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Comparative analysis of zooplankton diversity and physico-chemical parameters of various freshwater reservoirs in Surendranagar, Gujarat, India

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Abstract
The present study aimed to assess the diversity of zooplankton in the Surendranagar district of Gujarat, India, over a one-year period, from November 2021 to October 2022, in three selected sites. A total of 35 species belonging to five distinct groups, with Site 2 (Dholi Dhaja Dam) exhibiting the highest zooplankton diversity (29) and Site 1 (Falku Dam) having the lowest (16). To understand the water quality in these sites, various physico-chemical parameters such as dissolved oxygen (DO), biological oxygen demand (BOD), total dissolved solids (TDS), total suspended solids (TSS), total solids (TS), and pH were analysed. A comprehensive understanding of these parameters can provide valuable insights into the health of these ecosystems and aid in their preservation and management. The findings of this study can serve as a foundation for future research in this field, and contribute to a better understanding of the interactions between zooplankton and the water quality 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 reservoirs, rotifers, diversity indices, correlation

Introduction

The Earth is commonly referred to as the "blue planet" because a large portion of its surface, approximately 75%, is covered by water. The vast majority of this water, 97%, is found in the form of oceans, with the rest being in the form of polar ice caps and groundwater. Of this total amount of water, only a small fraction, 0.33%, is utilized by humans. India, in particular, is abundant in water resources and accounts for 4% of the world's total water supply (India-WRIS wiki 2015) [22].

Freshwater ecosystems play a critical role in mitigating the impacts of climate change, providing important ecosystem services such as flood control and water purification. They transfer salts and nutrients from high-elevation areas to lower-elevation lakes, ponds, and wetlands and maintain a constant exchange of nutrients. However, river and small lake ecosystems are facing significant challenges due to human activities such as eutrophication, acidification, the introduction of exotic species, and pollution (Moss *et al*., 2010) [14]. These anthropogenic factors exacerbate the impact on freshwater faunal biodiversity, which is already vulnerable to natural seasonal fluctuations (Dudgeon *et al*., 2006) [7].

Water is essential for life and acts as a medium for many biochemical processes. It supports life on the planet and is the foundation of the web of life. Water shapes the growth and functioning of the natural world and is composed of phytoplankton and zooplankton, which serve as the foundation of the aquatic ecosystem (Mishra 2014) [13]. Zooplankton, in particular, is a crucial component of freshwater ecosystems as it links the aquatic food web. Zooplankton encompasses all microscopic aquatic organisms that exhibit passive drift-based locomotion, ranging in size from micrometres to several centimetres (CSIRO 2000) [6].

Water quality evaluation involves analyzing various physical, chemical, and biological parameters of water, with emphasis on those that may affect human health and the health of the aquatic ecosystem (Chapman, 1996) [4]. The rapid economic growth associated with industrial waste, chemicals, and sewage discharge is leading to water contamination and degradation of water quality and aquatic life. Without proper monitoring and preventative measures, these water resources are at risk of depletion in the near future, emphasizing the need for sustainable utilization practices (Pathak & Mankodi 2013) [15].

Surendranagar district, situated in the western region of India, is renowned for its rich aquatic ecosystems, encompassing numerous lakes, dams, and important rivers such as the Falku, Dholi Dhaja, and Nayaka dams. These water resources play a critical role in sustaining the local ecosystem and economy, making it imperative to assess and understand their health and sustainability. The present study aims to investigate the biodiversity of zooplankton and the physico-chemical parameters of these aquatic systems, with the goal of gaining insights into the role of zooplankton in the food chain and evaluating water quality. The findings of this study will be crucial in informing and guiding effective management and conservation practices to ensure the long-term well-being of Surendranagar's aquatic ecosystems.

Materials and methods

Surendranagar is a district located in the Saurashtra region of Gujarat, India. It is home to several freshwater bodies, including lakes, dams, and important rivers. This study focuses on three dams in the district: Falku Dam (22°57'01.88"N, 71°24'50.51"E), Dholi Dhaja Dam (22°43'16.28"N, 71°35'06.87"E), and Nayaka (22°40'06.45"N, 71°28'06.88"E). These dams were selected as the sample collection sites for this study to assess the biodiversity of zooplankton and the Physico-chemical parameters of the water. Samples were collected from the surface of each dam and the GPS location was recorded to ensure the accuracy of the sample collection.

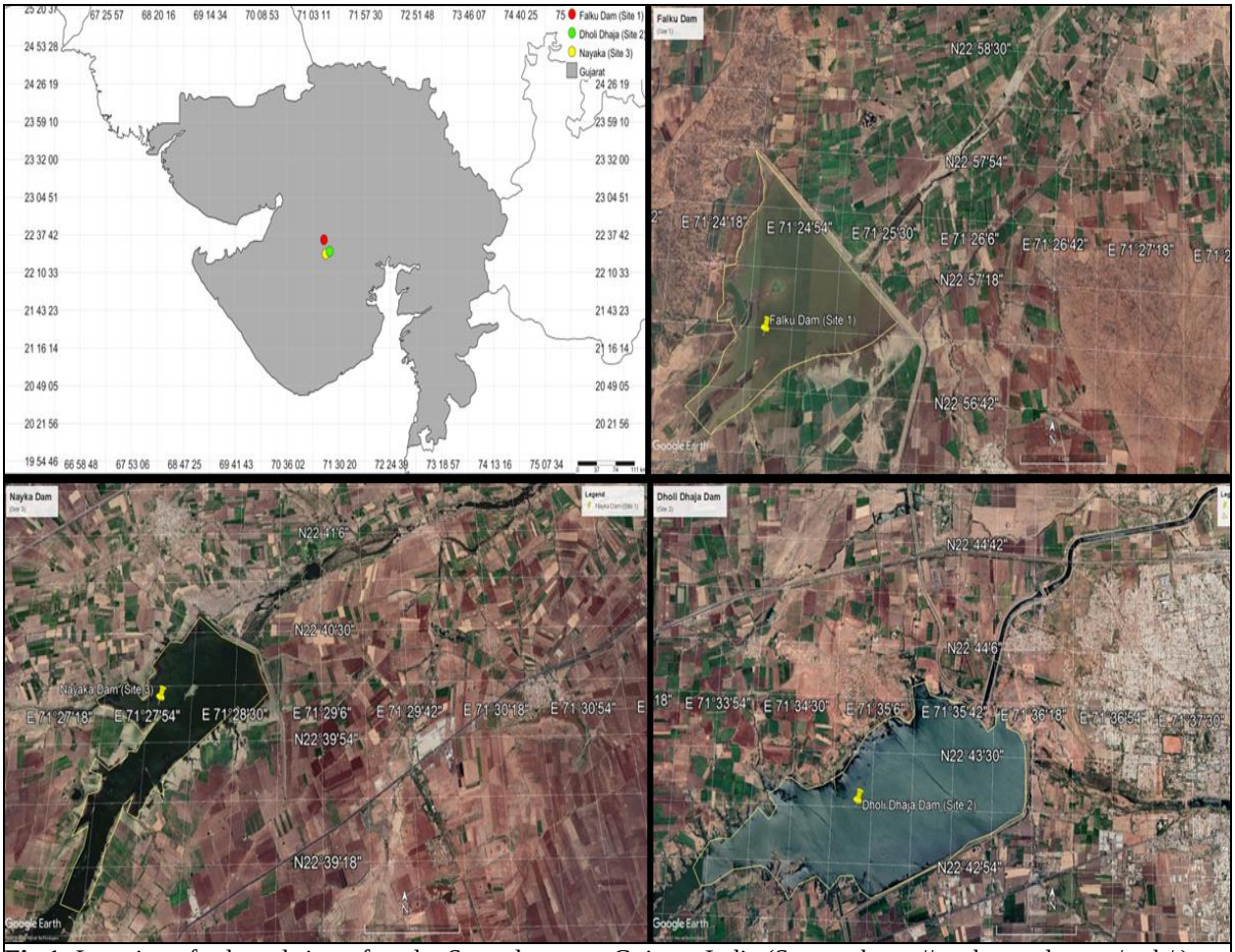

Fig 1: Location of selected sites of study: Surendranagar, Gujarat, India (Source: https://earth.google.com/web/)

Sample collection

Physico-chemical parameters

The study involved collection of water samples for evaluating the physico-chemical characteristics. On-site measurements of dissolved oxygen were taken at the time of sampling, while other parameters were analyzed in the laboratory using analytical procedures outlined in APHA (2012) [1]. Over the course of the study, seven key water quality parameters were analyzed including pH, Total Solids (TS), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Dissolved Oxygen (DO), and Biological Oxygen Demand (BOD). Zooplankton samples were collected from the surface water using a 60µ mesh Nylon plankton net with a conical shape.

Study of seasonal abundance of zooplankton in the water

The identification of zooplankton was conducted using several zooplankton identification manuals, including (Sharma 1998, Thorp and Covich 2009, Phan *et al*., 2015, Conway *et al*., 2003, Kasturirangan 1963, Michael and Sharma 1988, Bick 1972, Shiel 1995, and Khan 2000) [17, 19, 16, 5,10, 12, 3, 18, 11]. Qualitative analysis of the zooplankton samples was carried out using a compound microscope and a light microscope, examining various zooplankton species (Goswami & Mankodi 2012) [8]. Hardy species were immediately preserved in formalin. The qualitative and quantitative examination of zooplankton was performed using Lackey's drop method. Some other groups, such as Rotifers, undergo significant morphological changes during preservation, making it necessary to observe them in their living conditions (Mishra 2014) [12].

Result and discussion

35 zooplankton species from 5 different groups have been observed throughout the research (Table 1). i.e., Protozoa (15), Rotifera (12), Copepoda (3), Cladocera (4) and Ostracoda (1). Highest zooplankton diversity was observed in winter and lowest zooplankton diversity was observed during monsoon (Figure 2). Highest Zooplankton diversity was observed in Dholi Dhaja Dam and lowest diversity was noted from Falku Dam (Table 1). Baxi *et al*., in 2018 observed highest zooplankton diversity in winter followed by summer and monsoon (Baxi *et al*., 2018) [2]. Vyas & Raval also recorded highest zooplankton diversity in winter followed by summer and monsoon (Vyas & Raval 2023) [21]. High number of Rotifera species such as *Brachionus angularis angularis, Brachionus caylciflorus, Brachionus rubens, Brachionus urceolaris* and other Rotifera indicate eutrophic condition of selected study sites. other authors such as Jani *et., al* in 2022 also observed that high number of rotifera species were indicators of eutrophic condition of water bodies (Jani *et al.*, 2022) [9]. Both Rotifera species (*Brachionus angularis angularis, Brachionus caylciflorus, Brachionus rubens, Brachionus urceolaris*) and Copepod species (*Cyclops sp*) are indicators of the influence of contaminants and domestic sewage discharges suggested by Goswami & Mankodi in 2012 (Goswami & Mankodi 2012) [8].

(Figure 3, 4, 5) Shows variation in physico-chemical parameters of selected study sites. High pH levels were observed in winter while lower pH levels were observed in Summer. High DO levels were observed in the monsoon

while lower DO levels were observed in summer. High BOD levels were observed in Winter and lower BOD levels were observed in summer. High TDS levels were observed in summer while lower TDS levels were observed in Monsoon. Vyas *et al*., in 2022 also noted that highest DO was recorded in monsoon while lower levels of DO was recorded in summer (Vyas *et al*., 2022) [20]. High BOD levels and Highest Zooplankton diversity in winter indicate that there should be some correlation between these two Factors. Vyas & Raval in 2022 also stated that both BOD levels and zooplankton diversity was highest in winter (Vyas & Raval 2023) [21]. Lower values of Dominance D and Berger-Parker while Higher values of Simpson_1-D, Shannon H, Margalef indicate a good diversity of zooplanktons is observed at these selected Dams. highest Values of Dominance were found in Site 1(0.141) and lowest in Site 3(0.087) and Site 2 (0.093). For other diversity indices, highest values were obtained from Site 2 and lowest from Site 3. This indicate that Dominance was found to be negatively correlated with other diversity indices. Simpson's index was found to be highest in Site 3 (1-D- 0.912), Site 2 (1-D- 0.906) and lowest in Site 1 (1-D- 0.858) (Table.2). Shannon_H index was found highest in Site 2 (H- 2.753) and Site 3 (H- 2.540) and lowest in Site 1 (H-2.215). Hence, Site 1 shows least diversity and Site 2 and 3 shows highest diversity among selected study sites of Surendranagar, Gujarat, India

Table 1: Comparative zooplankton diversity of selected sites (Site 1- Falku Dam, Site 2- Dholi Dhaja Dam, Site 3- Nayaka Dam)

	Zooplankton species	**Site 1**	**Site 2**	**Site 3**
1	*Coleps hirtus*	1	1	1
2	*Dileptus sp.*	0	1	0
3	*Epistylis sp.*	0	1	0
4	*Euglena acus*	0	0	1
5	*Euglena gracilis*	1	0	1
6	*Euglena virdis*	1	1	1
7	*Euplotes patella*	0	1	0
8	*Tetrahymena pyriformes*	0	1	0
9	*Loxophyllum sp*	0	1	0
10	*Paramoecium Aurelia*	1	1	0
11	*Paramoecium caudatum*	1	1	1
12	*Phacus sp.*	1	1	1
13	*Stentor roeselii*	1	0	1
14	*Stentor sp.* (Free swimming)	1	1	0
15	*Vorticella campanula*	0	0	1
16	*Asplanchna sp.*	1	1	1
17	*Brachionus angularis angularis*	0	1	1
18	*Brachionus caylciflorus*	0	1	1
19	*Brachionus rubens*	0	1	1
20	*Brachionus urceolaris*	0	1	1
21	*Rotaria Neptunia*	0	0	1
22	*Filinia longiseta*	0	1	0
23	*Keratella quadrata*	0	1	0
24	*Keratella tropica*	0	1	0
25	*Lecane bulla*	0	1	0
26	*Polyarthra vulgaris*	1	1	0
27	*Trichocerca rattus*	1	1	0
28	*Nauplii sp.*	1	1	1
29	*Cyclops sp.*	1	1	1
30	*Heliodiaptomus viddus*	0	1	0
31	*Ceriodaphnia sp.*	0	1	0
32	*Ceriodaphnia pulchella*	1	1	1
33	*Daphnia obtuse*	1	1	0
34	*Daphnia carinata*	1	1	1
35	*Hemicycpris anomala*	0	0	1
	Total	16	29	19

Table 2: Diversity Indices of selected sites (Site 1- Falku Dam, Site 2- Dholi Dhaja Dam, Site 3- Nayaka Dam)

Diversity Indices	**Falku Dam (S1)**	**Dholi Dhaja Dam (S2)**	**Nayaka Dam (S3)**
Dominance_D	0.141884167	0.0935825	0.087781667
Simpson_1-D	0.858116667	0.906425	0.912225
Shannon_H	2.21525	2.75325	2.540166667
Evenness_e^H/S	0.86255	0.715575	0.940916667
Margalef	2.878	4.8085	3.458416667
Berger-Parker	0.224466667	0.209483333	0.1296375

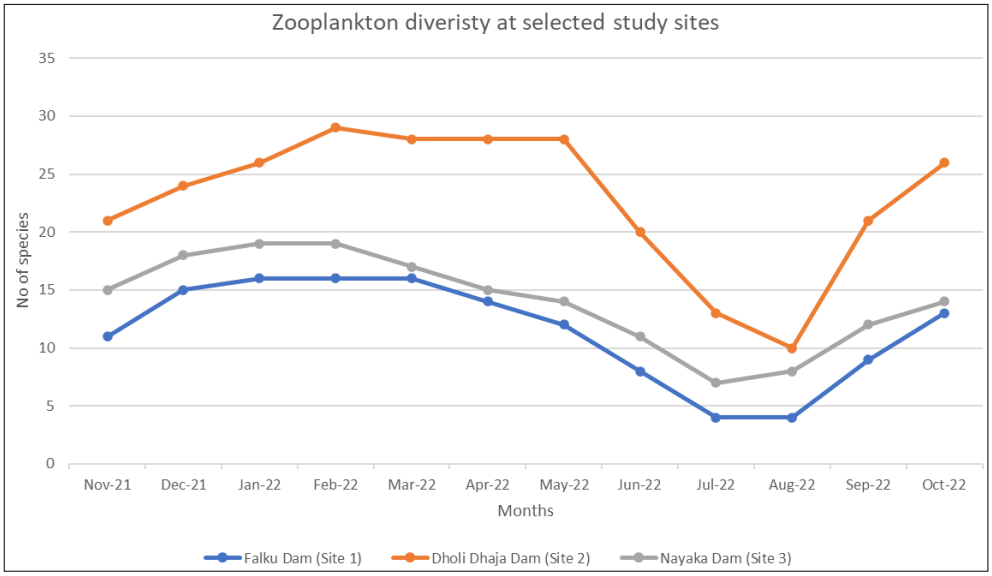

Fig 2: Monthwise distribution of Zooplankton species from the three selected study sites

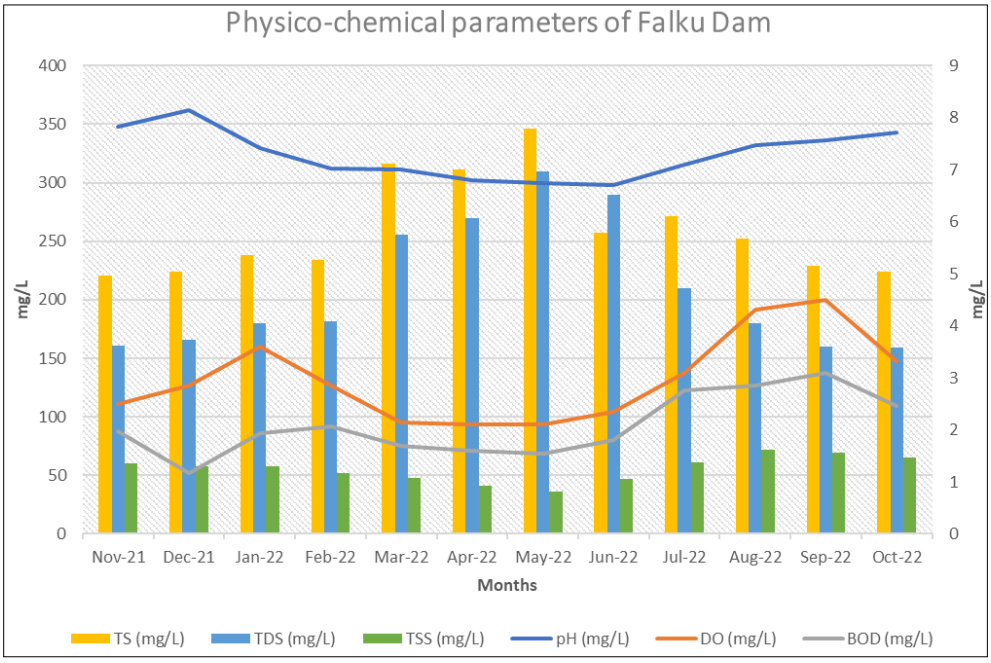

Figure 3: Physico-chemical parameters of Falku Dam.

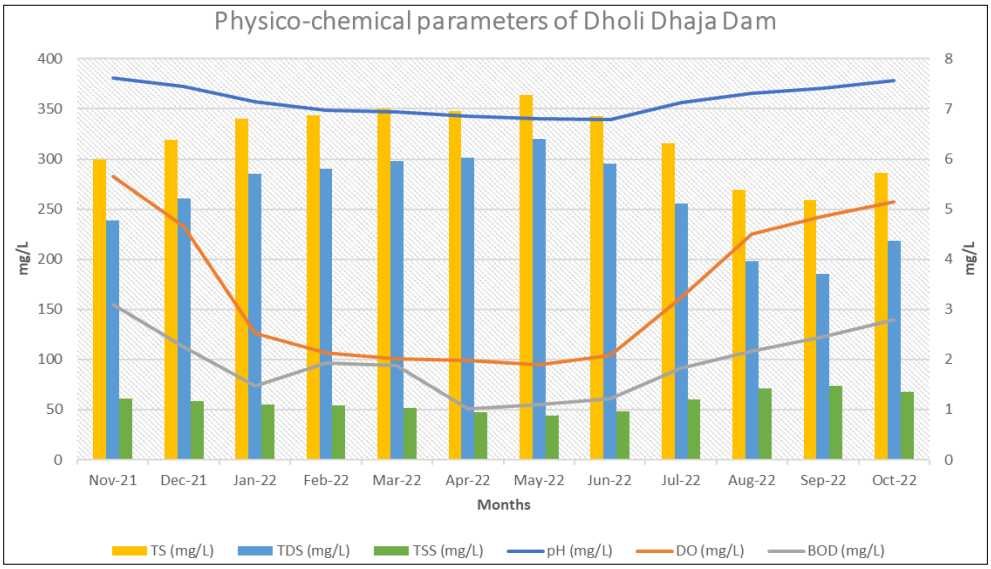

Fig 4: Physico-chemical parameters of Dholi Dhaja Dam

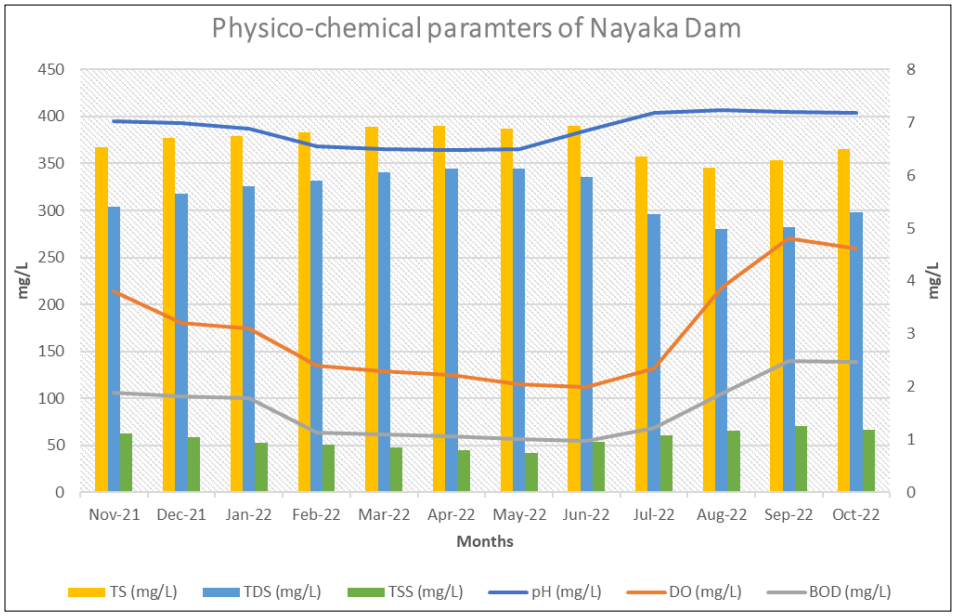

Fig 5: Physico-chemical parameters of Nayaka Dam

Conclusion

The present study aimed to assess the diversity of zooplankton communities in freshwater reservoirs of Surendranagar, Gujarat, India. The survey was conducted over a 12-month period, from November 2021 to October 2022. During this time, 35 species of zooplankton were identified, belonging to 5 distinct taxonomic groups, including Protozoa (15 species), Rotifera (12 species), Copepoda (3 species), Cladocera (4 species), and Ostracoda (1 species). The results of this study demonstrate the significance of studying the diversity of zooplankton communities in freshwater reservoirs, as zooplankton play a crucial role as bio-indicators in these ecosystems. Changes in the diversity of zooplankton populations can have far-reaching impacts on the overall ecological balance.

Given the importance of zooplankton as indicators of ecological health, monitoring both zooplankton communities and related physico-chemical parameters is crucial for a better understanding of freshwater reservoir ecosystems and the processes taking place within them. Further studies are needed to expand our knowledge of these ecosystems and to identify effective strategies for conservation and management.

In conclusion, this study underscores the importance of monitoring zooplankton communities and related physico-chemical parameters in freshwater reservoirs and highlights the need for conservation and management efforts to ensure the preservation of these valuable ecosystems.

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