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The Assessment of Plankton Diversity in Yamuna River at Selected Sites in Haryana: A Post-COVID-19 Study

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ABSTRACT

The study was conducted in three sampling sites: Yamunanagar, Panipat, and Faridabad, along the Yamuna River. The samples were collected monthly from selected sampling sites from September 2021 to April 2022. Depending on their nature, plankton can be separated into two major groups, phytoplankton and Zooplankton. The qualitative analysis of these four samples in one site revealed that there are 17 genera of phytoplankton in total, belonging to four major groups, (i) Bacillariophyceae (consisting of 3 genera), (ii) Chlorophyceae (consisting of 10 genera), (iii) Euglenophyceae (consisting two genera), (iv) Cyanophyceae (consisting three genera). A total of 30 genera of Zooplankton belong to four classes i) Protozoa, ii) Copepoda, iii) Cladocera and iv) Rotifers. Copepoda included ten genera, Cladocera included 13 genera, Rotifers included 05 genera, and Protozoa represented by two genera only. The diversity of phytoplankton was maximum in a segment first Yamunanagar (value of Simpson's index is lower than 0.3416). The diversity of Zooplankton was maximum in segment first and almost equal to segment second Panipat. The temperature of river water ranged from 8.38±0.08 –21.33±0.13 °C, pH range from 6.00±0.11 - 8.03±0.11, D.O. from 1.68±0.06 – 8.10±0.007mg/l, total alkalinity from 83.25±0.48 – 351.75±11.89mg/l and total hardness 121.75±1.93 – 279.25±6.29mg/l.

Keywords Plankton diversity, Investigation, Carried, Significant portion.

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INTRODUCTION

The term biodiversity refers to the variances among living organisms and the ecological structures in which these variations occur. It includes diversity inside a species, between species, and among the species in an ecosystem (Kumar *et al*. 2020). The Yamuna River flows through Haryana and Delhi's

national capital district, beginning at the Yamunotri glacier in the lower Himalayas in Uttrakhand State (Chopra *et al*. 2017). Rivers are critical biodiversity systems and among the most prolific ecosystems because of the exceptional circumstances supporting a diverse range of flora and fauna. River ecosystems are one of the natural resources that benefit humanity in various world regions. They play a vital role in productivity as they are beset with varieties of flora and fauna, including plankton (Komala *et al*. 2013).

"Plankton" refers to microscopic, free-floating creatures in the water at the mercy of winds and currents. Depending on the environment, plankton can be divided into two major groups: Phytoplankton and Zooplankton (Kumar and Khare 2015). Phytoplanktons are minute creatures suspended in water that contain chlorophyll. They are primarily algae. The bulk of phytoplankton members are algae from the Chlorophyceae, Cyanophyceae, and Bacillariophyceae families. Because phytoplanktons are the foundation of aquatic ecosystems, changes in phytoplankton population directly relate to changes in water quality in any aquatic medium. The number and species of phytoplankton determine the quality of a body of water (Durge *et al.* 2018). Zooplankton is microscopic animal components of aquatic systems that move in response to water movement (current). The main groups of Zooplankton are Protozoans, Rotifers, Cladocerans, and Copepods (Fig. 1). Zooplanktons are an essential link in aquatic food webs between primary producers (mainly phytoplankton) and higher consumers (usually fishes). They hold an intermediate position in the food web, mediating energy transmission from lower to higher trophic levels. Zooplankton diversity is a critical biological element in determining water quality (Kumar and Khare 2015). Research has been conducted in this sector due to the importance of plankton variety and variation in density (Rajshekhar *et al.* 2010, Khanna *et al*. 2012, Shinde *et al.* 2012, Kadam *et al*. 2014, Verma *et al*. 2016, Kumar *et al*. 2020). Water quality parameters describe the physico-chemical properties of river water. These elements change across time and space. Human intervention with nature significantly impacts the natural concentration of environmental factors. The magnitude of socio economic activity, urbanization, industry, and hydropower generation greatly influences water resources. These operations affected water quality and aquatic biodiversity (Jain *et al*. 2018).

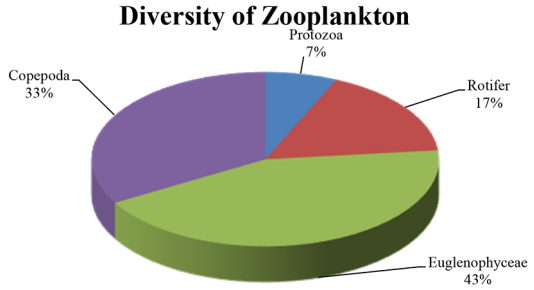


Fig. 1. Diversity of zootoplanktons.

MATERIALS AND METHODS

The present studies were conducted in three sampling sites named Yamunanagar, Panipat, and Faridabad along the Yamuna River were selected for the sampling purpose. The samples were collected monthly from selected sampling sites from September 2021 to April 2022. Plankton samples were collected between 8.0 AM and 9.30 AM at every selected sampling site. Plankton samples were collected by filtering 50L of water through a plankton net of mesh size 50µm with demarcating collecting tube. These samples were collected in 100 ml plastic bottles, and concentrated samples were then made up to a standard volume of 50 ml with distilled water. Samples were preserved with 4% buffered formalin. Plankton samples were examined under a high-power microscope and identified up to genus and species level with the help of standard books and monographs (Vijayan *et al*. 2021, Shukla *et al*. 2016).

The physico chemical parameters were analyzed at all three water sampling sites. Later, these samples were relocated to the research lab for further evaluation. All water samples collected from the river have gone through the laboratory procedure to evaluate physical and chemical parameters using the methodology available in APHA (2012). The water temperature was measured at the sampling sites using a digital thermometer. pH was recorded by a handy pH meter of Electronics India. However, total dissolved oxygen, total alkalinity, and total hardness were analyzed at the

Department by using the standard protocol mentioned in APHA (2012).

RESULTS AND DISCUSSION

During the study period, planktons were collected from three distinct places in the Yamuna River in Yamunanagar, Panipat, and Faridabad districts in Haryana. Depending on their nature, plankton can be separated into two major groups, phytoplankton and Zooplankton (Fig. 2). The qualitative analysis of these four samples in one site revealed that there are 17 genera of phytoplankton in total, belonging to four major groups, (i) Bacillariophyceae (consisting of 3 genera), (ii) Chlorophyceae (consisting of 10 genera), (iii) Euglenophyceae (consisting two genera), (iv) Cyanophyceae (consisting three genera). A total of 30 genera of Zooplankton belong to four classes i) Protozoa, ii) Copepoda, iii) Cladocera and iv) Rotifers. Copepoda included ten genera, Cladocera included 13 genera, Rotifers included 05 genera and Protozoa represented by two genera only (Table 1). The diversity of phytoplankton was maximum in a segment first Yamunanagar (value of Simpson's index is lower than 0.3416). The diversity of Zooplankton was maximum in segment first and almost equal to segment second Panipat (Tables 2-3). Kumar and Khare (2015) investigated the plankton Bacillariophyceae (5 species), Euglenophyceae (7 species), and Chlorophyceae (15 species), and Euglenophyceae (12 diversity and its seasonal change in density in the Yamuna River at Kalpi, district Jalaun, Uttar Pradesh. Thirty-five phytoplankton species were discovered, with 25 taxa represented, including species). Thirty-one genera in the five groups Bacillariophyceae, Chlorophyceae,

Table 1. Phytoplankton diversity in Yamuna riverine area at study sites.

Group	Study sites		
	Yamunanagar area	Faridabad area	Panipat area
Bacilliriophyceae	*Navicula sp.*	*Syendra sp.*	*Syendra sp.*
	Syendra sp.	*Cyclotella sp.*	-
	Cyclotella sp.	-	-
Cyanophyceae	*Anabaena sp.*	*Aphanizomenon sp.*	*Anabaena sp.*
	Microcystis sp.	-	*Microcystis sp.*
Chlorophyce	*Chlorella sp.*	*Coleastrum sp.*	*Chlorella sp.*
	Closterium sp.	*Oocystis sp.*	*Closterium sp.*
	Coleastrum sp.	*Protococcus sp.*	-
	Oocystis sp.	*Akinstrodesmus sp.*	*Oocystis sp.*
	Protococcus sp.	*Pedistrum sp.*	-
	-	*Anacystis sp.*	*Akinstrodesmussp*
	Pedistrum sp.	*Akinstrodesmus sp.*	*Pedistrum sp.*
	Anacystis sp.	*Desodesmus sp.*	*Anacystis sp.*
	Akinstrodesmus sp.	-	*Akinstrodesmus sp.*
	-	-	*Scenedesmus sp.*
	Desodesmus sp.	-	-
Euglinophyceae	*Euglena sp.*	*Euglena sp.*	-
	Phacus sp.	-	-

Myxophyceae, Euglenophyceae, and Xanthophyceae, as well as a total of 21 species of phytoplankton in the three significant categories Bacillariophyceae, Chlorophyceae, and Cyanophyceae, were observed

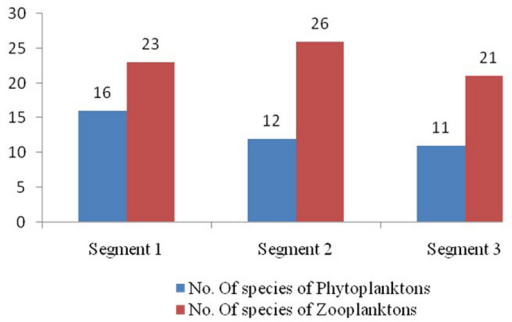


Fig. 2. Phytoplankton and zooplankton species in different segments.

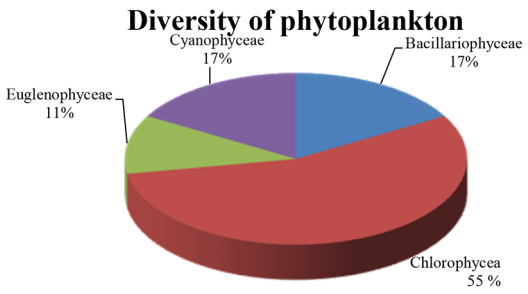


Fig. 3. Diversity of phytoplanktons.

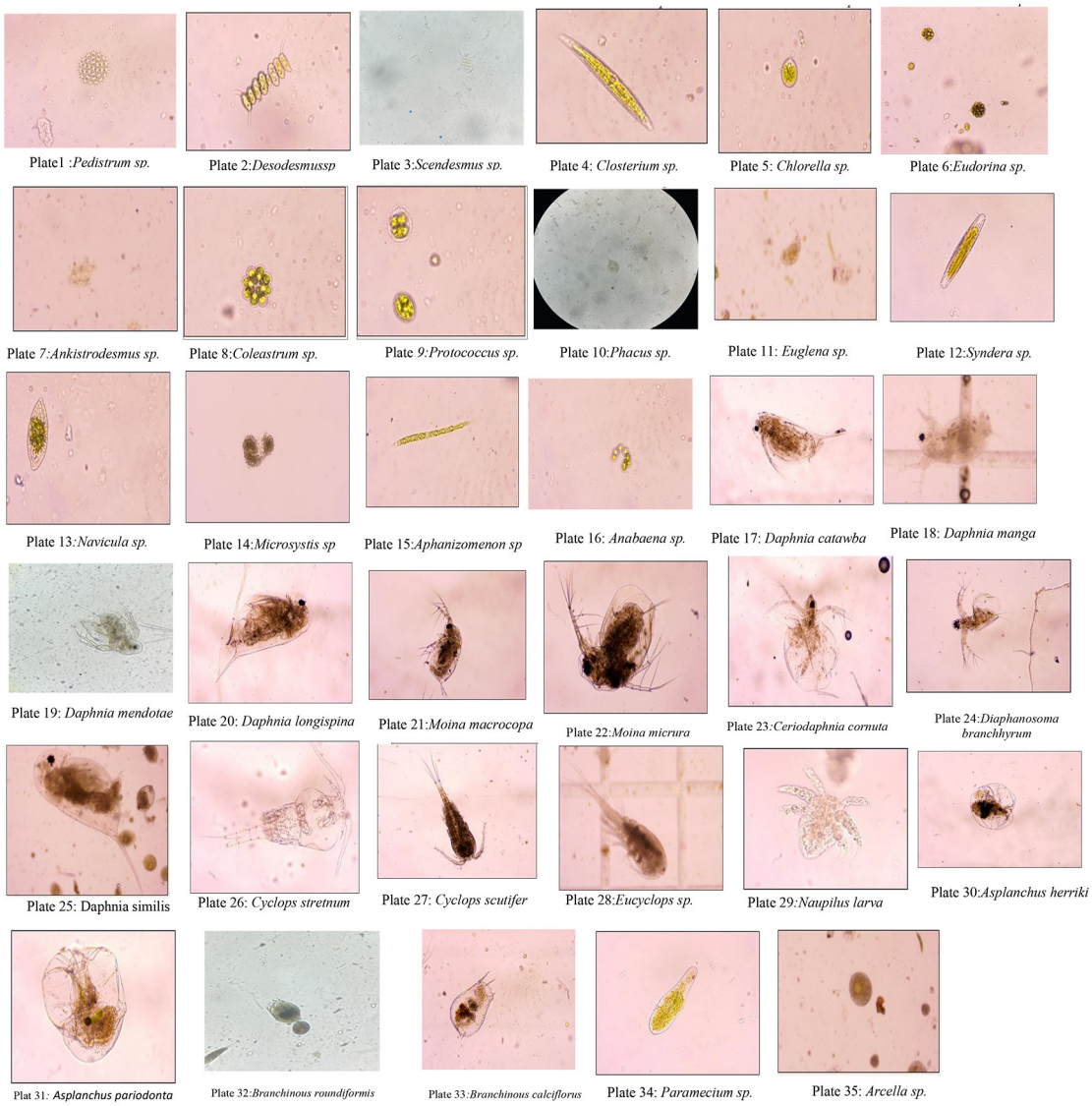
Table 2. Zooplankton diversity in Yamuna riverine area at study sites.

Group	Study sites		
	Yamunanagar area	Faridabad area	Panipat area
Protozoa	*Paramisium sp.*	*Paramisium sp.*	*Arcella sp.*
	Arcella sp.	*Arcella sp.*	
Copepoda	*Macrocyclopsalbidis*	*Cyclops stretnum*	*Eucyclops sp.*
	Phyllodiaptomus sp.		*Macrocyclopsalbidis*
	Mesocyclops sp.	*Macrocyclopsalbidis*	*Mesocyclops sp.*
	Diaptomus sp.	*Mesocyclops sp.*	-
	Naupilus larvae	*Hapacticoid copepods*	*Diaptomus sp.*
	Cyclops sutifer	*Naupilus larvae*	*Naupilus larvae*
	-	*Diacyclopsthemsi*	*Diacyclopsthemsi*
	-	*Cyclops sutifer*	*Cyclops sutifer*
Cladocera	*Daphnia pulicaria*	*Daphnia pulicaria*	*Daphnia catwba*
	Daphnia carinata	*Daphnia carinata*	*Daphnia carinata*
	Daphnia manga	*Daphnia longispina*	*Daphnia longispina*
	Daphnia laevis	*Daphnia manga*	*Daphnia manga*
		Daphnia laevis	*Daphnia laevis*
	Daphnia similis	*Daphnia similis*	*Daphnia similis*
	Daphnia mendotae	*Diaphnosomasarsi*	*Ceriodaphniacorunta*
	Diaphnosomasarsi	*Diaphno soma branchyrus*	*Moinamicrura*
	Diaphnosomabranchyrus	*Ceriodaphniacorunta*	*Moinamacrocopa*
	Moinamicrura	*Moinamicrura*	*Daphnia pulex*
	Moinamacrocopa	*Moinamacrocopa*	
	Daphnia pulex	*Daphnia pulex*	
		Moinamacrocopa	
Rotifera	*Branchinouspictilis*	*Branchinousroundiformis*	*Asplenchapariodonta*
	Branchinousroundiformis	*Branchinous variabilis*	-
	Asplenchaherrikki	*Asplenchaherrikki*	-
	Asplenchapariodonta	*Asplenchapariodonta*	-

and catalogued by Kumar *et al*. (2020). In the present investigation, 17 species belong to four major groups, i.e. Bacillariophyceae (3 genera), represented by *Navicula*, *Syndera*, and *Cyclotella*. Chlorophyceae (11 genera) represented by *Chlorella, Coleastrum, Pediastrum, Oocysits, Ankistrodesmus, Closterium, Scenedesmus, Desmodesmus, Protoccocus, Eudorina* and *Chlamydomonas*. Euglenophyceae (2 genera), represented by *Euglena*, *Phacus* and Cyanophyceae (3 genera) represented by *Anabaena, Microcystis*, and *Aphanizomenon* were reported (Tables 1 - 2) . The result was similar with different species compositions was different. The Chlorophyceae group was the most dominating group, which dominated the rest of the phytoplankton population (Fig. 3). The present inves-

Table 3. Simpson's diversity index of phytoplankton and zooplankton in all the segments.

Sl.No.	Diversity index	Yamunanagar	Panipat	Faridabad
1	Phytoplanktons	**0.3416**	0.4393	0.5272
2	Zooplanktons	**0.1936**	**0.1938**	**0.2047**



Plates 1-35. Phytoplanktons and zooplanktons reported in the study area.

Table 4. Water temperature of Yamuna River water at different study sites.

	Water temperature (°C)							
Studied sites	Sept (2021)	Oct (2021)	Nov (2021)	Dec (2021)	Jan (2022)	Feb (2022)	Mar (2022)	Apr (2022)
Yamunanagar	19.80±0.11	16.95±0.07	15.40±0.07	11.73±0.25	8.38±0.08	10.43±0.06	14.30±0.09	**20.68±0.05**
Panipat	19.80±0.31	18.05±0.09	15.90±0.17	11.95±0.33	8.50±0.18	10.43±0.06	14.13±0.11	**20.43±0.14**
Faridabad	21.25±0.10	20.63±0.55	17.25±0.10	13.95±0.07	9.88±0.09	11.23±0.09	15.68±0.09	**21.33±0.13**
CD (p=0.05)	0.64	1.04	0.39	0.79	0.40	0.23	0.31	0.36

Table 5. pH of Yamuna River water at different study sites.

Studied sites	pH							
	Sept (2021)	Oct (2021)	Nov (2021)	Dec (2021)	Jan (2022)	Feb (2022)	Mar (2022)	Apr (2022)
Yamunanagar	7.03±0.05	7.50±0.08	7.40±0.06	7.88±0.05	**8.03±0.11**	7.58±0.15	7.68±0.06	7.08±0.15
Panipat	6.95±0.03	7.13±0.15	7.15±0.10	7.08±0.13	7.13±0.06	**7.38±0.11**	6.85±0.07	6.80±0.07
Faridabad	6.85±0.07	6.50±0.08	6.53±0.08	6.33±0.17	6.00±0.11	**6.98±0.11**	6.83±0.09	6.33±0.13
CD (p=0.05)	NS	0.35	0.25	0.40	0.31	0.41	0.23	0.39

Table 6. Dissolved oxygen (DO) of Yamuna River water at different study sites.

Studied sites	Dissolved oxygen (DO) mgL^{-1}							
	Sept (2021)	Oct (2021)	Nov (2021)	Dec (2021)	Jan (2022)	Feb (2022)	Mar (2022)	Apr (2022)
Yamunanagar	**8.10±0.07**	7.90±0.07	**5.53±1.74**	6.58±0.15	6.68±0.10	6.40±0.11	6.53±0.09	7.20±0.13
Panipat	4.58±0.05	3.90±0.07	**4.80±0.11**	4.68±0.14	**3.63±0.08**	4.40±0.16	4.63±0.10	3.88±0.17
Faridabad	2.30±0.08	**2.33±0.09**	2.23±0.11	1.68±0.09	1.68±0.06	1.85±0.24	1.70±0.18	**1.33±0.06**
CD (p=0.05)	0.22	0.25	NS	0.41	0.27	0.57	0.42	0.42

tigation followed the same pattern as Chlorophyceae predominated among all species (Cladocera, Rotifera, Protozoa, Nematoda, Aostraca, Schizopyrenida). The water quality parameters were recorded in the present investigation from different sites (Yamunanagar, Panipat, and Faridabad). The temperature of river water range from 8.38±0.08 –21.33±0.13 °C (Table 4), pH range from 6.00±0.11 - 8.03±0.11 (Table 5), D.O. from 1.68±0.06 – 8.10±0.007mg/l (Table 6), total alkalinity from 83.25±0.48 – 351.75±11.89mg/l (Table 7) and total hardness 121.75±1.93 – 279.25±6.29mg/l (Table 8). Co-relation between water quality parameters was calculated, and it found a negative correlation between the water, temperature, pH, dissolved oxygen and total alkalinity. In comparison, there is a positive correlation between pH and dissolved oxygen. Similarly, the correlation between total alkalinity and total hardness shows a positive correlation (Table 9). The picture of planktons are listed from which includes both phytoplanton and Zooplankton (Plates 1 - 35).

Water parameter

Table 7. Total alkalinity of Yamuna River at different study sites.

Studied sites	Total alkalinity mgL^{-1}							
	Sept (2021)	Oct (2021)	Nov (2021)	Dec (2021)	Jan (2022)	Feb (2022)	Mar (2022)	Apr (2022)
Yamunanagar	83.25± 0.48	103.25±0.63	95.50± 0.96	139.75± 0.63	163.25± 1.38	124.75± 1.11	170.25± 0.63	**172.00±1.63**
Panipat	167.50±2.33	169.50±0.96	193.75± 2.53	147.00± 3.11	174.00± 2.94	158.00±2.86	177.00± 2.04	**194.00±2.16**
Faridabad	216.50±2.33	219.75±5.48	**351.75± 11.89**	289.75± 6.49	311.50± 10.48	175.50±25.39	330.50± 14.41	274.50±7.89
CD (p=0.05)	6.23	10.49	22.8	13.52*	20.55	NS	27.29	15.63

Table 8. Total Hardness of yamuna River water at different study sites.

	Total hardness mgL^{-1}							
Studied sites	Sept (2021)	Oct (2021)	Nov (2021)	Dec (2021)	Jan (2022)	Feb (2022)	Mar (2022)	Apr (2022)
Yamunanagar	121.75±1.93	146.25± 3.75	140.50± 2.26	146.75± 2.18	125.50± 2.87	169.75± 3.09	**209.50± 4.21**	182.75±1.44
Panipat	133.50±0.96	268.75± 2.69	268.75± 2.69	242.50± 2.10	127.00± 2.52	259.50± 3.78	**291.00± 1.92**	275.50±2.66
Faridabad	186.00±3.19	203.00± 2.35	203.00± 2.35	169.50± 9.74	186.25± 8.69	218.50± 12.09	**279.25± 6.29**	247.00±11.90
CD (p=0.05)	7.21	9.70	7.91	19.11	17.78	24.43	14.63	22.9

Table 9. Co-relation between water quality parameter.

	Water temperature	pH	Dissolve oxygen (DO)	Total alkalinity	Total hardness
Water temperature	1				
pH	-0.351**	1			
Dissolve oxygen (DO)	-0.058	0.731**	1		
Total alkalinity	0.031	-0.601**	-0.776**	1	
Total hardness	0.136	-0.264*	-0.408**	0.268	1

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

Temperature

In the present investigation, the maximum water temperature was recorded in different sites Yamunanagar (20.68±0.05), Panipat (20.43±0.14) and Faridabad (21.33±0.13) in April 2022 (Table 4). The minimum temperature was recorded during January 2022 (winter). That condition was observed due to low water levels during summer and natural climatic changes like minimum atmospheric temperature during winter and high summers.

pH

In the present investigation, the pH value recorded from Yamunanagar was a maximum of 8.03±0.11 (in January), in Panipat 7.38±0.11 (in February), and in Faridabad 6.98±0.11 (in February) (Table 5).

Dissolve oxygen

The dissolved oxygen in water is one of the most crucial parameters or factors of any aquatic ecosystem that decides its life. In Yamunanagar, the D.O. value ranges from 5.53±1.74 - 8.10±0.07. In Panipat, it was 3.63±0.08 – 4.80±0.4, while, in Faridabad, it was found to be the least among the recorded values, 1.33± 0.06 – 2.33± 0.09 (Table 6).

Total alkalinity

Water's total alkalinity is the capacity to neutralize a strong acid. Alkalinity in natural water bodies is mainly due to carbonates and bicarbonate ions in water. In the present investigation, it was observed at maximum in Yamunanagar at 172.00±1.63 mg/l, Panipat at 194.00±2.16 mg/l and in Faridabad (Table 7).

Total hardness

During the present investigation, the value of total hardness was recorded at maximum values in March,

209.50±4.21 mg/l (in Yamunanagar), 291.00±1.92 mg/l (in Panipat) and 279.25±6.29 mg/l (in Faridabad)—the sudden fluctuation in the value of total hardness in March in maximum value, maximum (351.75±11.89 mg/l) among the recorded values of total alkalinity (Table 8).

CONCLUSION

Yamuna River was rich in the diversity of plankton. A total of 17 genera of phytoplankton belong to four major groups, (i) Bacillariophyceae (3 genera), (ii) Chlorophyceae (10 genera), (iii) Euglenophyceae (2 genera), (iv) Cyanophyceae(3 genera). A total of 30 genera of Zooplankton belong to four classes i) Protozoa, ii) Copepoda, iii) Cladocera and iv) Rotifers. Copepoda included ten genera, Cladocera included 13 genera, Rotifers included 05 genera, and Protozoa represented by two genera only. The diversity of phytoplankton was maximum in a segment first Yamunanagar (value of Simpson's index is lower than 0.3416). The variety of Zooplankton was abundant in the first segment and almost equal to the second Panipat segment. Rotifer's population was dominant during the entire study period. The main goal of this investigation is to assess and observe the plankton diversity available in the Yamuna River in response to different essential physico chemical parameters and water quality.

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