SRI VENKATESWARA INTERNSHIP PROGRAM FOR RESEARCH IN ACADEMICS (SRI-VIPRA)



Project Report of 2025: SVPG-2504

"Comparative assessment of zooplanktons in selected waterbodies of Delhi NCR and correlation with water quality"

IQAC
Sri Venkateswara College
University of Delhi
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SRIVIPRA PROJECT 2024

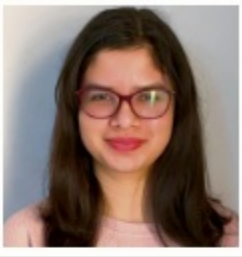
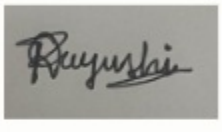
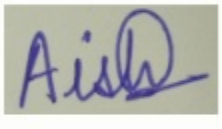
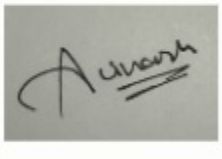
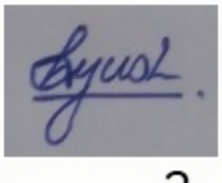
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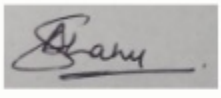
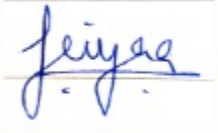
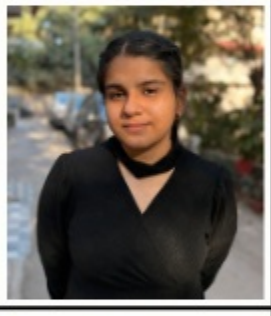
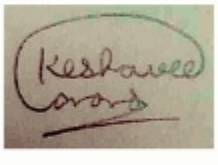
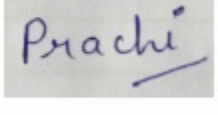
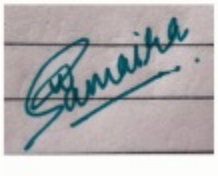
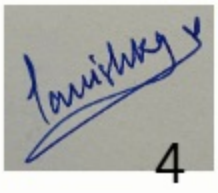
Name of Mentor: **Dr. Rajendra Phartyal** **Name of Department: Department of Zoology** **Designation:** **Assistant Professor**	



Signature

List of Students

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3		Aishwarya Gautam	2023007	B. Sc (H) Zoology	VI	
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8		Diptileena Sahu	1324033	B.Sc (H) Biological Sciences	IV	
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12		Samaira Wadhwa	1123015	B. Sc (P) Life Sciences	VI	
13		Tanishka Bodwal	1324005	B.Sc (H) Biological Sciences	IV	

Certificate of Originality

This is to certify that the afore mentioned students from Sri Venkateswara College have participated in the summer project SVPG - 2504 titled "Comparative assessment of zooplanktons in selected waterbodies of Delhi NCR and correlation with water quality" The participants have carried out the research project work under the guidance and supervision of Dr. Rajendra Phartyal - Department of Zoology from 1st July, 2025 to 18th February 2026. The work carried out is original and carried out in an offline mode.



Signature of Mentor
Dr. Rajendra Phartyal

Acknowledgement

We would like to extend our heartfelt appreciation to everyone who contributed to the successful completion of this project. Our sincere thanks go to our project team members for their dedication throughout the project. Each member played a significant role in shaping the outcome. We would like to thank Dr. Pankaj Kumar - Department of Environmental Sciences to grant access to the portable multiparameter probe to calculate physicochemical parameters. I would like to express my heartfelt gratitude to Sri Venkateswara College, University of Delhi for providing us the facility to conduct wet lab experiments to conduct Dissolved Oxygen estimation. Special thanks to our Principal Professor V. Ravi for their guidance and valuable feedback, which enriched our work.

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1. Abstract

Urban freshwater bodies are increasingly influenced by nutrient enrichment and physicochemical alterations resulting from anthropogenic activities (Williams et al., 2023). The present study evaluated zooplankton diversity in relation to selected water quality parameters across freshwater bodies of the Delhi-NCR region. Zooplankton samples were collected using standard plankton net methods and identified morphologically till genus level. Relative dominance, and qualitative evenness were assessed alongside measurements of pH, dissolved oxygen (DO), electrical conductivity (EC), total dissolved solids (TDS), and temperature.

Zooplankton assemblages were primarily composed of Rotifera, Cladocera, and Copepoda. Rotifers, particularly species of Brachionus and Keratella, dominated nutrient-enriched lakes, reflecting eutrophic conditions. Higher dissolved oxygen concentrations corresponded with greater species richness and more balanced community structure, whereas hypoxic systems exhibited reduced diversity and simplified assemblages . Elevated EC and TDS values were associated with increased rotifer dominance, indicating the influence of ionic and nutrient enrichment on community dynamics (Meredith et al., 2025). Among the measured parameters, dissolved oxygen emerged as the principal factor regulating zooplankton abundance.

The study demonstrates marked spatial heterogeneity in ecological status across Delhi-NCR lakes and underscores the utility of zooplankton as bioindicators for freshwater ecosystem assessment and urban lake management.

2. Introduction

Freshwater bodies are an essential component of urban and peri-urban ecosystems. They provide ecological services such as groundwater recharge, microclimate regulation, nutrient cycling, and habitat support for aquatic organisms (Oertli & Parris, 2019). Delhi–NCR, which is a rapidly urbanising area where freshwater bodies play a critical role. The freshwater bodies help in maintaining environmental stability amidst intense anthropogenic actions. Accelerated urban expansion, population growth, and unregulated land-use changes have resulted in the degradation of many waterbodies in this region through domestic sewage inflow, stormwater runoff, solid waste dumping, and nutrient enrichment (Vaid et al., 2025).

Zooplanktons are microscopic, heterotrophic planktonic organisms that drift or swim weakly in the water column of aquatic ecosystems. They can be both freshwater and marine. Zooplanktons form a crucial biological component of plankton communities and play a central role in aquatic food webs. Zooplanktons primarily function as primary consumers (Chowdhury et al., 2026). Zooplanktons mostly feed on phytoplanktons, bacteria and organic detritus. As a result they control the algal population in the water as well as play a vital role in transfer of energy from a lower trophic level to a higher trophic level (Declerck & Domis, 2022). Zooplanktons are highly sensitive to minor changes in physico-chemical properties of water such as temperature, pH, nutrient concentrations, dissolved oxygen, electrical conductivity, and total dissolved solids (Manickam et al., 2018). Changes in these properties result in change in zooplankton's community dynamics. Variations in zooplankton's diversity, community structure and abundance are used as biological indicators of water quality and trophic status in the freshwater ecosystem (Enawgaw et al., 2023).

In freshwater bodies, elevated nutrient loads and organic pollution lead to eutrophic conditions, favoring the dominance of tolerant taxa, particularly certain rotifer species, while reducing overall community diversity (Kuczyńska-Kippen et al., 2024). Whereas waterbodies with relatively better water quality support a more balanced and diverse assemblage of cladocerans and copepods (Zawisza, Zawiska, & Correa-Metrio, 2016). Thus, an integrated assessment of zooplankton diversity along with water quality parameters provides a comprehensive understanding of the ecological condition of freshwater lakes.

The freshwater bodies of the Delhi-NCR region have variation in their origin, hydrology, degree of urban influence, and management practices. Despite their ecological and socio-environmental significance, several waterbodies in this region remain inadequately studied, particularly with respect to combined biological and physicochemical assessments. Systematic evaluation of zooplankton diversity in relation to water quality is therefore essential for generating baseline data and identifying early signs of ecological degradation.

3. Objectives

The present study aims to assess the diversity, composition, and abundance of zooplankton in selected freshwater bodies of the Delhi-NCR region - Hauz Khas lake, Sanjay Van lake (Mayur Vihar), Surajpur wetland, Sanjay Van (Neela Hauz Biodiversity park), CITM lake, Badkhal lake, Rajendra Place and Jheel park (Dhaula Kuan). We aim to analyse key physicochemical parameters influencing their distribution. By examining the relationship between zooplankton community structure and water quality, this study seeks to evaluate the ecological status of these waterbodies and contribute to scientific knowledge that can support effective waterbody management, conservation strategies, and long term monitoring programs.

4. Study Sites

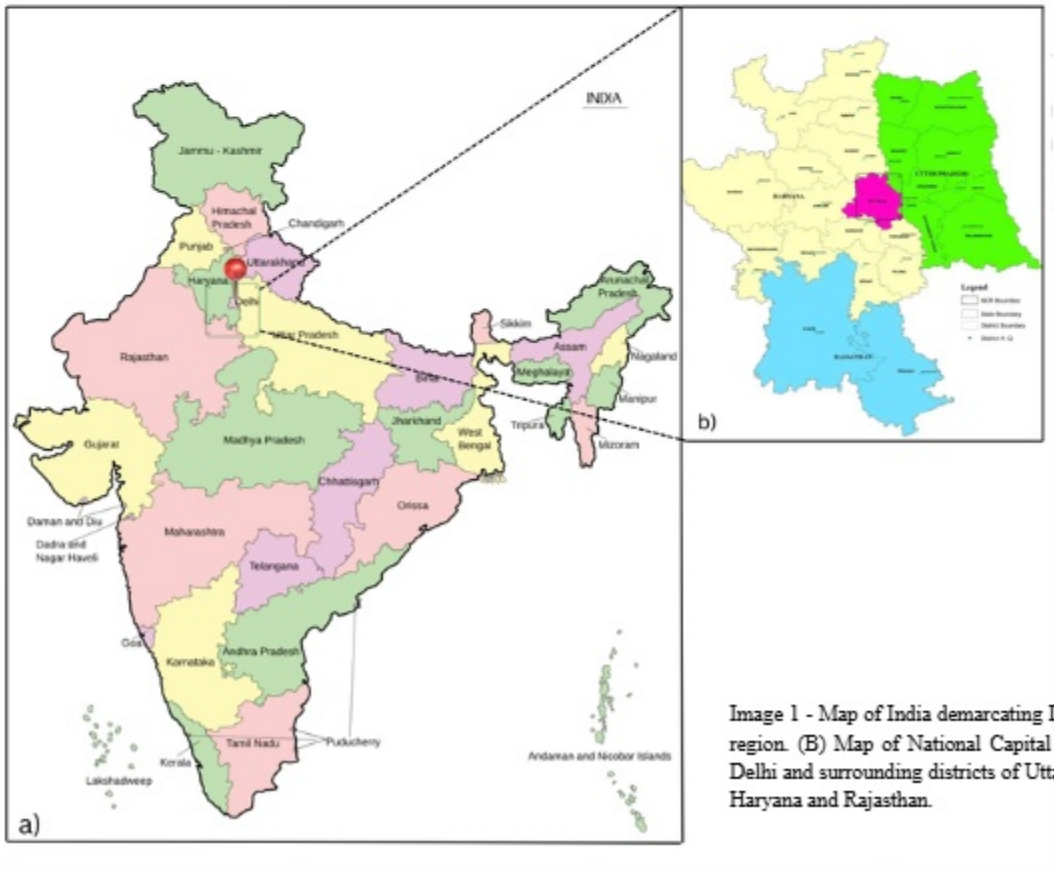


Image 1 - Map of India demarcating Delhi-NCR region. (B) Map of National Capital Region of Delhi and surrounding districts of Uttar Pradesh, Haryana and Rajasthan.

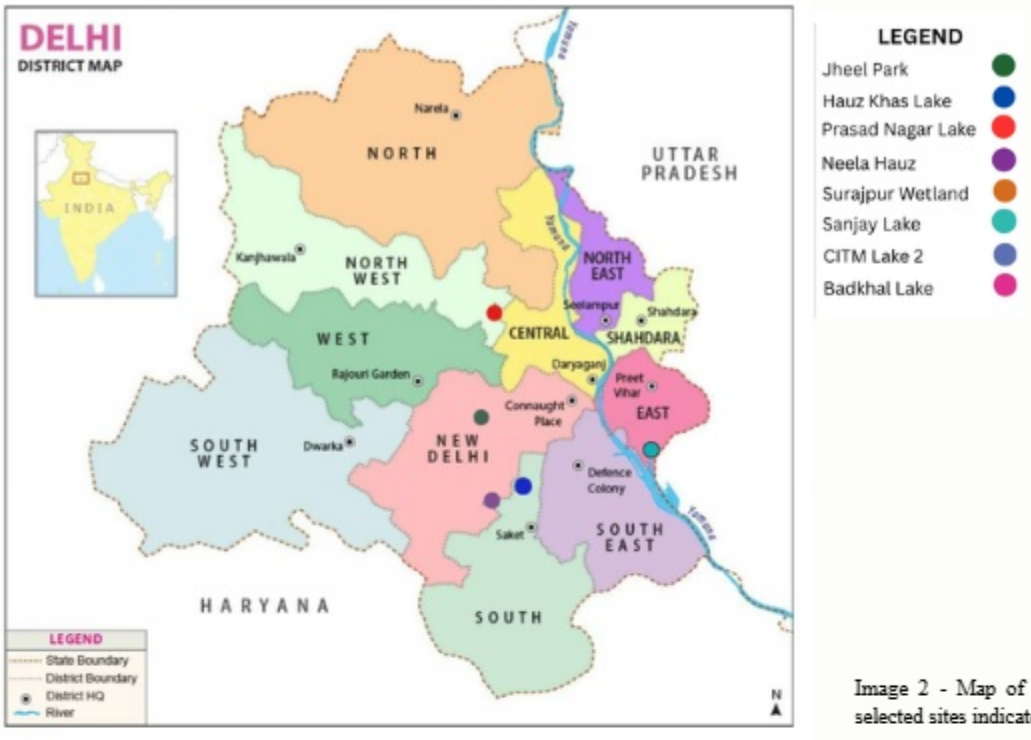


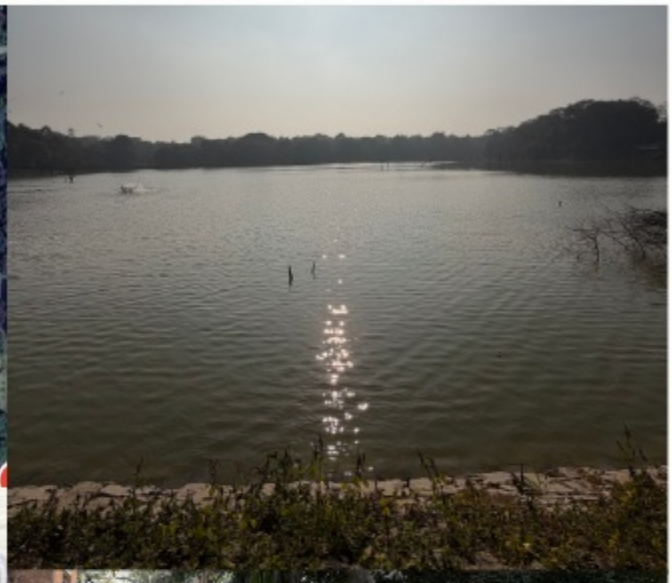
Image 2 - Map of Delhi showing location of selected sites indicated using different colours.

Site 1 – Prasad Nagar Lake, Jheel Park in Karol Bagh, Delhi - 110005



Site 2 – Hauz Khas Lake, X-31, Block X, Deer Park, Hauz Khas, New Delhi, Delhi - 110016









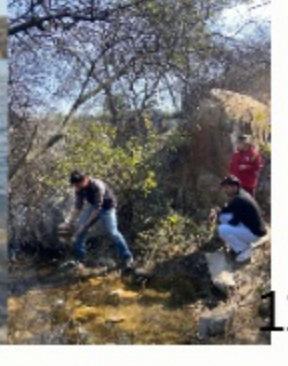
Site 3 – CITM Lake 2, Asola Wild Life Sanctuary, Asola, Haryana - 121004



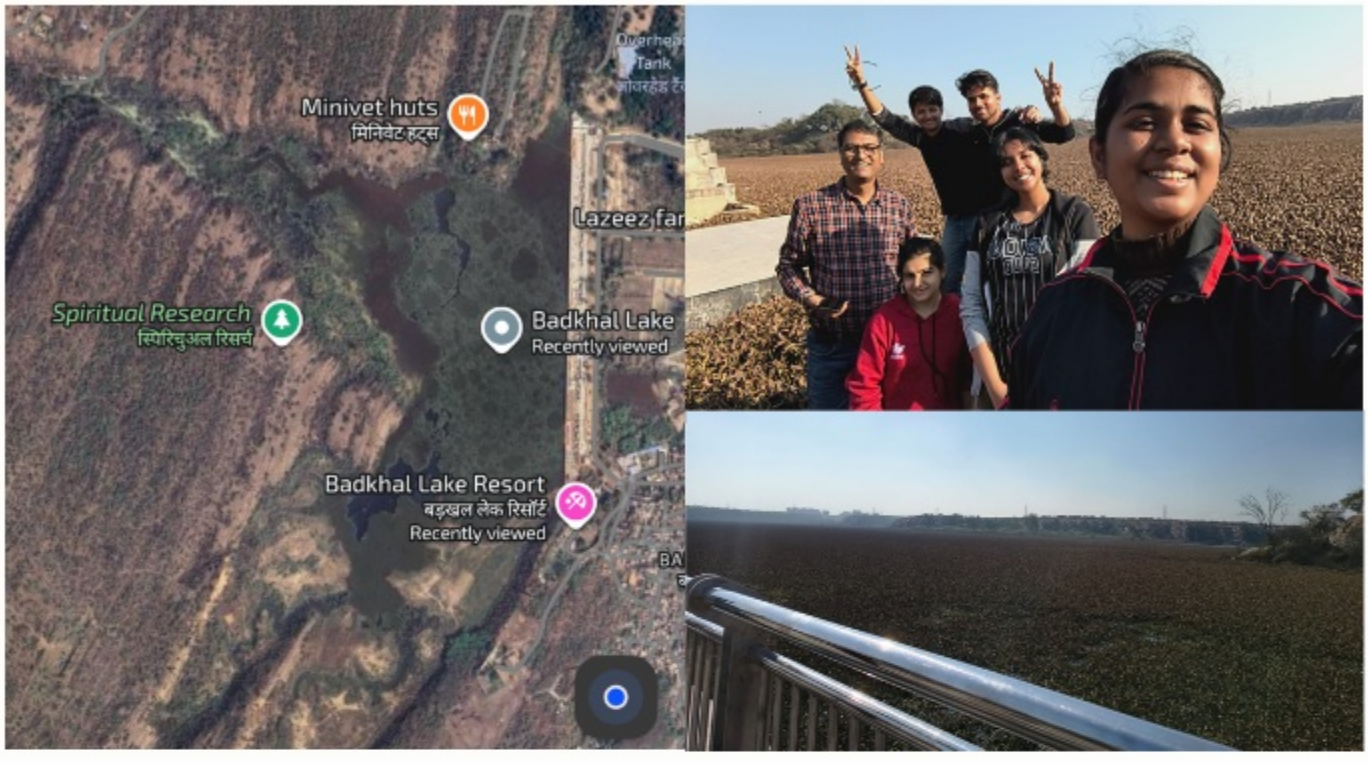








Site 4 – Badhkal Lake, Badkhal village, Faridabad, Haryana - 121004



Site 5 – Sanjay Lake, Pocket D, Mayur Vihar, Delhi - 110091



Site 6 – Surajpur Wetland, Surajpur, Greater Noida, Uttar Pradesh - 201306



Site 7 – Kitchners Lake, Jheel Park, situated in the Dhaula Kuan, New Delhi - 110021



Site 8 – Neela Hauz, Vasant Kunj,New Delhi, Delhi - 110067



The study was conducted at selected freshwater lakes located within the Delhi National Capital Region (Delhi–NCR), India. The selected sites represent urban, peri-urban, forest-associated, and semi-natural wetland ecosystems subjected to varying degrees of anthropogenic influence.

Sampling sites included:

1. Hauz Khas Lake (South Delhi),
2. Sanjay Lake (Mayur Vihar),
3. Neela Hauz/Sanjay Van Lake (Vasant Kunj),
4. Surajpur Wetland (Greater Noida),
5. CITM Lake 2 (Delhi NCR - Asola region),
6. Badkhal Lake (Delhi NCR-Faridabad),
7. Rajendra Place (Prasad Nagar) Lake, and
8. Kitchners Lake (Jheel Park, Dhaula Kuan).

The region experiences a semi-arid to subtropical climate characterised by hot summers (April-June), monsoon rainfall (July-September), and cool winters (December-February). Seasonal variation significantly influences water level, temperature, nutrient dynamics, and plankton distribution within these lentic systems.

5. Methodology

The study aimed to assess zooplankton diversity and evaluate its relationship with physicochemical characteristics of water. Sampling was carried out between November 2025 and February 2026 during morning and afternoon hours, when environmental conditions remain relatively stable and surface disturbances are minimal, thereby ensuring representative plankton sampling.

5.1 Zooplankton Collection

Zooplankton samples were collected using a multi-layer sieve assembly arranged in descending mesh sizes of 2000 µm, 180 µm, and 45 µm. Surface water was passed sequentially through the sieves to remove suspended matter and particulate debris and retain microzooplankton in the lowest mesh fraction (45 µm). This graded filtration method ensured selective concentration of planktonic organisms while minimizing contamination by suspended particulate matter (Uye & Kuwata, 1983).

The retained plankton fraction was carefully washed into labeled sample containers using distilled water. Samples were immediately fixed in 4% formalin at the collection site to preserve morphological integrity and prevent post-collection decomposition (Hahn et al., 2021). All samples were transported to the laboratory for further analysis.

5.2 Zooplankton Identification

In the laboratory, preserved samples were gently homogenized prior to examination. A sub-sample was withdrawn using a wide-mouth pipette and placed on a clean glass slide for microscopic observation.

Zooplankton were examined under a compound light microscope using 10× and 40× objectives. Identification was performed to the lowest possible taxonomic level, primarily genus and, where possible, species level. The major taxonomic groups recorded included Rotifera, Cladocera, Copepoda (including naupliar stages), and select protozoan taxa (Magny et al., 2011).

Identification was primarily carried out using the Google Lens application to identify the real time images of zooplanktons observed under microscope. Apart from that standard freshwater zooplankton taxonomic keys and literature, including classical limnological references. Morphological characteristics such as lorica shape, spine structure, appendage segmentation, and body symmetry were used as diagnostic criteria (Saksena & Sharma, 1986).

5.3 Quantitative Analysis

Relative abundance was determined by calculating the proportional representation of each taxonomic group within a sample. The dominance structure of the community was assessed based on frequency patterns, allowing identification of dominant and sub-dominant taxa across sites (Jones, 2008).

Although volumetric concentration using Sedgwick–Rafter cell was not employed, comparative abundance across sites was interpreted using consistent sampling methodology, ensuring relative reliability in spatial comparisons.

5.4 Water Quality Analysis

Physicochemical parameters were measured either in situ or immediately after sample collection. Water quality data were used to examine spatial variability among lakes and to assess correlations with zooplankton community structure.

5.5 Dissolved Oxygen (DO)

Dissolved Oxygen was determined using the Winkler iodometric titration method (Golterman, 1983). Water samples were collected in airtight BOD bottles, ensuring the absence of air bubbles. Manganous sulfate and alkaline iodide–azide reagents were added immediately at the sampling site to fix dissolved oxygen. After acidification in the laboratory, liberated iodine equivalent to the oxygen content was titrated against standardised sodium thiosulfate solution using starch as an indicator. DO concentration was calculated and expressed in mg/L.



Image 2: (A) Sieving process using multiple sieves stacked together in the order of 2000 µm, 180 µm, and 45 µm. (B) Collected of Zooplanktons from after successfully sieving 50 litres of water samples from each site. (C) Estimation of physicochemical parameters of water using a calibrated portable multi-parameter probe. (D) Collection of fixed water sample for Dissolved oxygen estimation.

5.6 Other Physicochemical Parameters

pH, temperature, electrical conductivity (EC), total dissolved solids (TDS), practical salinity units (PSU), oxidation–reduction potential (ORP), and pressure stability index (PSI) were measured using calibrated portable multi-parameter probe following standard limnological procedures. All instruments were calibrated prior to field measurements to ensure accuracy.

6. Results

6.1 Zooplankton Composition

The zooplankton assemblages recorded across the selected freshwater lakes comprised representatives of four major taxonomic groups: Rotifera, Cladocera, Copepoda (including naupliar stages), and Protozoa. Considerable spatial variation was observed in taxonomic composition and group dominance among the waterbodies. The zooplanktons were identified using googles image search tool.

6.2 Group-wise Composition

Rotifera

Rotifers constituted the most dominant and widely distributed group across all sampling sites. Genera such as Brachionus, Keratella, Polyarthra, Lecane, Lepadella, Mytilina, Trichocerca, Cephalodella, and bdelloid rotifers were recorded. Brachionus spp. were particularly dominant in Neela Hauz, Surajpur Wetland, and Sanjay Lake.

Keratella spp. showed high representation in Prasad Nagar and Hauz Khas Lake. Bloom-like dominance of Brachionus was observed in Neela Hauz. The widespread occurrence of rotifers indicates their adaptability to variable physicochemical conditions, especially in nutrient enriched urban lakes.

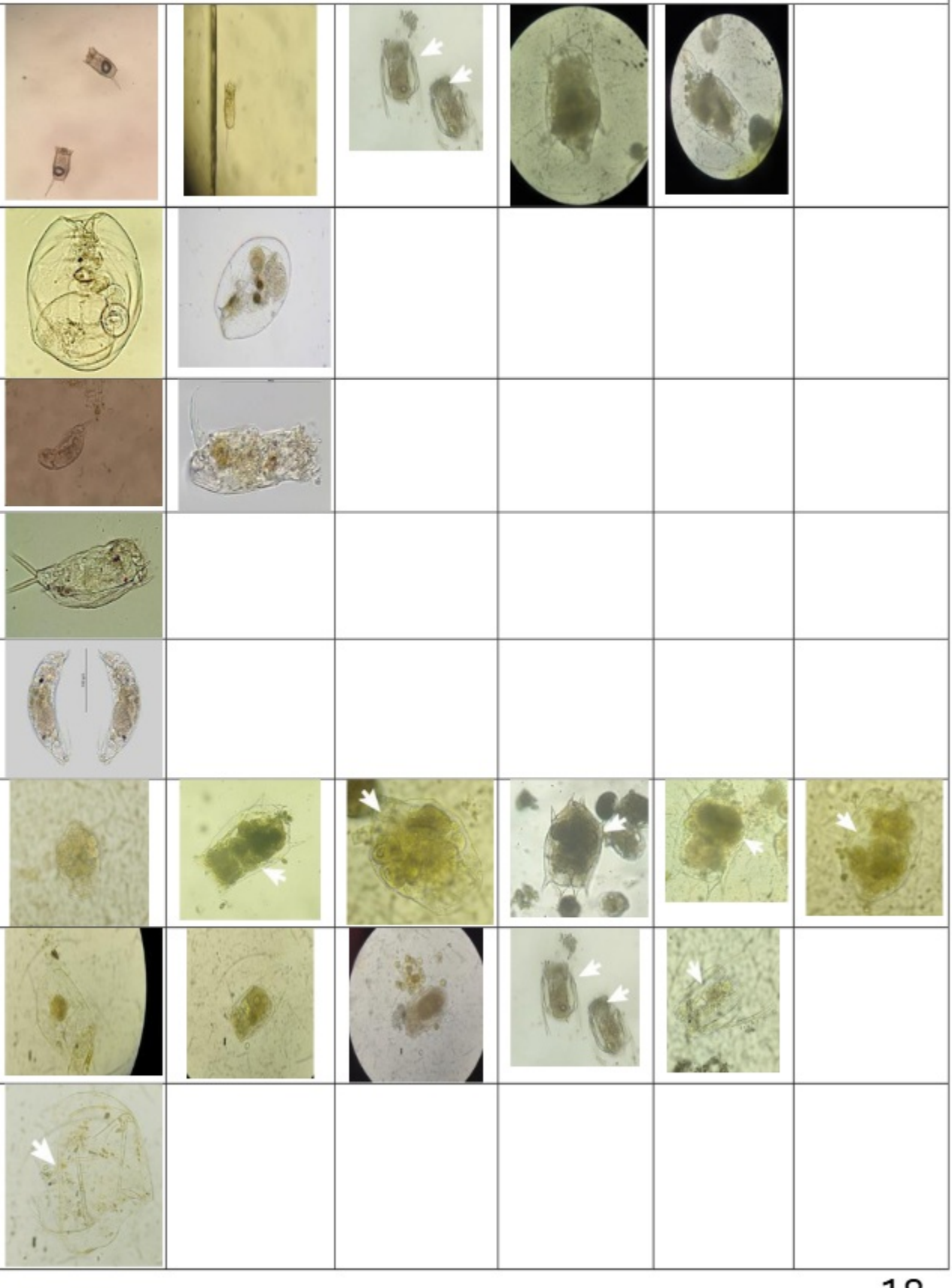
Cladocera

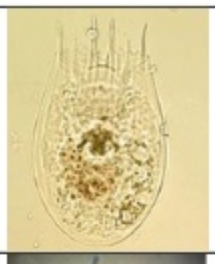
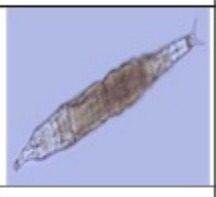
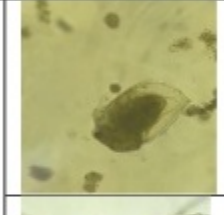
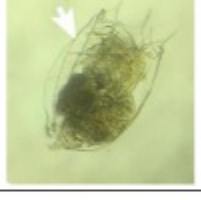
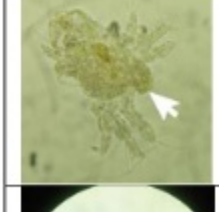
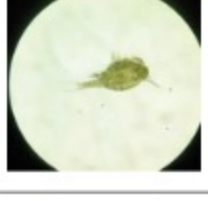
Cladocerans were moderately represented and included taxa such as Daphnia, Chydorus, Scapholeberis, and Polyphemus. Sanjay Lake and Hauz Khas Lake showed comparatively higher cladoceran representation. Cladocerans were sparse in Surajpur Wetland and Neela Hauz. CITM Lake 2 recorded limited cladoceran presence. Cladocerans were primarily observed in lakes with moderate to high dissolved oxygen, indicating sensitivity to hypoxic conditions.

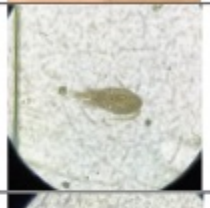
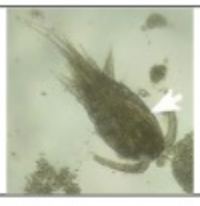
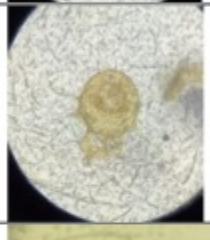
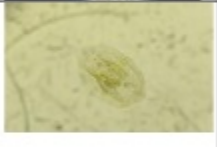
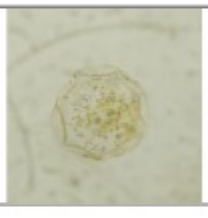
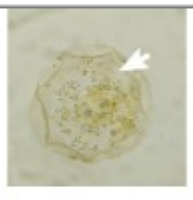
Copepoda

Copepods and their larval stages (nauplii) were recorded in multiple waterbodies. Identified taxa included Cyclops, Trophocyclops, Mesocyclops, Apocyclops, and naupliar forms. Sanjay Lake exhibited multiple copepod genera along with naupliar stages. Badkhal Lake showed relatively strong copepod representation despite low richness. Hauz Khas Lake recorded copepod larvae and nauplii in moderate numbers. The presence of naupliar stages across sites suggests active reproduction and recruitment within these systems.

Table 4: Comparison between different kinds of zooplanktons and lakes

GROUP	Zooplanktons observed under microscope at 4x magnification
Phylum: Rotifera	

						
						
						
						
Cladocera						
						
						
Copepoda						
						

						
						
						
Protozoa						
						

Protozoa and Other Taxa

Protozoan taxa such as Arcella, and Centropyxis were recorded in Kitchner's Lake and Badkhal Lake. Occasional nematodes and mosquito larvae were also observed in Prasad Nagar Lake. Protozoans were more common in sites exhibiting moderate to low water movement and possible organic enrichment.

Zooplankton Abundance

Zooplankton assemblages across the studied freshwater lakes of Delhi-NCR exhibited marked spatial variation in abundance, dominance structure, and taxonomic composition. A total of four major groups were recorded across sites: Rotifera, Cladocera, Copepoda (including naupliar stages), and protozoan taxa. Rotifera constituted the most dominant group in the majority of the waterbodies.

Table 2: Zooplanktons observed in each sample

Lake	Zooplanktons Identified	Frequency of Zooplanktons
Prasad Nagar Lake	Keratella sp. Asplanchna Nematoda Mosquito Larva Cephalodella sp. Daphnia Mytilina Copepod Trichocerca Brachionus Monognata rotifer Bdelloid rotifer	+++ ++ + + ++ +++ ++ + + ++ + +
Hauz Khas Lake	Cladocera Copepod larva(cyclop)- Nauplius Daphnia Chydorus Keratella sp.	++++ ++ +++++ ++ ++ ++++

Surajpur Wetland	Branchionus sp. Keratella sp. Copepod	+++++ +++ +
Sanjay Lake	Polyarthra Daphnia Branchionus sp. Cyclops Cyclops larva (Nauplius) Trophocyclops Notholca Asplanchna Keratella tropica Branchionus angularis Chydorus Keratella sp.	++++ ++ ++ ++ ++ + + + + + + +
Neela Hauz/ SanjayVan Lake	Branchionus app Polyarthra sp.	+++++ +
Kitchner's Lake	Arcella conica Lecane ungulata Lepadella Rotaria Keratella sp. Branchionus Keratella	+ + + + + +
CITM Lake 2	Polyarthra spp. Nauplius (cyclops larva) Chydorus Kellikotia	+ + + +

Badkhal Lake	Branchionus	+
	Mesocyclops	+++
	Apocyclops	+++
	Cyclops	++
	Copepod naupliar stage Larvae	+++++
	Lecane	+
	Polyphemus	+++

Site-wise study observations

Sanjay Lake is located in Trilokpuri in East Delhi. It is an artificial lake formed by the back flow of the Yamuna River and the Hindon River channel. It is developed by the Delhi Development Authority (DDA) in the 1970s in East Delhi, near Trilokpuri and Mayur Vihar II. It is spread across about 17 hectares, surrounded by a green belt and offers space for walking, jogging and outdoor activities. The area includes facilities such as boating, an adventure park and a tree-top course, making it a recreational spot for visitors. It also attracts bird-watchers and photographers at times. However, the overall experience may vary, as visitors sometimes notice issues like unpleasant smell and algae-filled water, which can affect the cleanliness and atmosphere of the place.

Upon arrival, the site exhibited signs of inadequate maintenance, including uneven pathways and scattered solid waste in certain sections. Despite these anthropogenic disturbances, the lake perimeter supported dense green vegetation, indicating the presence of an active terrestrial–aquatic interface and potential ecological productivity.

The combination of strong odor, visible algal biomass, and sediment accumulation indicates potential hypoxic or anoxic microenvironments within the lake. These conditions are typically linked to high biological oxygen demand (BOD), increased microbial activity, and ongoing organic matter decomposition.

(Mayur Vihar) recorded the highest overall zooplankton abundance and diversity. The assemblage included representatives from Rotifera (Brachionus, Keratella, Polyarthra), Cladocera (Daphnia, Chydorus, Scapholeberis), and Copepoda (including nauplii). The high abundance observed at this site coincided with elevated dissolved oxygen levels, supporting a multi-trophic zooplankton structure.

Neela Hauz / Sanjay Van Lake functions as an urban wetland ecosystem supporting diverse aquatic organisms, avifauna, and macrophytes. The surrounding area consists of dense vegetation and protected forest land, contributing to its ecological significance. Prior to sampling, official permission was obtained from the concerned authorities, as the lake lies within a protected forested zone.

visual observations indicated moderate turbidity and anthropogenic influence in certain areas. However, the lake continues to function as an ecologically important urban wetland supporting aquatic and avian biodiversity.

Water body exhibited pronounced dominance of Brachionus plicatilis, with counts substantially exceeding other taxa. Rotifers overwhelmingly dominated the assemblage, while cladocerans and copepods were comparatively sparse.

Surajpur Wetland, an urban wetland situated within the Yamuna River Basin. The wetland serves as a significant habitat for both migratory and resident bird species and plays an important ecological role in maintaining regional biodiversity.

The presence of diverse avifauna and visible aquatic activity suggests that Surajpur Wetland functions as a biologically productive ecosystem. The abundance of bird species indicates adequate food availability, likely supported by planktonic productivity and aquatic biodiversity.

Wetland showed high rotifer abundance, particularly Brachionus and Keratella species. Cladocerans were present but in lower proportions relative to rotifers. The assemblage structure indicated a skewed distribution favoring eutrophic-tolerant taxa.

Prasad Nagar (Rajendra Place) Lake, an urban water body located near Rajendra Place Metro Station. The lake falls under the jurisdiction of the Delhi Development Authority. The lake is estimated to be over 40 years old and was formerly part of Jheel Park. Historically, it suffered from neglect, pollution, encroachment, and water stagnation. However, it was revived in 2018 under a Delhi Government initiative aimed at restoring and maintaining urban water bodies.

A noticeable pungent odor was present, suggesting organic matter decomposition and possible sewage or municipal waste input. Residual floral and ritualistic materials were observed along the margins, likely contributing to nutrient enrichment following recent festive activities.

Study demonstrated moderate zooplankton abundance dominated primarily by rotifers, especially Keratella spp. and Brachionus calyciflorus. Occasional mosquito larvae and protozoans were also recorded, indicating localized stagnant conditions.

Hauz Khas Lake, functions as an urban wetland ecosystem supporting aquatic organisms, avifauna, and diverse plant life. The lake is surrounded by the historic structures of Hauz Khas Fort, contributing to its cultural and scenic importance. The site is also a popular public and tourist destination.

Prior to sampling, formal permission was obtained from the concerned authorities, as the lake area is protected and experiences high visitor footfall. A majority of the lake perimeter was secured with fencing and barricades to restrict direct access to the water body. Sampling was therefore conducted at the only accessible open section along the lake margin, ensuring both safety and compliance with site regulations.

Visual inspection indicated relatively clear water compared to other urban lakes studied. Occasional capture of small fish in the sieve during filtration confirmed the presence of active aquatic life. Additionally, the presence of ducks along the water surface further indicated ecological productivity and habitat suitability for avian species.

Waterbody exhibited moderate abundance with a relatively balanced distribution among rotifers, cladocerans, and copepods. The presence of Daphnia and copepod nauplii indicated comparatively stable ecological conditions.

Kitchners Lake (Jheel Park, Dhaula Kuan) the premises include landscaped park areas, walking pathways, public seating spaces, an open gym, and birdwatching shelters. Several birdwatching structures appeared abandoned, with some partially submerged, possibly due to increased water levels or sediment deposition. The consistent presence of local residents and families, even during weekday afternoons, indicates regular public usage of the site.

Visual and olfactory assessment suggested sewage inflow from adjacent residential areas, as evidenced by a persistent foul odor, possibly from the Dhaula Kuan Metro station, public toilets of bus stand and the eateries nearby. The water body exhibited a reddish appearance, likely attributable to algal bloom formation driven by nutrient enrichment. Elevated concentrations of nitrogen and phosphorus typically stimulate excessive phytoplankton growth, contributing to eutrophic conditions.

Waterbody showed low to moderate abundance, primarily composed of rotifers and protozoan forms. Cladocerans were limited in number, suggesting restricted trophic complexity

CITM Lake 2 also known as Bhardwaj Lake. The lake is located in Faridabad, Haryana, within the vicinity of the Asola Wildlife Sanctuary. CITM Lake 2 is an artificial water body formed as a result of illegal land excavation associated with former mining activities in the Aravalli region. The lake is surrounded by the rugged terrain of the Aravalli hills and is characterized by relatively clear, greyish blue water. The area remains comparatively isolated and minimally disturbed, contributing to its natural appearance.

The water appeared clear with minimal visible turbidity. A shaded marginal zone was selected for sampling to optimize zooplankton collection, as plankton density is often higher in relatively protected microhabitats.The clear water conditions suggest relatively low suspended particulate matter and potentially lower nutrient concentrations compared to eutrophic urban lakes. Such conditions may correspond with reduced plankton density but indicate comparatively lower levels of anthropogenic pollution.

The presence of diverse bird species and natural vegetation highlights the ecological value of the site within the Aravalli landscape. Despite its origin as a mining excavation site, the lake now functions as a semi-natural freshwater habitat supporting local biodiversity.

Waterbody recorded low overall zooplankton abundance. Only a few rotifer and cladoceran taxa were observed, and copepods were sparse. Species richness was notably lower compared to other sites.

Badkhal Lake was constructed shortly after India's independence in 1947 with the objective of storing runoff water to support irrigation in nearby agricultural fields. The lake was formed by constructing a bund between two low lying Aravalli hills to impound surface runoff.Over time, extensive illegal mining and quarrying activities in the surrounding region disrupted the natural inflow of water into the lake and damaged the underlying aquifers. These disturbances eventually resulted in severe depletion and near-desiccation of the lake. Additionally, urban expansion and environmental degradation in the catchment area contributed to the decline of its natural hydrological system.

In recent years, restoration efforts have been initiated to revive the lake. Currently, the primary source of water supply is a dedicated Sewage Treatment Plant located in Sector 21A, Faridabad. These efforts have led to partial recovery of the lake, with water levels reaching depths of approximately 7 meters in the central basin.

The lake surface was almost entirely covered by dense growth of Water Hyacinth, an invasive aquatic plant species. The thick mat of this vegetation blocks sunlight penetration into the water column, which can significantly reduce photosynthetic activity of submerged aquatic plants and phytoplankton. As a result, dissolved oxygen levels in the water may decline, leading to localized hypoxic conditions. In certain sections of the lake, the presence of foul odor was observed, possibly resulting from decomposition of organic matter and reduced oxygen availability beneath the dense plant cover.

The water body currently covers an estimated 250,000–300,000 square meters due to continuous inflow from the sewage treatment facility. The water appeared relatively clear, suggesting low turbidity levels.

Waterbody exhibited low species richness but moderate representation of copepods and nauplii relative to other groups. Rotifer abundance was comparatively limited. Overall density remained lower than highly productive sites such as Sanjay Lake.

Group-wise Abundance Trends

Across all sites, Rotifera emerged as the numerically dominant group. Cladocerans were primarily recorded in lakes with moderate to high dissolved oxygen concentrations. Copepods and their larval stages were distributed across multiple sites but were particularly evident in systems exhibiting either higher productivity (Sanjay Lake) or ecological stress (Badkhal Lake).

Lakes with elevated electrical conductivity and total dissolved solids demonstrated increased rotifer dominance, whereas hypoxic conditions were associated with reduced overall zooplankton abundance and simplified community structure.

Rotifera Dominance

Rotifera emerged as the dominant group in most lakes, particularly Neela Hauz / Sanjay Van – Strong dominance of Brachionus, contributing to overwhelming proportional dominance. Surajpur Wetland - Predominantly Brachionus and Keratella, representing the majority of recorded abundance. Prasad Nagar Lake – Multiple Keratella species and Brachionus collectively formed the dominant fraction.

Mixed Community Structure Sanjay Lake - Although rotifers were abundant, cladocerans and copepods contributed substantially to the total assemblage, resulting in lower dominance concentration. Hauz Khas Lake - Moderate rotifer representation with significant contributions from cladocerans and copepod nauplii.

Copepod/Cladoceran Influence in Badkhal Lake - Copepods and naupliar stages formed a considerable proportion of total abundance, indicating partial dominance shift toward crustacean zooplankton. CITM Lake 2 - Low overall abundance with relatively even representation of recorded taxa.

6.4 Water Quality Parameters

The physicochemical characteristics of water from different freshwater sites were analyzed to evaluate ecological status and trophic conditions. The parameters assessed included pH, Oxidation-Reduction Potential (ORP), Dissolved Oxygen (DO), Electrical Conductivity, Total Dissolved Solids (TDS), Practical Salinity Units (PSU), and Temperature.

Sites	pH	ORP	DO	Conductivity	TDS	PSU	Temperature	PSI
Hauz Khas	7.45	-75.5	4.8	510	255	0.25	14.27	14.249
Mayur Vihar (Sanjay Lake)	8.76	-61.6	7.8	1707	854	0.87	18.32	14.252
Surajpur	9.5	-61.8	4.8	1300	650	0.65	18.76	14.25
Sanjay Van	8.11	-70.4	5.4 (ML); 8 (OL)	935	468	0.46	15.55	14.334
CTIM	6.6	-86.9	2.8	396	198	0.19	18.07	14.253
Badkhal	6.85	9.6	1	842	421	0.42	17.71	14.255
Rajendra Place	8.1	38.2	#	810	405	0.29	22.7	14.273
Kitchners Lake	6.8	-283.9	1	2807	1403	1.46	21.93	14.288

Table 4: Physicochemical data observed for each selected sites using the portable calibrated physicochemical probe.

1. pH

The pH values ranged from 6.6 to 9.5, indicating variation from slightly acidic to strongly alkaline conditions. Highest pH was recorded at Surajpur (9.5), suggesting strong alkalinity, possibly due to high photosynthetic activity or carbonate dominance. Lowest pH was observed at CITM (6.6), indicating slightly acidic conditions. Most sites such as Hauz Khas (7.45), Sanjay Van (8.11), and Rajendra Place (8.1) were mildly alkaline, which is typical of productive freshwater ecosystems. Strongly alkaline conditions may influence zooplankton species composition, favoring tolerant taxa while excluding sensitive forms.

2. Oxidation-Reduction Potential (ORP)

ORP values varied widely from –283.9 mV to +38.2 mV. Extremely low ORP at Kitchners Lake (–283.9 mV) indicates highly reducing conditions, often associated with high organic load and oxygen depletion. Positive ORP at Rajendra Place (+38.2 mV) suggests comparatively oxidizing conditions. Most other sites showed moderately negative ORP values (–61 to –86 mV), reflecting reduced environments typical of organic-rich waters. Lower ORP values often correlate with eutrophication and increased microbial decomposition.

3. Dissolved Oxygen (DO)

DO values ranged from 1 mg/L to 8 mg/L, showing significant variation in oxygen availability. Sanjay Van (8{OL}), recorded the highest DO, indicating well-oxygenated conditions. Critically low DO was observed at Badkhal (1 mg/L) which was severely eutrpophicated with water hyacinths and had high organic load. At CITM the DO was low (2.8 mg/L) as it appeared to have very low phytoplankton content as its a recent lake with no anthropogenic interference. Moderate DO levels were recorded at Hauz Khas (4.8 mg/L), Surajpur (4.8 mg/L), and Mayur Vihar (7.8 mg/L). Sanjay Van showed DO of 5.4 mg/L . Low DO levels can significantly reduce zooplankton diversity and favor tolerant species.

4. Electrical Conductivity

Conductivity values ranged from 396 µS/cm to 2807 µS/cm, indicating differences in ionic concentration. Kitchners Lake (2807 µS/cm) and Mayur Vihar (1707 µS/cm) showed very high conductivity, suggesting high dissolved ion content. Lower conductivity was observed at CTIM (396 µS/cm) and Hauz Khas (510 µS/cm). High conductivity often reflects anthropogenic inputs, sewage inflow, or mineral enrichment.

5. Total Dissolved Solids (TDS)

TDS ranged between 198 mg/L and 1403 mg/L. The highest TDS was recorded at Kitchners Lake (1403 mg/L). The lowest was at CITM (198 mg/L). Moderate TDS levels were observed in Surajpur (650 mg/L) and Mayur Vihar (854 mg/L). Elevated TDS levels can influence osmotic balance in zooplankton and reduce sensitive taxa.

6. Salinity (PSU)

Salinity values ranged from 0.19 to 1.46 PSU (Practical Salinity Units/ Grams of salt per Kg of water), indicating predominantly freshwater conditions. Highest salinity was at Kitchners Lake (1.46 PSU). Other sites remained below 1 PSU, confirming freshwater nature with slight mineral enrichment. Even slight increases in salinity may alter freshwater plankton community structure.

7. Temperature

Water temperature ranged from 14.2°C to 22.7°C. Lowest temperature was recorded at Hauz Khas (14.2°C) and Highest at Rajendra Place (22.7°C). Most sites showed temperatures between 15–19°C, supporting active metabolic and reproductive processes in planktonic organisms. Temperature variation may influence seasonal plankton succession and dissolved oxygen solubility.

6.5 Correlation Between Zooplankton and Physicochemical Parameters

The relationship between zooplankton diversity and physicochemical parameters was analyzed to understand how environmental variables influence species richness, dominance, and distribution patterns across sampling sites.

1. Dissolved Oxygen (DO) and Zooplankton Abundance

A positive correlation was observed between dissolved oxygen (DO) and overall zooplankton diversity. Sites such as Mayur Vihar (DO: 7.8 mg/L) and Sanjay Van (DO: 5.4 mg/L) supported relatively higher zooplankton richness. In contrast, Badkhal (DO: 1 mg/L) and CITM (DO: 2.8 mg/L) showed reduced diversity and dominance of tolerant species. Higher DO levels enhance aerobic metabolic processes and favor sensitive taxa such as cladocerans and copepods, whereas low DO conditions promote dominance of rotifers and pollution-tolerant organisms (Nebeker et al., 1992).

2. pH and Species Composition

The pH values (6.6–9.5) showed moderate influence on species distribution. Strongly alkaline conditions at Surajpur (pH 9.5) may favor specific rotifer species adapted to high alkalinity. Slightly acidic to neutral conditions at CITM (pH 6.6) may restrict certain crustacean zooplankton. Overall, mildly alkaline conditions (pH 7–8.5) appeared most favorable for balanced zooplankton communities (Dorak et al., 2024).

3. Conductivity, TDS and Zooplankton Dominance

Electrical conductivity and TDS exhibited a negative correlation with species richness. Kitchners Lake (Conductivity: 2807 µS/cm; TDS: 1403 mg/L) showed reduced diversity and possible dominance of tolerant taxa. Lower conductivity sites such as CITM (396 µS/cm) supported comparatively stable freshwater assemblages. High ionic concentration may create osmotic stress, reducing the presence of sensitive zooplankton species (Moffett et al., 2020).

4. ORP (Redox Potential) and Community Structure

Strongly negative ORP values (e.g., Kitchners Lake: –283.9 mV) indicated reducing conditions associated with extremely high organic pollution.

Reducing environments are often linked to:

1. Increased microbial decomposition
2. Lower oxygen availability
3. Dominance of pollution-tolerant zooplankton

Thus, ORP showed an indirect negative relationship with overall diversity.

5. Temperature and Zooplankton Distribution

Temperature variation (14.27°C – 22.7°C) showed a moderate positive influence on zooplankton activity. Warmer sites such as Rajendra Place (22.7°C) may promote faster reproduction rates. Cooler sites like Hauz Khas (14.27°C) may show comparatively slower growth but higher oxygen solubility. Seasonal thermal differences likely influence reproductive cycles and population density.

6. Salinity Influence

Although all sites were freshwater (0.19–1.46 PSU), slightly elevated salinity at Kitchners Lake (1.46 PSU) may contribute to reduced freshwater species richness and favor tolerant taxa.

Overall Correlation Pattern

The correlation analysis suggests:

Positive correlation: DO and moderate temperature with zooplankton richness.
Negative correlation: High conductivity, TDS, strongly negative ORP, and extreme pH with species diversity.
Moderate influence: Slight salinity variations.

The results indicate that water bodies with moderate physicochemical parameters supported more diverse and balanced zooplankton communities, whereas sites exhibiting signs of eutrophication or pollution showed reduced diversity and dominance of tolerant species. These findings highlight the ecological sensitivity of zooplankton to environmental fluctuations and reinforce their importance as bioindicators of freshwater ecosystem health.

7. Discussion

The present study highlights significant spatial variation in zooplankton diversity and physicochemical characteristics across the selected freshwater sites. The observed patterns indicate that water quality parameters strongly influence zooplankton community structure, abundance, and dominance.

Influence of Dissolved Oxygen

Dissolved oxygen (DO) emerged as one of the most critical factors regulating zooplankton diversity. Sites with moderate to high DO levels supported comparatively richer and more balanced communities (Cross et al., 2021). Oxygen availability directly affects metabolic activity, reproduction, and survival of crustacean zooplankton such as cladocerans and copepods (Nebeker et al., 1992). In contrast, sites with critically low DO values showed reduced diversity and dominance of pollution-tolerant rotifers, indicating ecological stress. This pattern aligns with the established understanding that hypoxic conditions limit sensitive taxa and simplify trophic structure (Villnäs et al., 2012).

Role of pH and Alkalinity

The pH range from slightly acidic to strongly alkaline conditions influenced species composition. Mildly alkaline waters generally supported higher productivity, which in turn sustains zooplankton populations. However, extreme alkaline conditions may create physiological stress for certain taxa. The buffering capacity of water bodies with moderate alkalinity likely contributed to community stability (Wilkie et al., 1994).

Conductivity, TDS, and Anthropogenic Influence

High conductivity and TDS values in some sites suggest increased ionic concentration, possibly due to anthropogenic inputs such as sewage discharge, runoff, or mineral enrichment (Lu et al., 2015). Elevated ionic content can impose osmotic stress on freshwater zooplankton, reducing species richness and favoring tolerant forms (Arnott et al., 2022). The inverse relationship between conductivity/TDS and diversity observed in this study indicates ecological disturbance in highly mineralized waters (Clements & Kotalik, 2016).

Redox Conditions and Organic Load

Strongly negative ORP values in certain water bodies indicate reducing conditions associated with high organic matter decomposition (Li & Bishop, 2004). Such environments often correspond with eutrophic tendencies and lower dissolved oxygen availability. These conditions promote microbial activity but may suppress sensitive zooplankton species, leading to community simplification (King et al., 2024).

Temperature Effects

Temperature variation among sites likely influenced metabolic rates, reproduction, and seasonal succession of zooplankton (Forsblom et al., 2024). Warmer waters generally accelerate reproductive cycles but may reduce oxygen solubility, whereas cooler waters maintain higher DO levels but slower growth rates (Zhang et al., 2025). The observed diversity patterns suggest that moderate temperature conditions were most favorable for balanced community development. However, a year round study on these lakes need to be done to check variations with respect temperature as Delhi has a semi temperate climate with significant tempearture difference between summer and winter months.

Trophic Status and Ecological Implications

Based on nutrient enrichment indicators, oxygen levels, and ionic concentration, the studied water bodies range from mesotrophic to eutrophic conditions. Eutrophic tendencies were associated with reduced diversity and increased dominance of tolerant taxa, reflecting ecological imbalance (Berthelsen et al., 2024). Zooplankton communities effectively mirrored these variations, confirming their reliability as bioindicators of freshwater ecosystem health.

Comparison with Established Ecological Trends

The findings of this study are consistent with general limnological principles, where Higher DO correlates with increased biodiversity. Elevated organic load and eutrophication reduce community complexity (Lee et al., 2021). Moderate nutrient levels enhance productivity, but excessive enrichment leads to dominance shifts.

Overall Ecological Interpretation

The study demonstrates that physicochemical parameters collectively regulate zooplankton assemblages rather than acting independently. Sites exhibiting balanced water quality parameters supported diverse and evenly distributed communities, whereas ecologically stressed sites showed reduced richness and dominance by pollution-tolerant species.

These results emphasize the need for regular monitoring and management of freshwater bodies to prevent further ecological degradation. Zooplankton-based assessment, combined with physicochemical analysis, provides an effective tool for evaluating aquatic ecosystem health and guiding conservation strategies.

8. Conclusion

The present study demonstrates a clear relationship between zooplankton diversity and the physicochemical characteristics of the selected freshwater bodies. Significant spatial variations were observed in water quality parameters such as dissolved oxygen, pH, conductivity, TDS, ORP, temperature, and salinity, which collectively influenced zooplankton community structure and distribution.

Water bodies exhibiting moderate dissolved oxygen levels, balanced pH, and lower conductivity supported relatively higher species richness and more even community composition. In contrast, sites characterized by low DO, high TDS, elevated conductivity, and strongly reducing conditions showed reduced diversity and dominance of pollution-tolerant taxa. These patterns indicate ecological stress and eutrophic tendencies in certain locations.

The findings confirm that zooplankton serve as reliable bioindicators of freshwater ecosystem health. Their community structure effectively reflects variations in environmental conditions and trophic status. The study also suggests that several sites range from mesotrophic to eutrophic conditions, highlighting the influence of organic load and possible anthropogenic inputs.

Overall, the integrated assessment of biological and physicochemical parameters provides a comprehensive understanding of aquatic ecosystem functioning.

Regular monitoring and effective management strategies are essential to maintain ecological balance, improve water quality, and conserve freshwater biodiversity.

9. Management and Restoration Recommendations

The present study highlights varying degrees of eutrophication, oxygen stress, and community imbalance across freshwater lakes of the Delhi-NCR region. Based on the observed relationships between zooplankton diversity and physicochemical parameters, the following management and restoration strategies are recommended to improve ecological health and long-term sustainability.

9.1 Nutrient Load Reduction

Elevated electrical conductivity and total dissolved solids in several lakes indicate significant nutrient and ionic inputs, likely from urban runoff and domestic discharge. To mitigate eutrophication, Regulate and monitor inflow of untreated or partially treated wastewater. Establish vegetative buffer zones around lake margins to reduce surface runoff (Lukhele & Msagati, 2024). Implement sediment traps and constructed wetlands at inflow points to filter nutrients and suspended solids. Promote sustainable urban drainage systems (SUDS) to minimize nutrient-rich runoff. Reducing nutrient loading will help prevent rotifer-dominated bloom conditions and restore trophic balance (Yang & Lusk, 2018).

9.2 Enhancement of Dissolved Oxygen Levels

Low dissolved oxygen was strongly associated with reduced species richness and simplified community structure. To improve oxygen availability, Introduce mechanical aeration systems in hypoxic lakes (Carey, 2023). Improve water circulation through periodic flushing or controlled water exchange. Remove accumulated organic debris and excessive macrophyte biomass that contribute to oxygen depletion during decomposition (Xu et al., 2020). Maintaining adequate dissolved oxygen is critical for supporting diverse cladoceran and copepod populations and overall ecosystem resilience.

9.3 Periodic Ecological Monitoring

Regular monitoring of zooplankton diversity, coupled with physicochemical assessment, should be institutionalized as part of lake management programs. Conduct seasonal plankton surveys to track changes in species composition and dominance. Monitor key parameters such as DO, EC, TDS, and pH at fixed intervals. Use zooplankton assemblages as bioindicators to detect early signs of eutrophication or ecological stress. Long-term datasets will enable identification of trends and timely intervention.

9.4 Sediment and Organic Matter Management

Organic accumulation contributes to reducing conditions and oxygen depletion. Periodic desilting and sediment management may be necessary in lakes showing persistent hypoxia (Bormans, Maršálek, & Jančula, 2015). Controlled dredging can reduce internal nutrient loading. Management of macrophyte overgrowth can prevent excessive organic matter buildup (Sollie & Verhoeven, 2008). Such interventions should be carried out carefully to avoid disturbance to resident biota.

9.5 Conservation of Ecologically Balanced Systems

Lakes exhibiting moderate richness and balanced assemblages, such as Sanjay Lake and Hauz Khas Lake, should be prioritized for preventive conservation measures. Limit anthropogenic disturbance in catchment areas. Strengthen protection of forest-associated and semi-natural water bodies. Promote public awareness regarding the ecological importance of urban lakes. Preventive management is more sustainable and cost-effective than large-scale restoration.

9.6 Integrated Urban Lake Management

Given the urban setting of most study sites, lake restoration should be integrated with broader urban planning policies. Inter-agency coordination between municipal bodies, environmental authorities, and community stakeholders is essential to ensure sustainable freshwater ecosystem management.

10. Limitations and Future Scope

10.1 Limitations

While the present study provides valuable insight into zooplankton diversity and its relationship with physicochemical characteristics across freshwater lakes of the Delhi–NCR region, certain limitations must be acknowledged.

1. Temporal Constraint - The study was based on sampling conducted during a limited time frame. Zooplankton communities exhibit pronounced seasonal variation influenced by temperature fluctuations, hydrological changes, and nutrient dynamics. The absence of multi-seasonal data restricts the ability to capture temporal variability and long-term ecological trends.
2. Spatial Sampling Intensity - Sampling was conducted at selected representative points within each lake. However, freshwater lakes often display internal spatial heterogeneity influenced by depth gradients, macrophyte distribution, and inflow zones. More extensive spatial replication could provide finer resolution of community structure.

3. Limited Physicochemical Parameters - The analysis primarily focused on basic parameters such as pH, dissolved oxygen, electrical conductivity, total dissolved solids, and temperature. Direct measurements of nutrients (e.g., nitrate, phosphate, ammonia) and chlorophyll-a were not included, which would have enabled more precise trophic status classification.
4. Taxonomic Resolution - Zooplankton identification was performed using morphological keys under light microscopy. While effective for genus- and species-level identification in most cases, cryptic species and juvenile stages may not have been fully resolved. Molecular confirmation was not undertaken.
5. Absence of Advanced Statistical Modeling - The correlations presented are primarily descriptive and mechanistic in interpretation. Multivariate statistical analyses such as Canonical Correspondence Analysis (CCA) or Principal Component Analysis (PCA) were not performed, which could have strengthened inference regarding environmental drivers.

10.2 Future Scope

The findings of the present investigation provide a foundation for more advanced ecological assessment and long-term monitoring of urban freshwater systems. Future research may focus on the following directions:

1. Seasonal and Long-Term Monitoring - Conducting year-round sampling across pre-monsoon, monsoon, and post-monsoon periods would allow evaluation of seasonal succession patterns and hydrological influences on zooplankton dynamics.
2. Inclusion of Nutrient and Productivity Indicators - Incorporating analyses of nitrate, phosphate, ammonia, biological oxygen demand (BOD), chlorophyll-a, and primary productivity would allow precise trophic classification and improved understanding of eutrophication processes.
3. Application of Multivariate Statistical Approaches - Advanced statistical tools such as PCA, CCA, cluster analysis, and regression modeling could be applied to quantify relationships between environmental variables and community structure more robustly.
4. Molecular and DNA-Based Identification - Integrating DNA barcoding or environmental DNA (eDNA) approaches could improve taxonomic resolution, detect cryptic species, and enhance biodiversity assessment accuracy.
5. Assessment of Trophic Interactions - Future studies could examine phytoplankton–zooplankton interactions, fish predation pressure, and food web dynamics to better understand ecosystem functioning.
6. Restoration Impact Assessment - Monitoring zooplankton responses before and after restoration interventions (e.g., aeration, desilting, nutrient control) would help evaluate management effectiveness and guide adaptive strategies.
7. Urban Ecological Modeling - Development of predictive ecological models for Delhi–NCR lakes could support decision-making in urban water resource management.

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