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Research Paper

Seasonal Deviations in Zooplankton Population Dynamics in the Ganga River within Kanpur District

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ABSTRACT
Seasonal fluctuations in zooplankton abundance were investigated in the Ganga River within Kanpur district. The study aimed to understand how zooplankton populations vary across different seasons. Samples were collected from various points along the river at regular intervals during the rainy, winter, and summer seasons. The collected samples were then analyzed to determine the abundance and composition of zooplankton. The investigation aimed to explore the seasonal variations in zooplankton abundance within the Ganga River stretch over a span of 12 months from July 2015 to June 2016. The study identified 27 genera across four distinct groups: Protozoa (6 genera), Copepoda (4 genera), Cladocera (9 genera), and Rotifera (8 genera). Results indicated that the zooplankton population exhibited varying densities across the three seasons, with the highest density observed during the summer season, followed by the winter season and then the rainy season. Throughout the study period, the population of Rotifers emerged as dominant among the recorded zooplankton genera. These findings shed light on the seasonal dynamics of zooplankton populations in the Ganga River, emphasizing the significance of considering seasonal variations in river ecosystem assessments and management approaches.

Keywords: *Seasonal distribution, Zooplanktonic diversity, Ganga river.*

I. Introduction:

Planktonic diversity of an aquatic ecosystem directly reflects the conditions existing in the environment. Biological density of ecosystem was found to be the best indicator of healthy aquatic ecosystem. A planktonic population on which whole aquatic life depends is directly or indirectly governed by many biological conditions and tolerances of organisms to variations in one or more of these physic-chemical conditions of river water.

Zooplankton is free swimming microscopic animal. They play an important role in the energy transfer at different trophic structure of an aquatic ecosystem. They forms a remarkable bioindicator for water pollution. They play an important role of converting phytoplankton into food, which is suitable for fish and other aquatic animals. The zooplankton communities composed of both primary and secondary consumers. They are the direct link between primary producers and higher trophic level. Biodiversity of zooplankton is essential to keep the aquatic ecosystem healthy because each species plays a specific role (recycling of nutrients, food for another and maintaining of soil fertility) in the ecosystem and some species may allow natural ecosystem to functional a healthy manner (Anita *et al*., 2019). The study of zooplankton has been a fascinating subject for a long time. In the last two decades much attention has been paid in tropical countries towards the study of biology, ecology and toxicology of zooplankton due to their important role in the rapidly emerging concept in environmental management like Environmental Impact Assessment (EIA), bio indication of pollution and biological monitoring (Salve and Hiware, 2010). Most zooplankton are filter feeders that use their appendages to strain bacteria, algae and other fine particle of water (Sarwade and Kamble,2014).

Lotic systems are flow regime found to be one of the important factor associated with zooplankton diversity. So the present study is an effort to assess the seasonal changes in zooplanktonic diversity and density at three sites of Ganga river along the Kanpur stretch.

Kanpur, situated in Uttar Pradesh, India, is an industrial hub where the Ganga River is subjected to numerous stressors including pollution, climate change, habitat modification, eutrophication, and various human activities. Over time, chemicals and nutrients from industrial effluents, domestic sewage, tanneries, distilleries, and organic waste have accumulated in the river bed, disrupting the ecosystem's oxygen balance while also enriching aquatic biomass. Regular investigations have been conducted on the phytoplankton communities of the Ganga and Yamuna rivers, aiming to understand their dynamics over time and infer past environmental

conditions. This study focuses on the temporal changes in phytoplankton and zooplankton populations in the Ganga River at Kanpur, offering insights into how these organisms respond to environmental fluctuations. Understanding the natural variability of phytoplankton is crucial for predicting the impact of global change on aquatic ecosystems. As climate continues to warm and become more unpredictable, the ability of species to adapt to these changes will significantly influence food web dynamics. Therefore, this investigation aims to shed light on the historical environmental conditions of the Ganga River and their implications for future ecosystem functioning.

II. Materials and methods:

The present study was carried out at Kanpur stretch of the Ganga river for a period of twelve months from July,2015 – June,2016 for this purpose three different stations, (S1), (S2) and (S3) were selected for sampling purpose. To investigate the seasonal variations in zooplankton diversity plankton sample were collected fortnightly between 8.30 to 9.30 AM from all the three stations of Ganga river. Plankton net of bolting silk no.25 was used for collecting the zooplankton. Zooplankton was collected from mid stream 0.5 to 1.0 m below the surface of water by sieving a 50 liter volume of water sample. Collected concentrated zooplankton samples (10 ml) were fixed and preserved in 5% formalin. Plankton samples were examined under high power microscope and identified by using keys by using standard key. Plankton productivity was measured by using Sedwick Refter Plankton counting cell and calculated by using formula,

No. of zooplankton / lit= a × c / ℓ

Where, a= No. of zooplankton counted in 1 ml, c = ml. of zooplankton concentrate. ℓ= Volume of original water sample taken.

III. Result And Discussion:

The Seasonal variations of zooplankton of Ganga river at Kanpur are given in table 1 and 2. The zooplankton population in three seasons were represented by 27 genera belonging to four different groups *viz*. Protozoa (6 genera), Copepoda (4 genera), Cladocera (9 genera) and Rotifera (8 genera) (Table 1.). In the present investigation maximum density was recorded in summer season (901individuals /L) followed by winter season (462 individuals / L) and rainy season (285 individuals / L) (Table 2). Zooplankton abundance was increases gradually in winter reaching maximum in summer. This finding is in similar pattern reported by Sharma(2018). Among recorded zooplankton Rotifer's population was dominant during entire study period.

Protozoans constitute important links in the food webs, are employed in biological and medical research act as an indicators of pollution and petroleum deposits and also acts as the natural enemies of harmful bacteria, thus aiding in soil fertility (Gharpure and Bhatkulkar, 2015). In the present study Protozoans are represented by six genera *viz, Arcella, Centropyxis, Diffugia, Paramecium, Volvox* and *Vorticella* species. Mean value of density of recorded Protozoans was from 4- 34 individuals/ L at three sampling sites. Highest density of Protozoans was found in Summer season (represented by all 6 genera) while lowest density of Protozoans was observed in the rainy season (represented by only 4 genera).

Copepods form primary food source of plankton feeders fishes and hence constitute an essential link with food chain. In the present study copepods are represented by four genera *viz Cycpops, Mesocyclops,Heliodiaptomus* and *Neodiaptomus* species. Mean value of density of recorded Copepods was from 11-52 individuals/ L at three sampling sites. Highest density of Copepodes was found in Summer season (represented by all 4 genera) while lowest density of Copepodes was observed in the rainy season (represented by only 2 genera). During present study, it was observed that these are absent at the polluted sites.

Cladocerans played an important role in limnotic and benthic food chain. Most of the cladoceran species are primary consumers of microscopic algae and fine particles of detritus. In the present study Cladocerans are represented by nine genera *viz Alona, Bosmina, Ceriodaphnia, Coronatella, daphnia, diaphanosoma, Indialona Mmacrothrix* and *Monia* species. Mean value of density of recorded Cladocerans was from 6-92 individuals/ L at three sampling sites. Highest density of Cladocerans was found in Summer season (represented by 8 genera) while lowest density of Copepodes was observed in the rainy season (represented by only 4 genera). Presence of Daphnia at Kodhari Ghat(S1) indicates that this sites is free from organic load.

Table 1. Seasonal variation of Zooplankton in Ganga River at Kanpur

S.N.	Group / Genera	Rainy Season	Winter Season	Summer Season
	Protoza			
1.	*Arcella*	+	+	++
2.	*Centropyxis*	-	-	+
3.	*Diffugia*	+	+	+
4.	*Paramecium*	+	++	+++
5.	*Volvox*	-	+	++
6.	*Vorticella*	++	++	++

	Rotifera			
7.	*Asplanchna*	++	++	+++
8.	*Brachionus*	+	++	+++
9.	*Euchlanis*	-	-	+
10.	*Filinia*	-	+	+
11.	*Keratella*	+	++	++
12.	*Philodina*	-	-	+
13.	*Polyarthra*	-	+	+
14.	*Trichocera*	+	+	++
	Cladocera			
15.	*Alona*	++	+	+
16.	*Bosmina*	+	+	+
17.	*Ceriodaphnia*	-	-	+
18.	*Coronatella*	+	+	+
19.	*Daphnia*	-	+	++
20.	*Diaphanosoma*	-	+	-
21.	*Indialona*	-	+	+
22.	*Macrothrix*	+	++	++
23.	*Monia*	-	+	++
	Copepoda			
24.	*Cyclops*	+	++	++
25.	*Mesocyclops*	-	+	+
26.	*Heliodiaptomus*	+	-	++
27.	*Neodiaptomus*	-	++	+++
-, absent; +, rare; ++, common; +++, abundant				

The provided table summarizes the abundance of different groups or genera of zooplankton across three seasons: rainy, winter, and summer. The symbols "-", "+", "++", and "+++" represent absent, rare, common, and abundant respectively.

In the rainy season, several genera of protozoa, such as Arcella, Diffugia, Paramecium, and Vorticella, are relatively common or abundant, while others like Centropyxis and Volvox are rare or absent. Among rotifera, Asplanchna, Brachionus, and Keratella are common or abundant, while Euchlanis and Filinia are rare. In Cladocera, Alona and Bosmina are common or abundant, whereas Ceriodaphnia and Daphnia are rare or absent. Cyclops is common among copepods, while Mesocyclops is rare.

Moving to the winter season, some changes in abundance are observed. For instance, Protozoa like Arcella, Diffugia, and Paramecium remain common or abundant, with Volvox becoming more common. Among rotifera, Asplanchna, Brachionus, and Keratella are abundant, and Filinia becomes more common. In Cladocera, Alona and Bosmina remain common or abundant, whereas Coronatella and Daphnia become more common. Cyclops is abundant among copepods, while Mesocyclops becomes more common.

Transitioning to the summer season, there are further shifts in abundance. Protozoa like Arcella, Diffugia, Paramecium, and Vorticella continue to be common or abundant, while Volvox becomes even more common. Among rotifera, Asplanchna, Brachionus, and Keratella are abundant, with Philodina and Trichocera becoming more common. In Cladocera, Alona and Bosmina remain common or abundant, while Daphnia becomes abundant. Among copepods, Cyclops and Neodiaptomus are abundant, while Mesocyclops becomes more common.

Table 2. Seasonal density of Zooplankton (Individual / L) in Ganga river at Kanpur

Season/ Months		**Protozoa**	**Rotifera**	**Cladocera**	**Copepoda**	**Total**
Rainy Season	Jul.	5	18	8	25	56
	Aug.	4	11	6	12	33
	Sep.	6	24	12	11	66
	Oct.	14	59	33	24	130
Total		**29**	**112**	**62**	**72**	**285**
Winter Season	Nov.	19	55	45	39	158
	Dec.	11	34	29	39	113
	Jan.	9	29	32	12	82
	Feb.	12	34	47	16	109
Total		**51**	**152**	**153**	**106**	**462**
Summer Season	Mar.	17	44	65	23	149
	Apr.	21	59	72	35	187
	May.	22	104	92	52	270
	Jun.	36	129	83	47	295
Total		**104**	**352**	**319**	**164**	**901**
Grant Total		**184**	**616**	**534**	**342**	**1648**
Percentage (%) Contribution		**11.16%**	**37.37%**	**32.40%**	**20.75%**	-

The provided table presents the abundance of different zooplankton groups across three seasons: rainy, winter, and summer. Each cell indicates the count of individuals observed for each group in a particular month. Additionally, totals for each season and the grand total are provided, along with the percentage contribution of each group to the total count.

During the rainy season, the counts for Protozoa, Rotifera, Cladocera, and Copepoda gradually increase from July to October, with the highest total count observed in October. Protozoa show a relatively steady increase, while Rotifera and Cladocera exhibit more fluctuation, with peaks in October. Copepoda counts remain relatively stable throughout the season.

Moving to the winter season, there is a noticeable increase in the counts of all groups compared to the rainy season. The highest total count is observed in February, with Rotifera being the most abundant group followed by Cladocera. Protozoa and Copepoda also show significant increases in abundance during this season, with the highest counts observed in November and December for Protozoa and Copepoda respectively.

In the summer season, there is a further increase in the counts of all groups, with the highest total count observed in June. Rotifera remain the most abundant group throughout the season, followed by Cladocera. Protozoa and Copepoda also show substantial increases in abundance during this season, with the highest counts observed in June for both groups.

Overall, Rotifera consistently contribute the most to the total count across all seasons, followed by Cladocera and Protozoa. Copepoda show a relatively lower contribution compared to the other groups. The percentage contribution of each group to the grand total is provided, indicating the relative importance of each group in the overall zooplankton community. Rotifers are the prominent groups among the zooplanktons of any water body irrespective of its trophic status. This is because of the less specialized food, high fecundity and parthenogenetic reproduction. Most of the rotifers are primary consumers feeding on phytoplankton and forms important links in food chain. Rotifers respond more quickly to changes in water quality so, these are used as bioindicator. In the present investigation are represented by eight genera *viz Asplanchna Brachionus Euchlanis Filinia Keratella Philodina Polyarthra* and *Trichocera* species. Mean value of density of recorded Rotifers was from 11-129 individuals/ L at sampling sites. Highest density of Rotifers was found in Summer season (represented by 8 genera) while lowest density of Rotifers was observed in the rainy season (represented by only 4 genera).

IV. Conclusion:

Results revealed significant seasonal variations in zooplankton abundance. During the rainy season, there was a noticeable increase in zooplankton populations, likely due to increased nutrient inputs and favorable environmental conditions. The winter season showed a moderate abundance of zooplankton, while the summer season exhibited the highest abundance, indicating optimal conditions for zooplankton growth and reproduction. Further analysis identified specific taxa dominating each season, reflecting their adaptation to seasonal changes in environmental factors. These findings provide valuable insights into the dynamics of zooplankton populations in the Ganga River within Kanpur district, highlighting the importance of considering seasonal variations in river ecosystem studies and management strategies. The present investigation showed that the Ganga river was rich in diversity and density of zooplankton. The zooplankton diversity were represented by 27 genera belonging to four different groups *viz*. Protozoa (6 genera), Copepoda (4 genera), Cladocera (9 genera) and Rotifera (8 genera). In the present study maximum density was recorded in summer season (901individuals /L) followed by winter season (462 individuals / L) and rainy season (285 individuals / L). Among recorded zooplankton Rotifer's population was dominant during entire study period.

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