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Impact of seasonal variation on zooplankton diversity and physico-chemical parameters of Bhadar-II Dam-Dhoraji, India

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Abstract
The present study investigated the seasonal variations in zooplankton communities and water quality parameters in the Bhadar-II Dam Dhoraji, Rajkot district of Gujarat, India, over a one-year period, from January 2023 to December 2023. Four major zooplankton groups, Rotifera (13), Protozoa (13), Cladocera (8), and Copepoda (7) were found. To understand the water quality in this site, various physico-chemical parameters such as dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), Turbidity, electric conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), total hardness, color, cholorinity and pH were analyzed. Out of them Dissolved oxygen fixation were done at the sampling site while other parameters were analysed in a laboratory using standardized methods as per APHA,2017. A comprehensive understanding of these parameters can provide valuable insights into the health of these ecosystems and aid in their preservation and management in freshwater ecosystems. Overall, the study highlights the importance of monitoring and studying zooplankton diversity and associated parameters in freshwater ecosystems, as this information can provide crucial insights into the conditions of these ecosystems and contribute to their proper conservation and management.

Keywords: Freshwater zooplankton, rotifers, protozoa, Physico-chemical parameters

Introduction

Zooplankton diversity

The term "plankton" refers to the microscopic aquatic organisms that live suspended in free or pelagic water and are either non-motile or sufficiently motile to avoid being carried by currents. Planktonic creatures and plants are called zooplankton and phytoplankton, freely (APHA, 2017). The growth control link between primary producers and higher trophic levels comprises zooplankton. Zooplankton range from 0.2 to 20 µm in size. However, four primary Groups-Rotifer, Cladocera, Copepoda, and Ostracoda—dominate zooplankton classification based on morphological characteristics (Vanjare *et al*., 2010).

Zooplankton has unique adaptations that allow them to survive in water while avoiding from predation. Different zooplankton communities have various defenses against competition and predator pressure. Moreover, zooplankton is an exceptionally touchy community against changes in the physicochemical characteristics of water bodies in which they exist. Due to their small size, short lifespan, high-stress tolerance rate, and greater species variety, zooplankton is utilized as a "Biomonitoring tool" in the ecological monitoring of aquatic ecosystems.

The composition, abundance, and distribution of zooplankton are ultimately influenced by fluctuations in water quality. The zooplankton community is made up of a variety of species from various taxonomic groups, and because of the wide variety of morphologies, reproductive method, and food preferences among these species, productivity profiles vary both spatially and seasonally (Machado *et al*., 2015) [24]. Zooplankton research is necessary to comprehend the ecological status of biodiversity in all types of water, especially freshwater, estuarine, and marine habitats (Baxi *et al*.,2018) [4]. Zooplankton are a useful indicator of changes occurring in water quality because of their capacity to respond quickly to changes in environmental conditions as well as the physical and chemical characteristics of a water body, which aids in determining the status of water pollution (Contreras *et al*., 2009) [10]. Therefore, knowledge of zooplankton's function in wetlands is necessary for efficient conservation.

Physico-chemical parameters

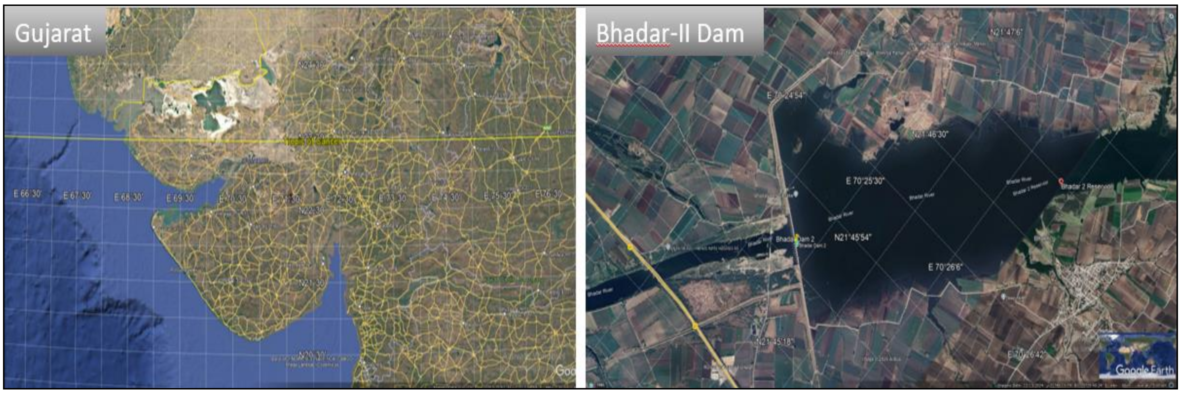
Wetlands primarily consist of three components: soil, aquatic creature and water, Without water, life on Earth is not conceivable. Even though 70% of the earth's surface is covered by water, only a relatively small amount of that area is connected to the continents where most people live. The study of the different structural and practical properties of water is known as limnology. This might be said to be the study of all aquatic ecosystems, both lentic and lotic. Physico-chemical and biological factors are typically examined, and they also represent the biotic and abiotic status of the surrounding ecosystems (Kamble, 2011) [19]. Unplanned urbanization, quick industrialization, and the careless use of synthetic chemicals in today's world are major contributors to the heavy and diverse contamination of aquatic ecosystems that results in declining water quality and the extinction of aquatic flora and animals.

Water quality changes have an impact on the aquatic ecosystem's biotic community, which ultimately lowers primary productivity. Limnological studies help to monitor the aquatic environment and offer a fundamental understanding of the nature of water. Regarding the presence and abundance of organisms in water, physico-chemical characteristics are crucial. An aquatic system's water quality not only influences its flora and fauna but also impacts the productivity, food web, and various other aspects of the aquatic ecosystem.

Material & Methodology

Study area

Bhadar dam (N21°45’40.9687”, E70°25’24.2724”) is situated in Bhukhi village, Tal. Dhoraji, Dis. Rajkot. This dam was built on Bhadar river for the purpose of irrigation and water supply. With a catchment area of 612.78 square kilometers and an annual rainfall of 586 millimeters. current study conduct over a one-year period, from January 2023 to December 2023



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Zooplankton collection

For plankton analysis, one liter of water sample was collected and filtered through a silk plankton net with a mesh size of 20 micrometers. The collected sample was immediately preserved in a 5% formalin solution for further biological analysis. The drop count method was used for quantitative analysis. Plankton was counted using a binocular compound microscope with different eyepieces such as 10X and 40X. Zooplankton identification were done by using different available manuals (Sharma, 1998, Conway *et al*, 2003; Balcer *et al*, 1984 [3]; Edmondson (1963) [13]; Michael & Sharma, 1988 [25]; Khan, 2003) [21]. For quantitative analysis drop count method were used.

Physico-chemical parameters

The water samples were collected for physico-chemical analysis. Eleven parameters, including pH, DO, BOD, COD, EC, TDS, TSS, Color, Chloride, Turbidity, and Total hardness, were evaluated. Out of them Dissolved oxygen fixation were done at the sampling site while other parameters were analyzed in a laboratory using standardized methods as per APHA.

BOD

BOD (Biological oxygen demand) analysis is for measuring organic pollution levels in wastewater and assessing the efficiency of treatment processes. BOD measurement. For measurement of BOD five-day BOD test by using starch indicator and phosphate buffer.

COD

The chemical oxygen demand (COD) determines the amount of oxygen required for the chemical oxidation of organic matter with the use of a strong chemical oxidant, such as potassium bichromate under reflux conditions. The COD test utilizes a titration method by using ferroin solution as an indicator.

TDS

TDS was measured by gravimetric method for the determination of filterable residue. This method was relevant to all types of water and wastewater. The sample was filtered, and the filtrate evaporated in a tared dish in a steam bath.

Total hardness

Water hardness is a measure of how "hard" it is to use soap in the water. Water hardness increases with the concentration of calcium and magnesium. Here one of the standard methods used to determine total hardness was Ethylenediamine tetraacetic acetate acid (EDTA). In this method Eriochrome black-T indicator

Turbidity

Turbidity is an Amount of the optical property of water that results from the scattering of light by suspended particles. Turbidity in water is caused by suspended and colloidal matter such as clay, silt, plankton and other micro-organisms. Turbidity was performed by using a self-contained conductivity instrument.

EC

Conductivity was the degree of the capacity of an aqueous solution to carry an electric current. The conductivity depends on the presence of ions and the properties arrangement of most inorganic compounds are moderately great conductors. EC was measured by the Instrumental method.

TSS

TSS was measured by gravimetric method. For sample preparation ensure that the sample is well mixed and then filtered through a glass fibre filter which allows The suspended particles to be captured on the filter. Weigh the filter and residue before and after the drying process. The difference in weight represents the mass of the suspended solids.

pH

Estimation of pH is one of the most critical and regularly utilized tests in water chemistry. Practically every phase of water supply and wastewater treatment. pH was performed by electrometric method APHA standard. pH is used in alkalinity and carbon dioxide estimations and numerous other acid-base equilibria.

Color

The colour of water can be influenced by the concentration of natural organic matter, particularly fulvic acid. Water and wastewater color were obtained by Calorimetry instrument

Chloride

The salty taste created by chloride concentrations is variable and subordinate to the chemical composition of the water. The titration method was used for analysing chloride. Solution. Titrate with standard AgNO 3 titrant to a pinkish-yellow endpoint.

Result & Discussion

The present study investigated the seasonal variations in zooplankton communities and water quality parameters in the Bhadar-II Dam. Four major zooplankton groups, Rotifera, Protozoa, Cladocera, and Copepoda found. Out of these 13 species of rotifera,13 species of protozoa,7 species of copepod and 8 species of cladocera were identified. Most protozoa species show a cyclical pattern of abundance throughout the year. *Vorticella campanula* and *Euglypha spp.* are among the most abundant species. Less abundant species include *Euglena viridis, Coleps hirtus Paramecium Aurelia, Euplotes spp.* During August to October population increase of many species due to favourable environmental conditions like temperature and food availability. Some species, like *Arcella spp*. and *Oxytrica spp*., have consistent populations throughout the year. The total plankton count per drop and litre fluctuates throughout the year. The highest total counts are observed in August and September, coinciding with the peak abundance of several protozoa species. The calculated values for total plankton count per litre range from 158 to 308 individual per liter. In Rotifera species, the total plankton count per drop and litre shows a general trend of increasing from March to May, followed by a decline towards August and September This pattern likely reflects the combined population dynamics of all species and their responses to seasonal changes. Many species, such as *Brachionus* spp., *Keratella* spp., and *Monostyla spp.*, experience peak populations during spring and summer months. This is likely due to favourable environmental conditions, such as increased food availability and warmer temperatures. The calculated values for total plankton count per litre range from 218 to 615 individual per liter. *Bosmina lonigrostris*, *Moina micrura* and *Alona spp.* Appear to be the dominant Cladocera species in the community, with consistently higher counts throughout the year. The highest population counts for many Cladocera species occur during the warmer months, likely due to favourable environmental conditions for growth and reproduction. The calculated values for total plankton count per litre range from 120 to 278 individual per liter. Most copepod species exhibit seasonal variations in their populations. For example, *Eucyclops spp.*, *Diaptomus spp.*, and *Microcyclops spp.* Show peaks in March to May, while *Mesocyclops spp.*, And *Nuplis spp*., have relatively consistent populations throughout the year. *Microcyclops spp*. and *Eucyclops spp.* are consistently present and often dominate the copepod community. The calculated values for total plankton count per litre range from 68 to 278 individual per liter. However, the highest DO values during the monsoon season same parameter analyzed by Das *et al*., (1997) [11], and Pandya *et al*., (2023) [26]. This is likely due to increased rainfall and dilution of pollutants. In Bhada-II Dam, Rotifera species dominated during the summer months aligning with the findings of Yannawar *et al*., (2022) [33] The presence of certain zooplankton species can serve as bioindicators of water quality. *Brachionus calyciflorus* and *Brachionus angularis*, two rotifera species found in Bhadar-II Dam, are often associated with eutrophic conditions similar to results observed by Pandya *et al*., (2023) [26]. Moreover, the detection of *Polyarthra spp.* in Bhadar Dam suggests the presence of organic pollution confirming the findings of Kaur *et al*., (2018) [20]. *Cyclops spp* are indicators of the influence of contaminants and domestic sewage discharges observed by Goswami & Mankodi (2012) [16]. In present study highest individuals were found of rotifer species. Rotifers were the dominant zooplankton in river Saundres and Lewis (1988; Van Dijk and Van Zanten, (1995) because of their short generation time and high reproductive rate (Allan, 1976). Copopodes were dominant in summer season same result were observed by Hedayati *et al*., (2017) [17].

Physico-chemical parameters of Bhadar- II Dam (Min-Max)

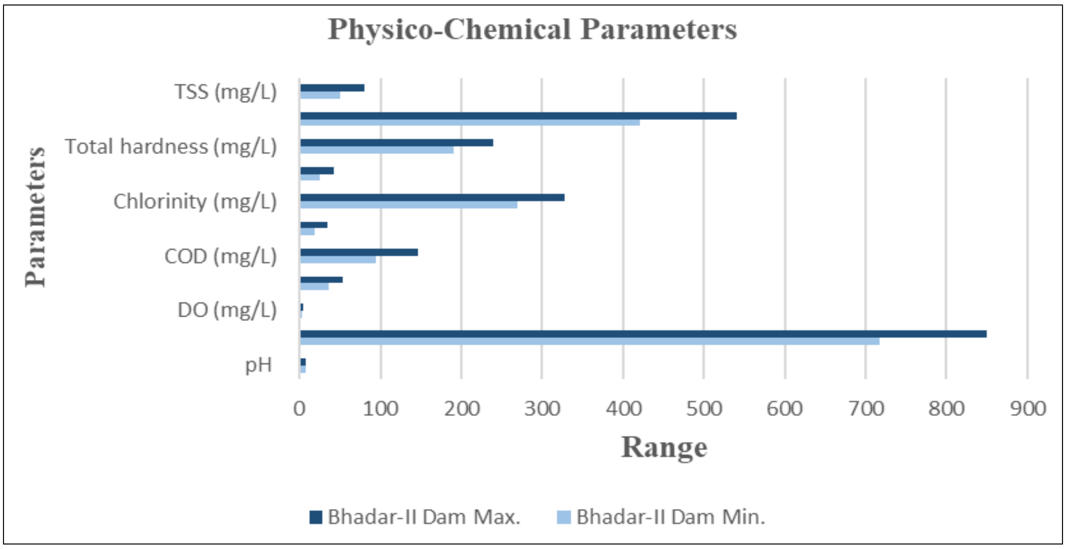

Fig 1: Physico-chemical parameters of Bhadar - II Dam (Max.-Min.)

Table 1 Zooplankton diversity variation in Bhadar - II Dam (Count per liter)

Zooplankton	**Month**													
Protozoa	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**		
Arcella spp.	2	2	3	4	2	3	1	0	3	2	1	2	25	48
Difflugia oblonga	2	4	3	2	2	4	4	5	6	4	3	2	41	80
Euglena gracilis	1	2	1	2	1	0	2	4	5	2	3	3	26	51
Euglena viridis	2	2	1	1	2	2	3	3	0	3	2	3	24	46
Coleps hirtus	3	2	2	0	0	2	1	3	2	3	2	1	21	39
Paramecium aurelia	2	1	1	0	2	0	2	4	2	3	2	3	22	42
Paramecium caudatum	2	2	4	2	3	1	3	2	3	0	4	5	31	60
Vorticella campanula	2	0	2	3	2	0	2	3	4	3	3	4	28	54
Amoeba proteus	1	1	3	1	2	1	0	4	3	4	2	1	23	45
Euplotes spp.	2	2	1	2	1	2	0	2	3	3	2	1	21	40
Stentor coeruleus	3	2	1	2	1	3	2	2	4	1	2	1	24	45
Euglypha spp.	3	3	2	2	0	2	2	4	4	3	3	3	31	59
Oppercular s spp.	4	4	0	0	4	2	1	2	2	4	3	3	29	54
Total plankton count per drop	29	27	24	21	22	22	23	38	41	35	32	32		
Total plankton count per litter=A*(1/L)*(n/v)	218	203	180	158	165	165	173	285	308	263	240	240		
Rotifera														
Brachionus falcatus	3	5	7	6	10	8	4	3	2	1	3	5	57	428
B. diversicornis	3	5	6	8	4	7	8	4	3	3	0	4	55	413
B. forficula	6	6	4	5	10	0	0	4	4	0	0	4	43	323
B.caudatus	0	5	3	7	8	0	0	4	3	0	2	4	36	270
B.calyciflorus	1	2	3	5	8	7	5	4	5	5	6	0	51	383
Keratella tropica	6	0	8	3	4	1	2	1	4	4	3	4	40	300
K. valga	5	0	0	8	6	5	5	0	4	5	7	6	51	383
Keratella chochlearis	5	4	5	9	7	3	2	2	0	3	5	5	50	375
Asplancha pridonta	4	5	3	5	2	8	7	5	0	7	4	6	56	420
Monostyla spp.	6	5	4	8	8	0	4	1	0	5	4	5	50	375
Rotaria neptunia	3	5	4	5	7	2	1	2	0	6	2	3	40	300
Filinia longiseta	4	3	4	5	8	4	3	2	2	5	4	5	49	368
Polyarthra vulgaris	7	6	6	7	0	2	1	1	2	0	2	0	34	255
Total plankton count per drop	53	51	57	81	82	47	42	33	29	44	42	51		
Total plankton count per litter=A*(1/L)*(n/v)	398	383	428	608	615	353	315	248	218	330	315	383		
Copapoda														
Diaptomus spp.	4	0	5	4	5	6	3	2	3	2	1	0	35	263
Eucyclops spp.	3	0	4	5	6	5	2	0	2	2	3	0	32	240
Diaptomus connexus	2	1	7	6	7	4	2	0	2	1	3	3	38	285
Ciriodaphnia spp.	0	4	3	5	4	0	1	2	2	3	0	4	28	210
Mesocyclops spp.	1	0	1	3	5	4	3	2	2	2	1	2	26	195
Nauplis spp.	1	1	2	6	5	3	2	1	3	1	2	2	29	218
Microcyclops spp.	4	3	2	3	5	3	2	4	3	2	2	1	34	255
Total plankton count per drop	15	9	24	32	37	25	15	11	17	13	12	12		
Total plankton count per litter=A*(1/L)*(n/v)	113	68	180	240	278	188	113	83	128	98	90	90		
Cladocera														
Moina micrura	5	3	3	0	9	8	6	5	4	5	5	4	57	428
M.branchiata	0	0	0	4	4	6	4	7	6	2	3	4	40	300
Alona spp.	5	6	0	6	5	4	0	7	5	4	4	4	50	375
Diaphanosoma branchita	4	0	8	4	4	0	5	0	3	5	4	0	37	278
Daphnia carinata	2	0	7	5	5	4	5	0	0	5	3	0	36	270
Ceriodaphnia reticulata	0	0	6	7	3	3	6	8	7	6	0	0	46	345
Bosmina lonigrostris	0	8	8	7	6	5	7	6	6	4	0	6	63	473
Ceridaphnia reticulate	0	7	0	3	1	3	2	5	7	0	0	4	32	240
Total plankton count per drop	16	24	32	36	37	33	35	38	38	31	19	22		
Total plankton count per litter=A*(1/L)*(n/v)	120	180	240	270	278	248	263	285	285	233	143	165		

Conclusion

This study revealed distinct seasonal patterns in zooplankton communities and water quality within Bhadar-II Dam. Protozoa dominated during warmer months, while Rotifera peaked in spring, Cladocera showed consistent presence, and Copepoda exhibited species-specific seasonal variations. These fluctuations highlight the dynamic interplay between environmental factors and zooplankton populations, emphasizing the importance of seasonal monitoring for effective water resource management.

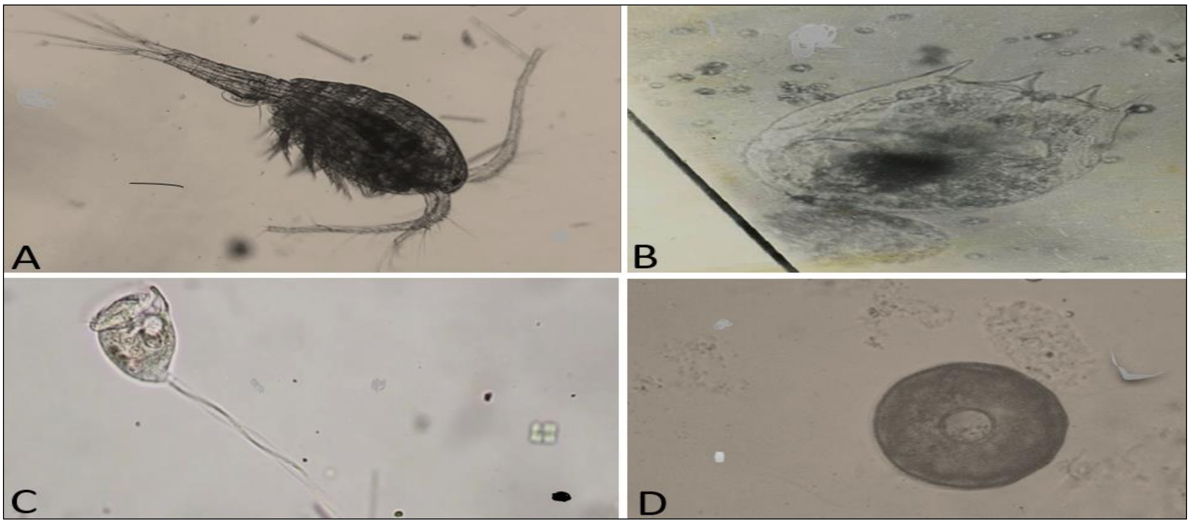

Fig 2: Images of Zooplankton (A. Mesocyclops spp., B. Brachionus calyciflorus, C. Vorticella campanula, D. Arcella spp.)

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