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Plankton Diversity and Hydro-biological Parameters at Wazirabad Barrage in Yamuna River

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study conducted a comprehensive investigation into the qualitative and quantitative analysis of plankton diversity and Physico-chemical water quality parameters in the Yamuna River. Samples were collected from the Wazirabad barrage from June 2022 to November 2022, revealing a diverse phytoplankton community consisting of 50 genera distributed across five major classes. The abundant classes were Bacillariophyceae, with 18 genera, followed by Chlorophyceae with 20 genera, Cyanophyceae with 9 genera, Euglenophyceae with 2 genera, and Dianophyceae

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represented by a single genus. The qualitative analysis uncovered a zooplankton community with 20 genera from Protozoa and Rotifera, Copepoda, and Cladocera. Protozoa were represented by two genera, Copepods exhibited eight genera, Cladocera included five genera, and Rotifera featured four genera. The most abundant class of phytoplankton is Chlorophyceae and Zooplankton is Copepods. Physico chemical water quality parameters more fluctuation during the study period. These findings offer valuable insights into the biodiversity and composition of phytoplankton and zooplankton communities in the Wazirabad Barrage ecosystem.

Keywords: Water quality parameters; plankton; zooplankton.

1. INTRODUCTION

India has the most diversity globally due to its rich biological heritage. Biodiversity refers to the genetic and biological diversity of populations, species, communities, and ecosystems [1]. Freshwater habitats are Earth's most abundant and diverse ecosystems Revenga and Mock, [2]. About 6% of all identified species are found in freshwater ecosystems, which hold 0.01% of the world's water, cover only 0.8% of the planet's surface, yet provide nearly 3% of the world's net primary production (Dudgeon et al., 2006). Plankton are aquatic organisms that cannot swim against the water's currents Suthers et al., [3]. They are essential for maintaining marine life and fisheries [4]. Zooplankton, the primary consumer in the energy transfer between phytoplankton and higher trophic levels, is the other important component [5]. Plankton reacts at the slightest variation in surrounding ecosystems (Araujo et al., [6]. Therefore, plankton communities are frequently used as bioindicators to monitor ecological changes in aquatic ecosystems [7]. Aquatic food networks were founded by phytoplankton, and any modification to their organizational structure directly reduces output Malhotra et al., [8]. For a very long time, and with remarkable effectiveness, phytoplankton has been used to estimate and quantify the health of the aquatic ecosystem. A longer food chain and more instances of symbiosis result from greater diversity, which increases stability. Bhatnagar et al., [9]. Phytoplankton has been used with success in the estimation of water pollution. Water's physical, chemical, and biological properties significantly impact plankton productivity and the final aquaculture product output Dhanasekaran et al., [10]. The absolute and relative levels of nutrients in the watershed, particularly phosphorus, are typically used to forecast the effects of nutrients on the biomass of phytoplankton, which is frequently used to determine the trophic status [11]. Physical-chemical elements, the trophic condition of any water body, and the availability of nutrients directly impact the production of planktonic biomass, including zooplankton. The type and quantity of available and consumed food generally affect how big a fish grows, and any variations in food material quality and quantity will impact the fish growth rate. Additionally, within the given time frame, the type and abundance of phytoplankton can provide insight into the trophic state and nutritional health of the water body Busing, [12] Diazpardo et al., [13].

2. MATERIALS AND METHODS

2.1 Study Sites

Yamuna River is one of the largest tributaries of the Ganga River system. Samples were collected seasonally, pre-monsoon, monsoon, and post-monsoon, from the 'Wazirabad' barrage using plankton net. The integrated study of hydrobiological parameters of phytoplankton of the river was done to determine the health of the water bodies. The monitoring was done for six months, from June 2022 to November 2022. In the morning hours, at Wazirabad, barrage from four directions (East, West, South, and North) in the national capital region New Delhi. For this purpose, laboratory studies were conducted in the College of Fisheries Science, CCS HAU Hisar.

2.2 Plankton Sample Collection

Samples for plankton analyses at Wazirabad barrage were collected with the help of a plankton net and fitted with a wide-mouthed bottle. Fifty litres of water were sieved through the net at one spot. Sample materials were collected from each sampling point, fixed in Lugol's iodine, and transported to the laboratory in polythene bottles. Plankton enumeration was performed using samples preserved in Lugol's iodine Rodhe et al. 1958; Anderson [14]. Fifty-millilitre samples from each incubation were collected and immediately distributed into amber bottles with pre-dispensed Lugol's iodine,

resulting in a final concentration of 2 % (v/v) fixative. Fixed samples were enumerated using a Sedgwick–Rafter counting slide on a light microscope. Plankton was counted with the help of "Sedgwick– Rafter counting cell" as per the procedure given by Wetzel and Likens [15]. Samples were allowed to settle in the counting chamber for 2–4 minutes before enumeration. Ten fields of view were randomly selected across each slide and repeated three times. The data were statistically analyzed using PAST software. Biodiversity indices (Shannon and Wiener 1949) were determined. The methods of Ward and Whipple [16], Needham and Needham [17] and APHA [18] were used for plankton identification.

2.3 Water Quality Parameters Analysis

For the investigation, monthly water and plankton samples were collected from Wazirabad barrage, spanning June 2022 to November 2022. Four designated locations within the barrage were established in the east, west, north, and south. Surface water was obtained from each of the four sampling points at every site, utilizing 1-litre plastic containers thoroughly rinsed with test water before use. The filled containers were sealed and transported to the laboratory for physicochemical analysis. Standard procedures, as outlined by APHA (2005), were employed to assess the physicochemical characteristics of the water. Temperature and pH were promptly measured using a thermometer and pH meter. The Labrotonic Microprocessor was employed for monitoring salinity and electrical conductivity, while a TDS meter instantly determined the total dissolved solids (TDS). Free carbon dioxide was immediately calculated through titration against 0.041 N sodium hydroxide with phenolphthalein as an indicator. Immediate fixation of dissolved oxygen (DO) was conducted by carefully transferring water samples into 250 ml glass reagent vials to avoid air bubbles. Following sample collection, alkali-iodide azide and manganese sulfate reagents were added, and the bottles were taken to the lab for further analysis. Additionally, 1 litre of water samples was brought to the lab to assess the remaining parameters, APHA (2012).

3. RESULTS AND DISCUSSION

3.1 Plankton Diversity

Qualitative analysis of samples collected from the Wazirabad barrage found that the phytoplanktons in the barrage consisted of a total of 50 genera, belonging to five major groups, i.e. Bacillariophyceae (18 genera) and represented by *Achnanthes*, *Amphora*, *Caloneis*, *Cyclotella*, *Diatoms*, *Fragillaria*, *Gyrosigma*, *Melosira*, *Navicula*, *Nitzschia*, *Stauroneis*, *Synedra*, *Tabellaria*, *Binuclearia*, *Ankistrodesmus*, *Neidium*, *Stauroneis*, *Chlorella.* Chlorophyceae (20 genera) *Echinosphaerella*, *Elakatothrix*, *Eudorina*, *Hormidium*, *Hyalotheca*, *Microspoora*, *Oedogonium*, *Oocystis*, *Pandorina*, *Pleurotaenium*, *Schroederia*, *Scenedesmus*, *Tetraspora*, *Tetrastrum*, *Trochiscia*, *Ulothrix*, *Volvox*, *Zygnema*, *Pediastrum*, *Acutodesmus.* Cyanophyceae (9 genera) represented by *Merismopoedia*, *Microcystis*, *Nostoc*, *Oscillatoria*, *Spirulina*, *Anabena*, *Aphanocaspa*, *Aphnothecea*, *Gloeocapsa.* Euglenophyceae (2 genera) represented by *Euglena* and *Phacus.* Dianophyceae is represented by one genus, *Peridinium.* A similar type of research was conducted by Kshirsagar et al., 2012 and they found the qualitative analysis of algae in the water samples throughout the study period showed high algal diversity. A total of 75 genera and 162 species of algae were recorded from three sampling stations of the Mula River. At the Wazirabad barrage, the qualitative analysis of water samples found the 20 genera of zooplanktons belonging to Five groups: Protozoa and Rotifera, Copepoda, and Cladocera. Protozoa include two genera represented by *Paramecium, Arcella*. Copepods include eight genera represented by *Macrocyclops, Phyllodiaptomus, Mesocyclops, Nauplius, Cyclops*, *Hapacticoid Dicyclops, Eucyclops.* Cladocera comprises five genera: Moina, Alona, Moina, Daphnia, Ceriodaphnia, and *Bosmina.* Rotifera consists of four genera: Branchinous, Asplencha, Lecane, and *Diaphanosoma.* Rajagopal et al*.* [19] also recorded 47 taxa: 24 rotifers, nine copepods, eight cladocera, four ostracods and two protozoans.

3.2 Phytoplanktons Diversity in Yamuna River at Wazirabad Barrage

At the Wazirabad barrage, 53 species were found in different months. Out of 53 species, 20 belong to the Chlorophyceae 20 species belong to the Bacillariophyceae, ten belong to Cyanophyceae, two to the Euglenophyceae, and one to the Dianophyceae. Similarly, Kumar et al*.* (2020) also recorded and classified a total of 31 genera of phytoplanktons across five groups, namely Bacillariophyceae, Chlorophyceae, Myxophyceae, Euglenophyceae, and Xanthophyceae.

Table 1. Phytoplanktons diversity in Yamuna River at Wazirabad barrage

Groups	Species	June	July	Aug.	Sept.	Oct.	Nov.
Bacillariophyceae	*Achnanthes sp.*	+	-	-	-	-	+
	Amphora sp.	+	-	+	+	-	+
	Caloneis sp.	+	+	+	-	-	-
	Cyclotella sp.	+	-	-	+	-	+
	Diatoma sp.	+	-	+	+	+	-
	Fragillaria sp.	+	-	+	-	+	+
	Gyrosigma sp.	+	+	-	-	-	+
	Melosira sp.	+	-	+	+	-	+
	Navicula sp.	+	-	+	-	+	-
	Nitzschia sp.	-	-	+	-	+	-
	Stauroneis sp.	+	-	+	+	-	+
	Synedra sp.	+	-	+	-	-	-
	Tabellaria sp.	+	-	+	+	-	+
	Binuclearia sp.	+	-	+	+	+	-
	Ankistrodesmus sp.	-	-	+	-	+	-
	Neidium sp.	+	-	+	+	-	+
	Stauroneis sp.	+	+	-	-	+	+
	Chlorella sp.	+	+	+	+	+	+
Chlorophyceae	*Echinosphaerella sp.*	+	+	-	+	-	+
	Elakatothrix sp.	+	+	+	+	+	+
	Eudorina sp.	+	+	-	-	-	+
	Hormidium sp.	+	+	+	-	-	+
	Hyalotheca sp.	-	+	-	+	+	-
	Microspoora sp.	+	-	-	+	-	+
	Oedogonium sp.	-	-	+	-	+	-
	Oocystis sp.	+	-	-	+	-	-
	Pandorina sp.	+	-	+	-	+	+
	Pleurotaenium sp.	+	-	-	+	-	+
	Schroederia sp.	-	-	+	+	-	-
	Scenedesmus sp.	+	+	+	+	+	+
	Tetraspora sp.	-	+	-	-	+	+
	Tetrastrum sp.	+	-	+	-	-	-
	Trochiscia sp	+	+	+	-	+	+
	Ulothrix sp.	+	+	-	-	+	+
	Volvox sp.	+	-	+	-	+	-
	Zygnema sp.	+	-	-	+	-	+
	Pediastrum sp.	+	+	-	-	+	+
	Acutodesmus sp.	+	-	+	-	-	+
Cyanophyceae	*Merismopoedia sp.*	+	-	+	+	-	-
	Microcystis sp.	+	+	+	+	+	+
	Nostoc sp.	-	+	-	-	-	+
	Oscillatoria sp.	+	-	-	-	+	-
	Spirulina sp.	+	-	+	-	+	+
	Anabena sp.	+	-	+	+	+	+
	Aphanocaspa sp.	+	-	+	-	+	-
	Aphnothecea sp.	+	+	+	-	-	+
	Aphanocapsa sp.	+	+	+	+	+	+
	Gleocapsa sp.	-	+	-	+	+	+
Euglenophyceae	*Phacus sp.*	+	-	-	-	+	+
	Euglena sp.	+	-	-	-	+	+
Dianophyceae	*Peridinum spp.*	+	-	+	+	+	+

3.3 Composition of Different Phytoplanktons Species at Wazirabad Barrage

The per cent variation of Chlorophyceae, Bacillariophyceae, Cyanophyceae, Eugleno phyceae and Dianophyceae was 38 per cent, 37 per cent, 19 per cent, 4 per cent and 2 per cent. The maximum percentage shown by group Chlorophyceae was 38 per cent, and the minimum shown by group Dianophyceae was 2 per cent. The percentage variation of different phytoplanktons groups at the site Wazirabad Barrage (Fig.1).

3.4 Zooplanktons Diversity in Yamuna River at Wazirabad Barrage

At the Wazirabad Barrage, the total number of species observed in different months was 31. Out of 31 species, two belong to the Protozoa, five belong to the Rotifera, nine belong to Copepoda, and 15 belong to the Cladocera (Table 2).

3.5 Composition of Different Zooplankton Species at Wazirabad Barrage

The percentage variation of different groups, Cladocera, Copepoda, Rotifer and Protozoa, was 52 per cent, 31 per cent, 10 per cent and 7 per cent, respectively. The maximum percentage shown by Cladocera was 52 per cent, and the minimum shown by Protozoa was seven per cent. The percentage variation of different zooplankton groups at the site Wazirabad Barrage is given in (Fig. 2), and the monthly distribution species of zooplankton are given in (Table 2). Similarly Islam et al*.* (2022) similarly recorded a total of 71 species of zooplanktons under 37 genera belonging to 9 groups the dominant group of zooplanktons was 44 species of Rotifers (61.98 %), followed by 12 species of Copepods (12.68 %), five species of Cladocerans (7.05 %), three species of Protozoans (4.22 %), two species of Mollusks larvae (2.82 %), two species of Insects (2.82 %), one species of Cnidarian (1.41 %), one species of Nematode (1.41 %) and one species of Ostracod (1.41 %).

3.6 Quantitative Analysis of Phytoplanktons

The abundance of phytoplankton at Wazirabad Barrage in 2022, measured in numbers per litre. Over the studied period, the phytoplankton population fluctuated, reaching its peak in October (24,200 per litre) and its lowest point in July (15,600 per litre). Senthikumar and Sivakumar also reported an increased value of phytoplankton density during summer and post-monsoon seasons. In the present investigation, the phytoplankton fluctuates monthly, and its productivity was high during October and low during July, as evidenced earlier by Sadguru et al. [20]. A substantial proportion of the river is constituted by phytoplankton. The production of phytoplankton is intricately linked to factors such as temperature, turbidity, and nutrient levels, as indicated by the studies conducted by Srinivasan et al. [21] and Sukumaran and Das [22].

3.7 Quantitative Analysis of Zooplanktons

The abundance of zooplankton at Wazirabad Barrage in 2022, measured in numbers per litre, over the study period, the phytoplankton population fluctuated, reaching its peak in September (16,800 per litre). Its lowest point was in July (13000 per litre); similarly, Naskar et al*.* (2020) also reported the range of zooplankton between 174 to 769 n/l, and the average was 378.42 n/l. The abundance of herbivorous zooplankton in lakes and estuaries has been found to be associated with chlorophyll a and phytoplankton biomass, as documented by Pace [23], Nowaczyk et al. [24], and Hsieh et al. [25]. Generally, the overall stocks of zooplankton tend to increase with higher eutrophication levels, primarily due to an increase in small herbivores, as observed in studies by Hsieh et al. (2011). These factors are often recommended as key 'bottom-up' indicators, as suggested by Jeppesen et al. (2011).

3.8 Diversity Index of Phytoplankton and Zooplankton

The diversity index of phytoplankton sampling sites at Wazirabad Barrage varied from 1.076 to 1.220. The maximum value of the Shannon and Weaver Diversity Index was recorded in June, while the minimum was in July. The diversity index of zooplankton sampling sites at Wazirabad Barrage varied from 1.079 to 1.350. The maximum value of the Shannon and Weaver Diversity Index was recorded in July, and the minimum was recorded in November. Zargar and Ghosh (2006) also found that Shannon Weaver diversity values were generally higher in summer and winter compared to the monsoon season.

Table 2. Zooplanktons diversity in Yamuna River at Wazirabad Barrage

Groups	Species	June	July	Aug.	Sept.	Oct.	Nov.
Protozoa	*Paramecium sp.*	-	+	+	+	-	+
	Arcella sp.	+	+	-	+	-	+
Copepod	*Macrocyclops albidis*	-	+	-	-	+	-
	Phyllodiaptomus sp.	+	+	-	+	-	+
	Mesocyclops sp.	+	-	+	-	+	+
	Nauplius larva	-	+	+	-	-	-
	Cyclops sutifer	+	-	-	+	-	+
	Cyclops stretnum	+	+	+	+	-	+
	Hapacticoid copepods	+	-	-	+	-	+
	Dicyclops themsi	-	+	-	-	+	+
	Eucyclops sp.	+	+	+	-	-	+
Cladocera	*Daphnia pulicaria*	+	+	-	+	+	+
	Daphnia carinata	-	+	-	+	-	+
	Daphnia manga	+	+	-	+	-	+
	Daphnia laevis	-	+	+	-	-	+
	Daphnia similis	-	+	-	+	+	-
	Daphnia mendotae	-	+	-	+	-	+
	Alona sp.	+	+	+	-	+	+
	Moina micrura	+	+	-	-	-	-
	Moina macrocopa	+	+	+	-	+	+
	Daphnia pulex	-	+	+	+	-	-
	Daphnia longispina	+	+	-	+	+	+
	Diaphnosoma branchyrus	-	+	+	-	-	-
	Ceriodaphnia corunata	+	-	-	+	-	+
	Bosmina sp.	+	+	-	-	+	+
Rotifer	*Branchinous roundiformis*	+	-	+	+	-	+
	Branchinous variabilis	+	+	-	+	+	+
	Asplencha pariodonta	+	+	+	+	-	+
	Lecane mira	+	+	+	+	-	+
	Diaphnosoma sarsi	+	+	-	+	-	+

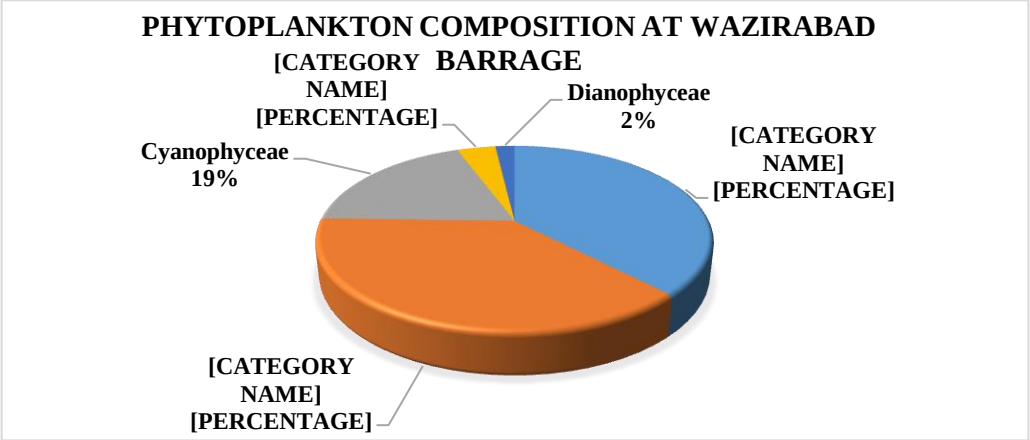

Fig. 1. Composition of different phytoplankton species at Wazirabad Barrage

3.9 Water Quality Parameters

During the study period, water quality parameters at Wazirabad Barrage for June to November 2022: The values are provided with their respective standard deviations for each month. Water temperature ranges from 20.48°C to 32.19°C, pH ranges from 7.42 to 8.40, Dissolved

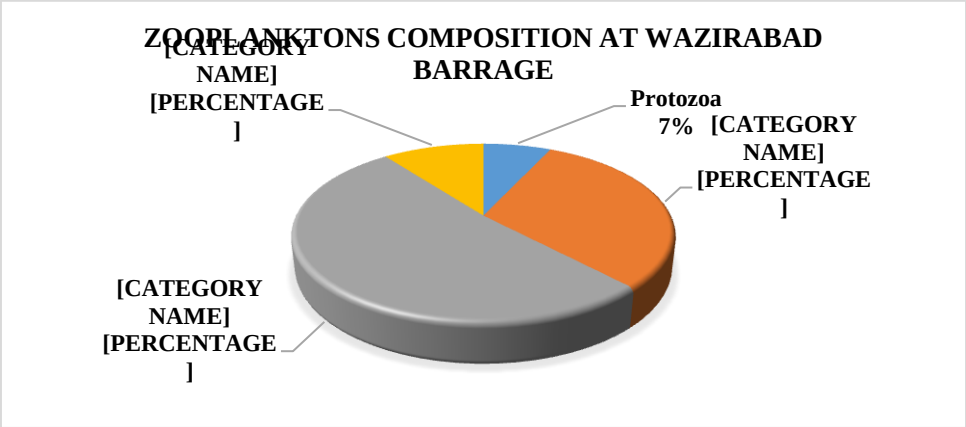

Fig. 2. Composition of different zooplankton species at Wazirabad Barrage

Table 3. Water quality parameters at Wazirabad barrage

Months(2022)	Temperature	pH	DO	EC	Free CO_2	TDS
June	32.19±0.04	8.40±0.04	4.12±0.08	1227.75±18.68	8.1±0.08	302.875±6.482
July	31.73±0.07	8.22±0.07	4.92±0.06	446±24.82	8.0±0.12	114.625±5.822
August	28.46±0.04	7.50±0.04	5.25±0.06	421.25±12.80	8.2±0.08	107.25±2.394
September	25.4±0.04	7.42±0.02	4.62±0.09	450±4.70	8.130.84	213.75±2.689
October	21.38±0.02	7.52±0.02	5.07±0.06	513.75±17.48	7.9±0.14	240.25±4.479
November	20.48±0.03	7.52±0.04	4.52±0.10	474.87±6.98	8.2±0.12	284±5.715

Oxygen (DO) varies from 4.12 mg/L to 5.25 mg/L, Electrical Conductivity (EC) ranges from 421.25 µS/cm to 1227.75 µS/cm, Free Carbon Dioxide (CO2) ranges from 7.9 mg/L to 8.2 mg/L and Total Dissolved Solids (TDS) ranges from 107.25 mg/L to 302.875 mg/L. Singh et al. [26] and Khanna et al. [27] observed a comparable conductivity pattern in the Ganga River at Bulandshahar and the Panvdhoi River at Saharanpur, respectively. The elevated conductivity values during the monsoon season are likely attributed to a significant presence of salts, silts, and higher ionic concentrations from the river inflow [28]. Khanna et al. [29] reported increased pH values during the monsoon season in their study on the Ganga River, possibly due to a heightened chemical load in the river, with minimum values observed in the winter season. This finding aligns with the results of Gautam et al. [30] in their study on the Subarnarekha River [31-35].

3.10 Correlation with Plankton Density and Water Quality Parameters at Wazirabad Barrage

In the Wazirabad Barrage, plankton density was positively correlated with free carbon dioxide (0.12) and total dissolved solids (0.63). In contrast, it is negatively correlated with temperature (0.95), electric conductivity (0.22), pH (0.64) and dissolved oxygen (0.14) [36-39].

4. CONCLUSION

This study provides valuable information on the diversity and distribution of plankton and water quality parameters in Wazirabad barrages located at Yamuna River. Seventy genera of plankton belonging to different groups were identified, with Bacillariophyceae and Chlorophyceae being the most dominant groups. The water quality parameters measured, including temperature, pH, electrical conductivity, and dissolved oxygen levels, varied across the barrages, indicating the potential influence of various factors such as industrial and municipal waste disposal and sewerage effluents. This study highlights the importance of regularly monitoring water quality parameters and plankton diversity in barrages to ensure sustainable management and conservation.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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