marginally moving in the direction of bad water quality. The Pong Reservoir has been categorized as having satisfactory water quality within acceptable bounds based on the findings. The Pong Reservoir's water quality and ability to support a wide range of aquatic life are both quite strong. Some biological parameters of the ecosystem exhibited rising tendencies, but they remained within acceptable bounds. Similar patterns were seen for all the parameters in both sampling zones. It was also observed during the current study that certain construction operations, such as building a road and bridge across a river, building a dam and barrages, and mining stream beds, have the potential to affect habitat ecology and aquatic biodiversity adversely. However, these behaviors are regularly observed and should be reduced systematically.

Acknowledgments

The authors are thankful to the Department of Animal Sciences, Central University of Himachal Pradesh, Kangra, for providing the lab facilities.

Author contributions

Amit Kumar Sharma : Conceptualization, Visualization, Writing- original draft; Rakesh Kumar Daroch: Data curation; Investigation, Supervision; Akshay Kumar, Chakshu Thakur: Methodology, Resources; Akshay Kumar: Software; Rakesh Kumar: Validation, Data curation; Deeksha Thakur: Writing- review & editing.

Funding Information

No Funding.

Conflict of interest

There is no conflict of interest.

Ethical Approval

Not Applicable.

References

Adekunbi, F., Elegbede, I., Akhiromen, D., Oluwagunke, T., & Oyatola, O. (2018). Impact of Sand Dredging Activities on Ecosystem and Community Survival in Ibeshe Area of Lagos Lagoon, Nigeria. *Journal of Geoscience and Environment Protection*, *06*(02), 112-125. https://doi.org/10.4236/gep.2018.62008.

Bhatti, M., & Latif, M. (2011). Assessment of water quality of a river using an indexing approach during the low-flow season. *Irrigation and Drainage*, *60*(1), 103-114. https://doi.org/10.1002/ird.549.

Chang, H. (2008). Spatial analysis of water quality trends in the Han River basin, South Korea. *Water Research*, *42*(13), 3285-3304. https://doi.org/10.1016/j.watres.2008.04.006.

Dhembare, A. J. (2011). Diversity Indices of Rotifer from Dynaneshwar Water Rahuri, Ahmednagar, Maharashtra. *European Journal of Experimental Biology*, *1*(3), 139-144.

Effendi, H., & Wardiatno, Y. (2015). Water Quality Status of Ciambulawung River, Banten Province, Based on Pollution Index and NSF-WQI. *Procedia Environmental Sciences*, *24*, 228-237. https://doi.org/10.1016/j.proenv.2015.03.030.

Jindal, R., Gautam, S., & Kumar, R. (2010). Hydrobiological studies on Hillstream Nogli, a tributary of river Sutlej at Rampur Bushahr, District Shimla, Himachal Pradesh, *India. J. Aquat. Biol*, *25*(2): 22–29.

Kale, V. S. (2016). Consequence of temperature, pH, turbidity and dissolved oxygen water quality parameters. *International Advanced Research Journal in Science, Engineering and Technology*, 3(8), 186–190.

Kamboj, V., & Kamboj, N. (2020). Spatial and temporal variation of zooplankton assemblage in the mining-impacted stretch of Ganga River, Uttarakhand, India. *Environmental Science and Pollution Research*, *27*(21), 27135-27146. https://doi.org/10.1007/s11356-020-09089-1.

Kamboj, V., Kamboj, N., & Sharma, N. (2020). A review on general characteristics, classification and degradation of river systems. In *Environmental Degradation: Causes and Remediation Strategies* (pp. 47-62). Agro Environ Media - Agriculture and Ennvironmental Science Academy, Haridwar, India. https://doi.org/10.26832/aesa-2020-edcrs-04.

Kamboj, V., Kamboj, N., & Sharma, S. (2017). Environmental impact of river bed mining- a review. *International Journal of Scientific Research and Reviews*, *7*(1), 504–520.

Khanna, D. R., Bhutiani, R., Matta, G., & Ishaq, F. (2012). Physico-chemical and microbiological status of River Asan in Dehradun, Uttarakhand. *Environment Conservation Journal*, *13*(1&2), 145–150.

Khattak, T. M., Bhatti, N. Z., & Murtaza, G. (2005). Evaluation of algae from the effluent of Dandot cement company, Dandot, Pakistan. *J. Appl. Sci. Environ. Manage*, *9*, 147–149.

Kumar V, Malik DS, Sharma AK (2018). Study on Distribution Pattern of Benthic Diversity in Relation to Water Quality of River Ganga and Its Tributaries. *Journal of Emerging Technologies and Innovative Research, 5*(5), 88–103.

Kumar, A., Thakur, C., Thakur, K., Sharma, A. K., Daroch, R. K., Kumar, R., Kumar, S., & Sharma, A. K. (2026). A systematic review on classification, exposure pathways of micropollutants in the aquatic environment, and its associated human health risks. *Journal of Applied Toxicology*. https://doi.org/10.1002/jat.70246

Malik DS, Sharma AK, Sharma AK (2020). Status of Zooplankton Diversity, Abundance in Relation to Hydrography of Ganga River and its Tributaries at Rishikesh. *Indian Journal of Ecology*, *47*(3), 739–745.

Malik, D. S., Sharma, A. K., & Bargali, H. (2018). Status of phytoplankton diversity in relation to water quality of Bhagirathi riverine system in Garhwal Himalaya. *International Journal of Advanced Science and Research*, *3*(1), 30–37.

Malik, D. S., Sharma, A. K., & Sharma, A. K. (2020). Current status of macrobenthic diversity and their habitat ecology in River Ganga and its tributaries, Uttarakhand. *Journal of Experimental Zoology India*, *23*(2).

Malik, D., Sharma, A., Kamboj, V., & Sharma, A. (2024). Anthropogenic Impact on Habitat Ecology and Zooplankton Diversity in Ganges Riverine System Using Enviro Assessment Techniques. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, *94*(3), 505-518. https://doi.org/10.1007/s40011-024-01556-w.

Malik, D., Sharma, A., Kumar, S., Kumar, R., Kumar, R., Kamboj, V., & Sharma, A. (2022). Anthropogenic Impact on Fish Faunal Diversity and Their Habitat Ecology in the Ganga River and Its Tributaries, Uttarakhand. In *Springer Proceedings in Earth and Environmental Sciences* (pp. 53-71). Springer International Publishing. https://doi.org/10.1007/978-3-031-05335-1/_4.

Needham JG, Needham PR (1978). A guide to the study of freshwater biology, Halden, Day, Inc. Pul. San. Francisco, 225pp. A guide to the study of freshwater biology: Needham, James G. (James George), 1868-1957.

Obaidy, A. H. M. J., Talib, A. H., & Zaki, S. R. (2015). Application of water pollution index for assessment of Tigris River ecosystem. *Int J Adv Res*, *3*(2), 219–223.

Seiyaboh, E. I., Ogamba, E. N., & Utibe, D. I. (2013). Impact of dredging on the water quality of Igbedi Creek, Upper Nun River, Niger Delta, Nigeria. I*OSR Journal of Environmental Science, Toxicology and Food Technology*, *7*(5), 51-56.

Sharma, A. K., Kamboj, V., Sharma, A. K., Thakur, R., & Sharma, M. (2020). Water quality and its impact on phytoplankton diversity: A case study of Tehri Reservoir, Garhwal Himalayas. *Science Archives*, *01*(03), 166–173. https://doi.org/10.47587/sa.2020.1315

Sharma, A. K., Malik, D. S., & Bargali, H. (2018). Present status of fish diversity and population abundance of selected fish species in Bhagirathi river at Uttarakhand. *International journal of creative research thoughts*, *6*(1), 432–438.

Sharma, A. K., Malik, D. S., & Tyagi, D. (2019). Food and feeding habits of Tor tor (Hamilton, 1822) and Schizothorox richordsonii (Gray, 1832) inhabiting Bhagirathi River, Tehri Garhwal, India. *International Journal of Science and Nature*, *10*(1), 97-103.

Sharma, A., Malik, D., Kamboj, V., & Sharma, A. (2022). Waterbody status of upper Ganga basin and its major tributaries using enviro-assessment techniques. *World Water Policy*, *8*(2), 216-231. https://doi.org/10.1002/wwp2.12084.

Sharma, P., Shekhar, C., Sharma, A., Kumar, A., Dorach, R., Kumar, R., Kumar, S., & Sharma, A. (2026). A Systematic Review on Biodiversity and Ecological Integrity of Himalayan Freshwater Lakes. *Sustainable Environmental Insight*, *3*(2), 133-151. https://doi.org/10.53623/sein.v3i2.1086.

Shekhar, C., Khosya, R., Thakur, K., Mahajan, D., Kumar, R., Kumar, S., & Sharma, A. (2024). A systematic review of pesticide exposure, associated risks, and long-term human health impacts. *Toxicology Reports*, *13*, 101840. https://doi.org/10.1016/j.toxrep.2024.101840.

Wetzel RG (1983). Limnology. 2nd ed. Saunders College Publishing Co. New York, 767.

Xiong, W., Li, J., Chen, Y., Shan, B., Wang, W., & Zhan, A. (2016). Determinants of community structure of zooplankton in heavily polluted river ecosystems. *Scientific Reports*, *6*(1). https://doi.org/10.1038/srep22043.

Publisher's Note: JBRC remains neutral with regard to jurisdictional claims in published maps, figures and institutional affiliations.