International Journal of Multidisciplinary Research and Technology
ISSN 2582-7359, Peer Reviewed Journal, Impact Factor 6.325
www.ijmrtjournal.com

A STUDY ON ZOOPLANKTON DIVERSITY IN FEW WATER SOURCES OF SHRI NARAYAN SAROVAR, BURHAR TAHSIL, SHAHDOL, MADHYA PRADESH

[1]Singh Hema, [2]Kumar K

[1]Research scholar, [2]Professor

Department of Zoology, Pandit S N Shukla University, Shahdol, MP

Abstract

This research paper presents a comprehensive study on zooplankton diversity in selected water sources within Shri Narayan Sarovar, Burhar Tahsil, District Shahdol. Zooplankton, as key indicators of aquatic ecosystem health, were assessed for their composition, abundance, and distribution patterns. The study aims to contribute valuable insights into the ecological dynamics of the region and aid in the development of sustainable management strategies. Water samples were collected from various sites, and zooplankton were identified through microscopic analysis. Physicochemical parameters were measured to understand environmental conditions. Statistical analyses were conducted to evaluate zooplankton diversity and its correlation with environmental factors. The findings of this study offer a baseline for future research and inform decision-makers about the state of aquatic ecosystems in Burhar Tahsil, facilitating effective conservation measures.

Keywords: Zooplankton, diversity, water sources, Burhar Tahsil, Shahdol, aquatic ecosystems, environmental health.

Introduction

The Narmada, which originates near Amarkantak in the Shahdol district of Madhya Pradesh, is the largest west-flowing river on the peninsula. It courses through several districts, including Mandla, Jabalpur, Narsinghpur, Hoshangabad, Raisen, East Nimar, West Nimar, Dewas, and Dhar District. Its total length, from the source to its mouth at the Gulf of Khambhat, spans 1,312 kilometers. Of this length, 1,079 kilometers are within Madhya Pradesh, followed by 35 kilometers serving as the boundary between Madhya Pradesh and Maharashtra, then 39 kilometers forming the border between Maharashtra and Gujarat, with the final 159 kilometers flowing through Gujarat. The Narmada River is home to approximately seven dams, and the construction of these dams has significantly degraded the river's ecology, posing a threat to its aquatic biodiversity. The concept of damming the Narmada dates back to the late 19th century, during the era of British rule in India. Among the proposed 30 major dams along the Narmada, the Sardar Sarovar Project and Narmada Sagar Project stand out as megadams. Additionally, the Maheshwar and Omkareshwar dams, in conjunction with the Sardar Sarovar Project and Narmada Sagar Project, are designed to create a complex to fulfill the requirements of the Sardar Sarovar Project. The resistance against large dams in the Narmada valley began when people facing displacement due to the Sardar Sarovar Project started organizing in 1985-86. Since then, this movement has expanded to encompass other significant dams in various stages of planning and construction, including the Maheshwar, Narmada Sagar, Maan, Goi, and Jobat dams.

The completion of Tawa and Bargi Dams in 1973 and 1989, respectively, led to organized efforts by affected communities post-displacement to assert their rights. However, the government's plans to construct 30 large dams, 135 medium dams, and 3000 small dams on the Narmada and its tributaries pose a grave threat. If all these dams are realized, the Narmada River, as we currently know it, would vanish, leaving behind only a series of artificial lakes. Biodiversity encompasses the diverse array of biological organisms in a particular habitat, area, or ecosystem. It comprises various components, including species variation, ecosystem diversity, and genetic diversity. Biodiversity plays a crucial role in stabilizing ecosystems, safeguarding overall environmental quality, and recognizing the intrinsic value of all species on Earth (Nelson, 2006).

Zooplankton play a crucial role in energy transfer at the secondary level in aquatic ecosystems. They occupy an intermediary position between autotrophs and heterotrophs in aquatic food webs. The distribution and diversity of zooplankton in aquatic ecosystems depend largely on the physicochemical properties of the water. Pollution from various sources can lead to significant alterations in the potential of zooplankton populations within an ecosystem.

Zooplankton are capable of accumulating chemicals through direct absorption from the water and via food intake. These animal plankton are at the mercy of water currents, moving passively through aquatic environments. They serve as a vital link between autotrophs and other heterotrophs in aquatic ecosystems, forming a major component of the food chain and serving as a primary energy source for fish. In freshwater environments, zooplankton are primarily comprised of Rotifera, Cladocera, and Copepoda, with protozoans also constituting a significant portion of the zooplankton community. Zooplankton hold immense ecological significance within ecosystems, serving critical roles in the food web, nutrient recycling, and organic matter transfer from primary producers to secondary consumers, such as fish (Krishnamurthy et al., 1979). They are particularly abundant in mangrove waterways compared to adjacent coastal waters, and a significant portion of juvenile fish in mangrove habitats feed on zooplankton (Robertson and Blabber, 1992). Zooplankton populations directly influence the abundance of fish stocks, with declines in copepod (zooplankton) populations often linked to failures in fishery resources (Stottrup, 2000). Therefore, zooplankton communities, characterized by their quality and species diversity, are crucial indicators for assessing ecosystem productivity, fertility, and the health of fisheries resources. The present study aims to investigate the distribution of zooplankton in the Narmada River. It seeks to address pollution issues stemming from anthropogenic activities and domestic waste, which threaten zooplankton populations in the river. Ultimately, the study aims to contribute to the conservation of zooplankton populations, which are facing decline over time.

Material and Methods

The study was conducted over a span of three years, from 2021 to 2023, focusing on the selected sampling station of Omkareshwar. Omkareshwar holds significant religious importance as one of the holiest Hindu sites in the nation, located approximately 77 kilometers away from the city of Indore. Sampling activities took place during the morning hours twice a month. Samples collected during the fieldwork were preserved in formalin and subsequently transported to the laboratory for identification. The counting of individual zooplankton specimens was carried out using the "Lac Keys" dropping method, as described by Lac (1935). This method involves dropping a known volume of the preserved sample onto a counting chamber, followed by identification and enumeration of zooplankton individuals.

Zooplankton units/Liter = $[(N \times C)/y] \times 10$

N = Number of zooplankton counted in 0.1ml. concentrate.

C = Total volume of concentrate in ml.

Y = Total volume of water filtered for sample in litres.

The density of zooplankton was quantified in terms of individuals per liter. Zooplankton identification was facilitated using taxonomic keys provided by various sources, including Pennak (1978), Sehgal (1983), Needham and Needham (1962), Tonapi (1980), and the American Public Health Association (APHA) (1980). These keys offer systematic guidance for identifying different species of zooplankton based on morphological characteristics and other distinguishing features.

Results

Water Quality Assessment

Shri Narayan Sarovar 2021

The water quality of Shri Narayan Sarovar was evaluated across three seasons—winter, pre-monsoon, and post-monsoon—revealing both stability and seasonal variations in key parameters. The temperature increased from 22.8°C in winter to 28.64°C during pre-monsoon, then decreased to 25.2°C post-monsoon, reflecting natural seasonal temperature shifts. The water remained consistently clear, colorless, and odourless throughout the year, indicating a low level of turbidity and pollutants. The pH was stable, ranging from 7.8 to 7.9, showing a neutral to slightly alkaline environment conducive to aquatic life. Total solids (TS) ranged from 385 mg/L in pre-monsoon to 410 mg/L in winter, while total dissolved solids (TDS) fluctuated slightly between 265 mg/L (pre-monsoon) and 274 mg/L (winter). Total suspended solids (TSS) varied from 408 mg/L (pre-monsoon) to 415 mg/L (winter), showing minimal seasonal impact on particulate content.

Chloride levels remained stable across seasons, ranging from 472 mg/L (winter) to 473.4 mg/L (post-monsoon). Biological oxygen demand (BOD) was moderate, with values decreasing from 6.7 mg/L in winter to 6.2 mg/L during the pre-monsoon, reflecting a slight reduction in organic load before the rains. Similarly, chemical oxygen demand (COD) slightly decreased from 125 mg/L in winter to 121 mg/L post-monsoon. Water hardness saw a significant increase from 83.42 mg/L in winter to 148 mg/L post-monsoon, likely due to the accumulation of minerals following rainwater dilution. Alkalinity varied, with the highest value of 156 mg/L pre-monsoon and a drop to 98.4 mg/L post-monsoon, reflecting changes in the water's buffering capacity. Trace metal concentrations showed slight seasonal increases, with cadmium rising from 1.0 µg/L (winter) to 1.3 µg/L post-monsoon, and mercury increasing from 0.76 µg/L (winter) to 0.98 µg/L post-monsoon. Chromium levels remained low but consistent, ranging from 0.78 µg/L (pre-monsoon) to 0.88 µg/L (winter). Overall, the reservoir exhibited acceptable water quality, with low levels of organic pollutants and heavy metals, indicating its suitability for aquatic ecosystems despite minor seasonal fluctuations.

Table 1: Shri Narayan Sarovar, Burhar Tehsil, Shahdol, Madhya Pradesh 2021

SN	Characteristic	Unit	Winter	Pre-monsoon	Post-monsoon
1	Temperature	ºC	22.8	28.64	25.2
2	Appearance	-	Clear	Clear	Clear
3	Colour	-	Colorless	Colorless	Colorless
4	Odour	-	Odourless	Odourless	Odourless
5	pH	-	7.8	7.9	7.8
6	Total Solids	mg/L	410	385	390
7	Total Dissolved solids	mg/L	274	265	270
8	Total Suspended Solids	mg/L	415	408	411
9	Chloride	mg/L	472	472.8	473.4
10	BOD	mg/L	6.7	6.2	6.3
11	COD	mg/L	125	122	121
12	Hardness	mg/L	83.42	142.6	148
13	Alkalinity	mg/L	132.45	156	98.4
14	Cd	µg/L	1.0	1.1	1.3
15	Hg	µg/L	0.76	0.59	0.98
16	Cr	µg/L	0.88	0.78	0.87
17	Ni	µg/L	0.2	0.1	0.1
18	Cu	µg/L	0.1	0.12	0.16
19	Zn	µg/L	0.7	0.6	0.7
20	Mn	µg/L	0.87	0.84	0.82

Shri Narayan Sarovar 2022:

The water quality of Shri Narayan Sarovar in Burhar Tehsil, Shahdol, Madhya Pradesh, was monitored across the winter, pre-monsoon, and post-monsoon seasons in 2022. This assessment revealed slight seasonal variations in key water quality parameters, maintaining overall stability.

The temperature showed seasonal fluctuations, rising from 21.8°C in winter to 27.64°C pre-monsoon due to increased solar radiation and falling to 24.2°C post-monsoon as ambient temperatures cooled. The appearance of the water remained clear across all seasons, and the colour stayed consistently colorless, reflecting low levels of suspended or dissolved particulates. Similarly, the water was odourless throughout the year, indicating minimal organic or chemical contamination.

The pH values were stable, ranging between 7.8 and 7.9, suggesting a neutral to slightly alkaline environment, which supports diverse aquatic life. Total solids (TS) were highest in winter at 415 mg/L, dropping to 380 mg/L pre-monsoon and increasing slightly to 385 mg/L post-monsoon. The total dissolved solids (TDS) varied slightly, from 273 mg/L in winter to 264 mg/L pre-monsoon and 279 mg/L post-monsoon, reflecting consistent ionic concentrations. Total suspended solids (TSS) showed minimal variation, with values of 412 mg/L in winter, 410 mg/L pre-monsoon, and 413 mg/L post-monsoon, indicating a stable particulate load across seasons.

Chloride concentrations remained stable, ranging from 470.8 mg/L to 472 mg/L, reflecting minimal saline or anthropogenic influence. Biological oxygen demand (BOD) decreased from 5.7 mg/L in winter to 5.2 mg/L pre-monsoon, indicating a slight reduction in organic material and microbial activity during the pre-monsoon. Chemical oxygen demand (COD) also showed a minor reduction from 123 mg/L in winter to 119 mg/L post-monsoon, reflecting a seasonal decline in the oxidation of organic and inorganic matter.

Hardness ranged from 140.6 mg/L in pre-monsoon to 146 mg/L post-monsoon, with the highest value recorded post-monsoon, likely due to increased mineral content from runoff. Alkalinity fluctuated significantly, increasing to 154 mg/L pre-monsoon and decreasing to 100.4 mg/L post-monsoon, suggesting changes in the buffering capacity of the water due to seasonal rainfall and dilution.

Heavy metals showed seasonal variations but remained within safe limits. Cadmium (Cd) levels remained relatively stable, with 1.1 µg/L in both winter and post-monsoon, and a slight increase to 1.2 µg/L pre-monsoon. Mercury (Hg) concentrations were lowest pre-monsoon at 0.48 µg/L and peaked post-monsoon at 0.78 µg/L, potentially due to atmospheric deposition and surface runoff. Chromium (Cr) levels showed a minor decrease from 0.87 µg/L in winter to 0.79 µg/L post-monsoon, indicating stable industrial or agricultural input.

Nickel (Ni) concentrations were low throughout, ranging from 0.09 µg/L pre-monsoon to 0.18 µg/L in winter, reflecting minimal industrial contamination. Copper (Cu) levels remained stable, with minor fluctuations between 0.09 µg/L (winter) and 0.11 µg/L (pre- and post-monsoon). Zinc (Zn) concentrations remained low, varying between 0.5 µg/L and 0.6 µg/L, indicating minimal metal contamination. Manganese (Mn) levels were highest in winter (0.88 µg/L) and declined slightly to 0.77 µg/L post-monsoon.

The water quality of Shri Narayan Sarovar in 2022 remained within acceptable ranges, with minimal seasonal variations and stable concentrations of dissolved solids, organic pollutants, and heavy metals. The results indicate that the reservoir maintains good water quality suitable for aquatic ecosystems despite minor changes due to seasonal weather patterns and runoff.

Table 2: Shri Narayan Sarovar, Burhar Tehsil, Shahdol, Madhya Pradesh 2022

SN	Characteristic	Unit	Winter	Pre-monsoon	Post-monsoon
1	Temperature	^oC	21.8	27.64	24.2
2	Appearance	-	Clear	Clear	Clear
3	Colour	-	Colorless	Colorless	Colorless
4	Odour	-	Odourless	Odourless	Odourless
5	pH	-	7.8	7.9	7.8
6	Total Solids	mg/L	415	380	385
7	Total Dissolved solids	mg/L	273	264	279

8	Total Suspended Solids	mg/L	412	410	413
9	Chloride	mg/L	472	470.8	471.4
10	BOD	mg/L	5.7	5.2	5.3
11	COD	mg/L	123	120	119
12	Hardness	mg/L	141.42	140.6	146
13	Alkalinity	mg/L	130.45	154	100.4
14	Cd	µg/L	1.1	1.2	1.1
15	Hg	µg/L	0.67	0.48	0.78
16	Cr	µg/L	0.87	0.81	0.79
17	Ni	µg/L	0.18	0.09	0.12
18	Cu	µg/L	0.09	0.11	0.11
19	Zn	µg/L	0.6	0.5	0.6
20	Mn	µg/L	0.88	0.8	0.77

Shri Narayan Sarovar 2023:

The water quality analysis of Shri Narayan Sarovar in Burhar Tehsil, Shahdol District for the year 2023 provides insight into seasonal variations across several key physico-chemical parameters. Temperature ranged from 22.8°C in winter to 29.64°C in the pre-monsoon season, dropping to 26.2°C post-monsoon, indicating natural seasonal fluctuations. The water remained consistently clear, colorless, and odorless across all seasons, pointing to the absence of visible contamination or significant pollutant discharge.

pH values were stable at 7.8 in winter and post-monsoon, with a slight increase to 7.9 during the pre-monsoon, suggesting near-neutral conditions. The concentration of total solids fluctuated slightly from 413 mg/L in winter to 378 mg/L pre-monsoon and 383 mg/L post-monsoon, with total dissolved solids (TDS) following a similar pattern, ranging from 271 mg/L to 261 mg/L and 277 mg/L, respectively. These values reflect moderate levels of dissolved minerals and organic matter, typical of freshwater bodies in the region.

Biological Oxygen Demand (BOD) was recorded at 6.6 mg/L in winter, dropping to 6.3 mg/L in pre-monsoon, and then rising slightly to 6.4 mg/L post-monsoon, indicating stable levels of organic matter and microbial activity. Similarly, Chemical Oxygen Demand (COD) values showed a gradual decrease from 120 mg/L in winter to 116 mg/L post-monsoon, reflecting a modest reduction in the amount of oxidizable pollutants.

In terms of hardness, levels remained consistent, decreasing slightly from 139.41 mg/L in winter to 137.8 mg/L post-monsoon, while alkalinity varied slightly between 145.41 mg/L and 141.4 mg/L, suggesting minimal changes in buffering capacity throughout the year.

Trace metal analysis revealed low concentrations, with cadmium (Cd) at 0.1 µg/L in both winter and post-monsoon, rising to 0.2 µg/L in pre-monsoon, while mercury (Hg) and chromium (Cr) remained consistently low at 0.76–0.9 µg/L, indicating limited heavy metal contamination. Similarly, levels of nickel (Ni), copper (Cu), zinc (Zn), and manganese (Mn) showed minimal fluctuations, staying within safe limits, with Zn at 0.58–0.6 µg/L and Mn at 0.89–0.9 µg/L across all seasons. This consistent heavy metal profile suggests that the lake's water quality remains largely unaffected by anthropogenic sources of metal pollution.

Table 3: Shri Narayan Sarovar, Burhar Tehsil, Shahdol, Madhya Pradesh 2023

SN	Characteristic	Unit	Winter	Pre-monsoon	Post-monsoon
1	Temperature	°C	22.8	29.64	26.2
2	Appearance	-	Clear	Clear	Clear
3	Colour	-	Colorless	Colorless	Colorless
4	Odour	-	Odourless	Odourless	Odourless
5	pH	-	7.8	7.9	7.8
6	Total Solids	mg/L	413	378	383
7	Total Dissolved solids	mg/L	271	261	277
8	Total Suspended Solids	mg/L	402	400	403
9	Chloride	mg/L	402	400.8	401.4
10	BOD	mg/L	6.6	6.3	6.4
11	COD	mg/L	120	117	116
12	Hardness	mg/L	139.41	138.5	137.8
13	Alkalinity	mg/L	145.41	144	141.4
14	Cd	µg/L	0.1	0.2	0.1
15	Hg	µg/L	0.76	0.7	0.7
16	Cr	µg/L	0.8	0.9	0.8
17	Ni	µg/L	0.11	0.1	0.12
18	Cu	µg/L	0.1	0.09	0.1
19	Zn	µg/L	0.58	0.6	0.58
20	Mn	µg/L	0.9	0.89	0.9

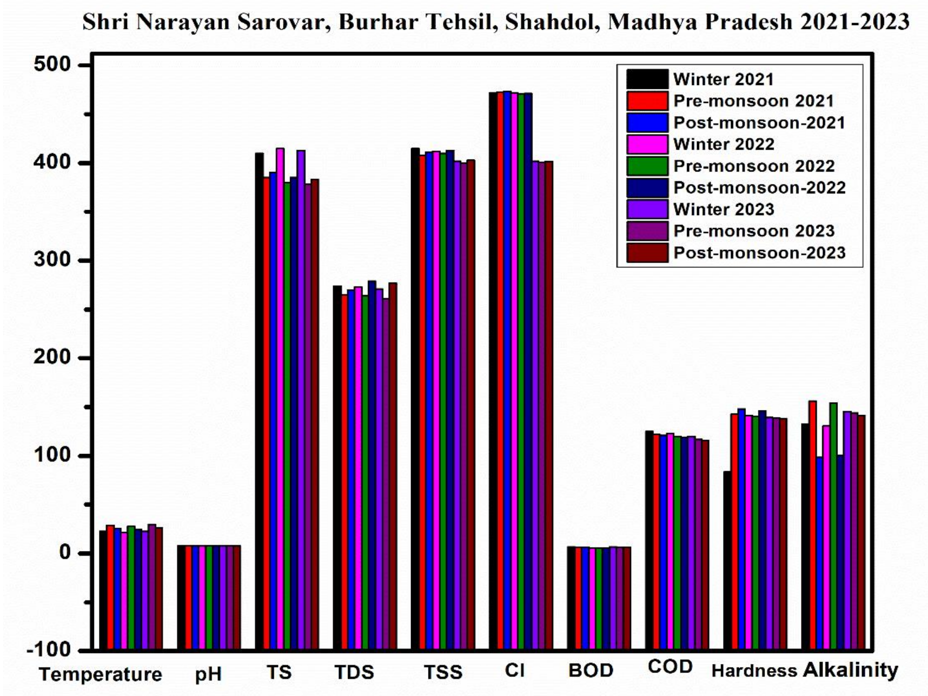

Figure 1: Water quality assessments of Shri Narayan Sarovor 2021-2023

Phytoplankton and Zooplankton study

Shri Narayan Sarovar

The phytoplankton density in Shri Narayan Sarovar from November 2022 to October 2023, as shown in Table 4, highlights seasonal variations across different taxonomic groups. The Euglenophyceae dominated the phytoplankton population with an average annual density of 744.67 org/l, contributing 41.53% of the total density. Chlorophyceae followed with an annual density of 635 org/l, representing 35.42% of the phytoplankton. Cyanophyceae showed an average density of 385.33 org/l, making up 21.49%, while Bacillariophyceae had the least presence with only 1.58% at 28.33 org/l. The overall total phytoplankton density reached 1793.33 org/l, reflecting higher densities during the summer season (2704 org/l) compared to winter (1213 org/l) and rainy (1463 org/l) seasons, indicating that warmer temperatures and nutrient availability during the summer promote phytoplankton growth.

Table 4: Annual density of phytoplankton in Shri Narayan Sarovar

from November 2022 to October 2023

		Mean annual density (org/l) Nov. 2022 to Oct. 2023				
S.N.	**Taxonomic group**	**Winter**	**Summer**	**Rainy**	**Average**	**Annual density percentage**
1	Euglenophyceae	470	1164	600	744.67	41.53
2	Chlorophyceae	438	953	514	635.00	35.42
3	Cyanophyceae	283	544	329	385.33	21.49
4	Bacillariophyceae	22	43	20	28.33	1.58
	Total	1213.00	2704.00	1463.00	1793.33	100

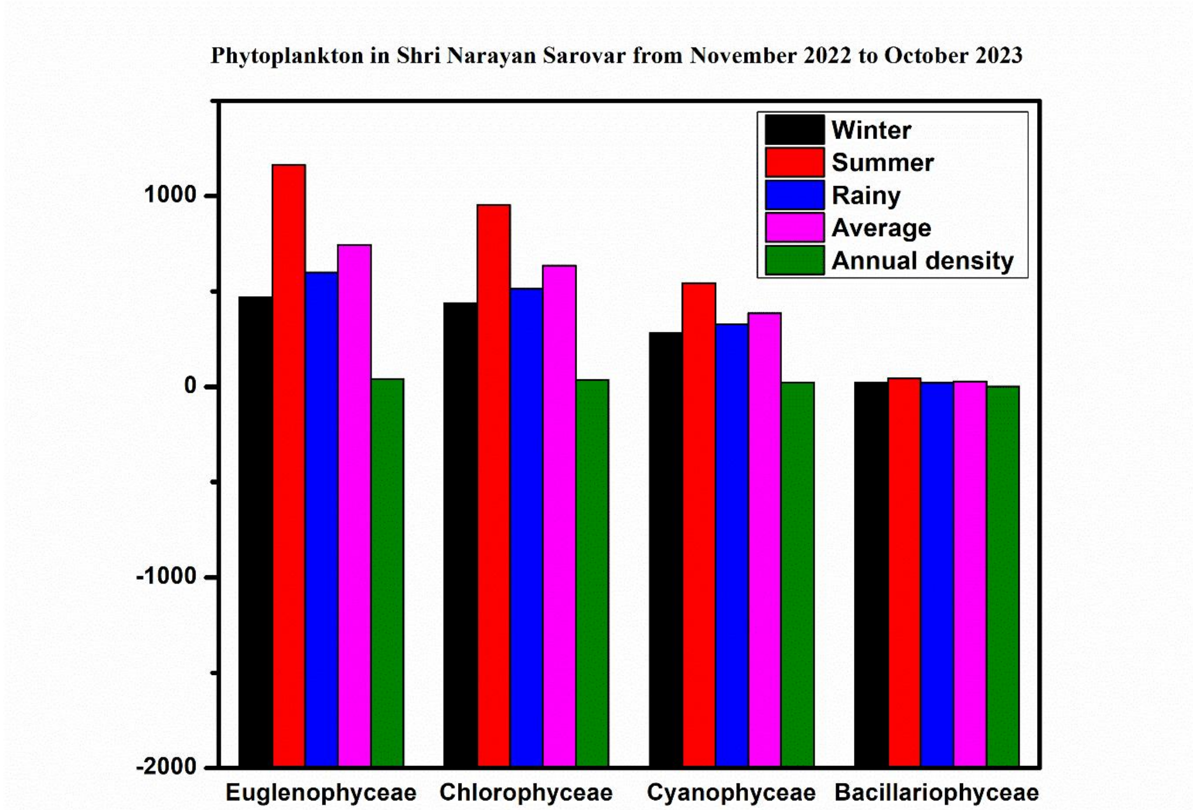

Figure 2: Phytoplankton in Shri Naryan Sarovar 2022-2023

The zooplankton composition in Shri Narayan Sarovar (Table 5) consists of five major groups, with Rotifera being the most abundant, accounting for 48.48% of the total genera and species composition. This dominance, with 16 genera and species, indicates favorable conditions for rotifer reproduction in the ecosystem. Cladocera contributed 18.18%, with 6 genera and species, followed by Copepoda at 15.15% (5 genera and species), suggesting their important role in the zooplankton community. Protozoa and Ostracoda had lower percentages, contributing 12.12% and 6.06%, respectively, with 4 and 2 genera and species each. In total, 33 genera and species were identified, highlighting a diverse zooplankton population that plays a crucial role in maintaining ecological balance in the water body.

Table 5: Genera and species percentage composition of different zooplankton classes in Shri Narayan Sarovar

S.No.	Group	Genera	Species	Percentage
1	Protozoa	4	4	12.121212
2	Ostracoda	2	2	6.0606061
3	Rotifera	16	16	48.484848
4	Copepoda	5	5	15.151515
5	Cladocera	6	6	18.181818
	Total	33	33	100

Zooplankton, being animal plankton, are subject to the movement of water currents, drifting passively through aquatic environments. They occupy a central position between autotrophs and other heterotrophs in aquatic ecosystems, forming a critical link in the food chain and serving as the primary energy source for fish. In freshwater environments, truly planktonic animals are predominantly Protozoa, Rotifera, Cladocera, and Copepoda, with protozoans making up a significant portion of the freshwater zooplankton community.

In the Narmada River, the zooplankton population primarily consists of Protozoans, Rotifers, Cladocerans, and Copepods. These zooplankton exhibit variations in abundance throughout the year, with peak populations observed during the winter and summer months over the study period.

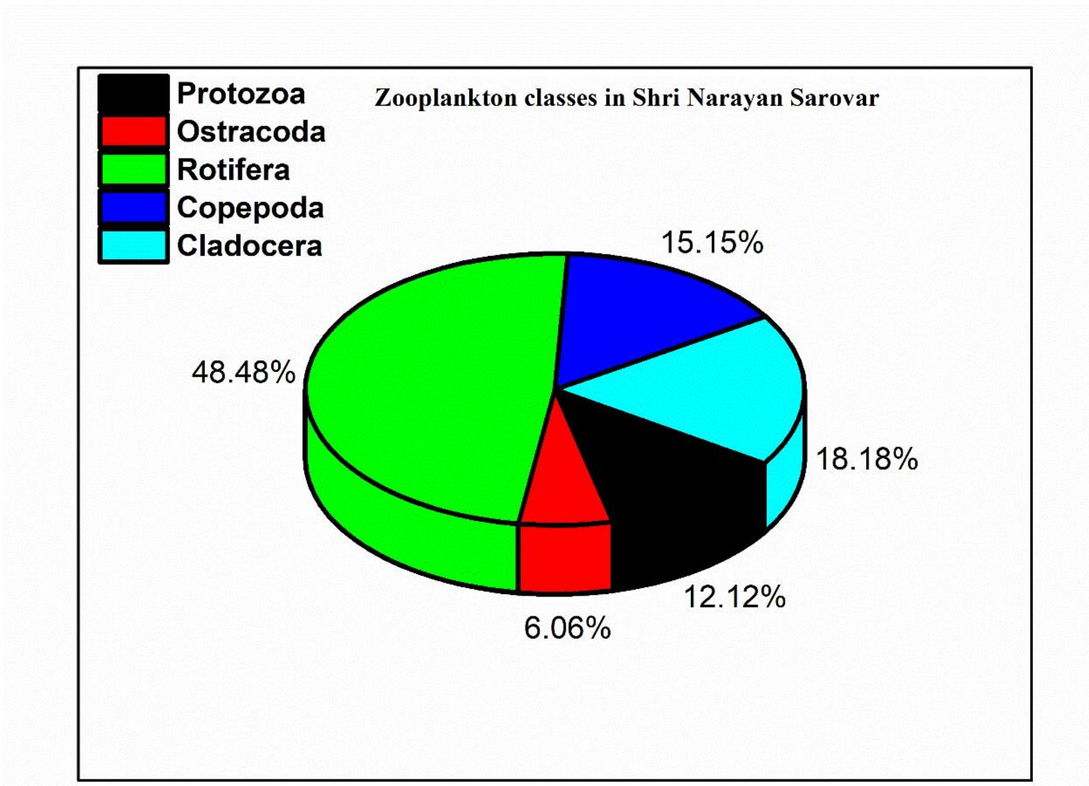

Figure 3: Zooplankton classes in Shri Narayan Sarovar

Population dynamics of Zooplanktons:

Protozoa:

During the current investigation, a total of 8 taxa of protozoa were identified, including Opercularia sp., Oxytricha, Epistylis sp., Euglypha sp., Diffugia sp., Arcella sp., Glaucoma sp., and Centropyxis sp. Among these, the highest abundance of protozoans was observed in March, while the lowest counts were recorded during July, August, and September. The decrease in protozoan diversity during the rainy season can be attributed to several factors. Heavy rainfall and flooding can disrupt the habitat and flow patterns, leading to unfavorable conditions for protozoan populations. Additionally, poor water quality resulting from runoff and increased sedimentation during the rainy season may further limit the growth and survival of protozoans. Moreover, reduced food availability, possibly due to dilution of nutrients and organic matter in floodwaters, could contribute to the decline in protozoan diversity during this period.

Rotifera:

During the study period, the zooplankton population was predominantly comprised of rotifers, with the highest population density observed in March and the lowest in August. A total of fifteen species of Rotifera were recorded during the investigation. Rotifers play a significant role in aquatic ecosystems, contributing to nutrient cycling and serving as an important food source for many organisms, including fish larvae and small invertebrates. The fluctuations in rotifer abundance observed throughout the year may be influenced by various environmental factors such as temperature, nutrient availability, and water quality parameters.

This group, presumably referring to rotifers based on the context, exhibited dominance during the winter and summer months, with significantly lower numbers recorded during the rainy months of both years. The peak diversity observed in February to April could be attributed to an abundance of food resources during these months. Conversely, the reduced diversity of this group from July to September may be a consequence of heavy rainfall, resulting in floods, poor water quality, and limited availability of food resources. These environmental factors likely contribute to fluctuations in the abundance and diversity of rotifers throughout the year.

Cladocera:

During the present investigation, nine species of Cladocera were identified in the Narmada River at Omkareshwar. Cladocera exhibited abundance from January to April, with the highest numbers recorded in March. However, their population declined from May onwards. Among the common genera of Cladocera observed in the study area were Moina, Ceriodaphnia, Daphnia, and Macrothrix species. These genera are known representatives of Cladocera and contribute significantly to the diversity and abundance of this group in freshwater ecosystems like the Narmada River.

Copepoda:

During the present investigation, seven taxa of protozoa were identified. The highest number of protozoans was reported in March, while the lowest counts were observed during July, August, and September. Protozoans thrived particularly well from March to April, with the maximum number recorded in March. The decrease in diversity during the rainy season may be attributed to factors such as heavy rainfall and floods, resulting in poor water quality and reduced food availability. These environmental conditions likely contribute to the observed fluctuations in protozoan abundance and diversity throughout the study period.

Figure 4: Zooplankton in Shri Narayan Sarovar

Discussion

Indian inland freshwater ecosystems boast a rich diversity of primary producers, which play a fundamental role in shaping the quality and quantity of life across various trophic levels within the water body. Each organism within the ecosystem, whether a plant or a member of the food chain or food web, contributes significantly to the flow of energy and nutrients within the system. Therefore, a comprehensive understanding of the biotic parameters is essential for gaining insights into the functioning of the ecosystem. The Narmada River is renowned for its remarkable diversity of zooplankton, which serve as vital links in the aquatic food chain, thereby maintaining the ecological pyramid of the ecosystem. Throughout the study period, zooplankton were recorded in abundant numbers, highlighting their importance in the river's ecology. Among the protozoan phylum, Arcella species exhibited higher numbers, followed by Glaucoma species. Within the minor phylum Rotifera, Filinia loniseta was the most abundant species, followed by Monostyla species, while Branchinus caudatus was recorded in lesser numbers. Among Cladocera, Moina branchiate was the most prevalent species, followed by Simicephalus species. Among copepods, Phyllodiaptomus species were recorded in higher numbers. This evaluation underscores the significant contribution of zooplankton to the biodiversity and ecological dynamics of the Narmada River, emphasizing the importance of studying and conserving these key organisms.

During the summer season, zooplankton from all major groups were observed in abundance. The peak population of zooplankton during summer correlates with higher temperatures, lower water transparency, and an increased standing crop of primary producers, resulting in greater availability of food resources. These findings align with those of Salve and Hiware (2010), who conducted a study on zooplankton diversity in the Wan Reservoir, Nagpur (Maharashtra, India). Their research also found that zooplankton populations peaked during the summer months, likely due to similar environmental conditions favoring zooplankton growth and reproduction.

According to Bais and Agrawal (1995), an upward trend in water alkalinity is associated with an increase in zooplankton population. Additionally, the concurrent presence of dissolved oxygen and hard water also promotes zooplankton production during the summer season in both lakes. Similar findings have been reported by other researchers, including Ramakrishnan and Sarkar (1982), Bhati and Rana (1987), and Kumar and Datta (1994). These studies collectively suggest that higher alkalinity levels, along with adequate dissolved oxygen and hard water conditions, contribute to the proliferation of zooplankton populations during the summer months in freshwater ecosystems.

Typically, during the monsoon season, lower population densities of zooplankton are observed due to the dilution effect caused by increased rainfall and reduced photosynthetic activity by primary producers. This decrease in zooplankton populations during the monsoon has been similarly documented by Bais and Agrawal (1995). Conversely, the population of total zooplankton tends to rise during the winter season due to favorable environmental conditions, including suitable temperatures, adequate dissolved oxygen levels, and the availability of abundant food resources such as bacteria, nanoplankton, and suspended detritus. These findings are supported by research conducted by Edmondson (1965) and Baker (1979), who also observed increased zooplankton populations during the winter months in response to these favorable environmental factors.

The abundance and distribution of zooplankton are influenced by a diverse array of ecological factors. Physiochemical parameters such as temperature, light intensity, pH levels, and the presence of organic and inorganic constituents play pivotal roles in shaping the nature and patterns of fluctuation in zooplankton population densities within an environmental unit. Numerous researchers, including Arora (1966), John et al. (1980), Rajendra (1992), Kumar and Datta (1994), Kodarkar (1992), and Desilva (1996), have emphasized the significance of these factors. However, it's important to note that these parameters exhibit considerable variability across different locations and over time. Furthermore, these parameters often interact with each other in complex ways, influencing zooplankton populations through intricate ecological relationships. Understanding the interplay of these factors is essential for elucidating the dynamics of zooplankton communities and their responses to environmental changes.

In the present study, the total zooplankton density exhibited a single peak during March. However, a sudden increase was observed in the month of October, which persisted until March. This increase can be attributed to the settling of rainwater and the return of favorable conditions in the post-monsoon period. It's noteworthy that several researchers, including Welch (1952), Das and Shrivastava (1956), and Mohanta (2000), have reported a bimodal pattern of zooplankton distribution. Additionally, Sompato et al. (2002) and Patil et al. (2003) have reported a single peak, but in the month of October, from the Madurai water body. These variations in zooplankton density patterns highlight the complex interplay of environmental factors and regional differences in zooplankton dynamics across different water bodies.

References

1. APHA (2002): Standard methods for Examination of water and waste water American public health Association 20th Ec. APHA, New York. Arora HC. (1966). Rotifers as indicators of trophic nature of environments, Hydrobiologia 27 (1&2): 146-149.
2. Bais V. S. and Agrawal NC. (1995). Comparative study of the zooplanktonic spectrum in the Sagar Lake and Military engineering lake. J. Environ. Biol. 16 (1): 27-32.
3. Bhati D. P. S. and Rana K. S. (1987). Zooplankton in relation to abiotic components in the fort moat of Bharatpur. Proc. Nat. Acad. Sci. India. 57 (13): 237-242.
4. Desilva K. (1996). limnological aspects of three, manmade lakes in Sri Lanka. Fresh water Forum 6: 39-56.
5. Edmondson, W. P. (1997). Population dynamics and secondary production, Ergeb. Limnol. Vol. (8). PP. 56-64.
6. John M, Winner PH and Patrick D. (1980). Zooplankton species diversity in lake St./Clairontaria, Canada. Hydrobiologia 75: 57-63.
7. Kodarkar M. S. (1992). Methodology for water analysis, physico-chemical, biological and
8. microbiological. Hyderabad, Indian Association of Aquatic Biologists (I.A.A.B.) Publ.
9. Krishnamurthy S. R., Barti, S. G. (1979). Aninvestigation on the dissolved oxygen oxiddizanle
10. organic matter and water temperature of river Roli, Near Dandelli in Karnataka, Indian J. Env. Polln. Vol. 1 (3 & 4) PP.93-95.
11. Kumar S and Datta SPS. (1994). Population Dynamics of Cladocera in a subtropical pond, Jamu, India. J. Environ. Hlth 36 (1): 19-23.
12. Mohanta B. K. and Patra A. K. (2000): Studies on the water quality index of river Sanamachhakandana at Keonjhargarh Orissa, India. Poll Res. 19: 371-385.
13. Needham, J G. Needham, P. R. (1962). A Guide to the study of freshwater biology. Holdend-day inc. Sanfrancisco, California: 108.
14. Nelson, J.S., (2006). Fishes of the World, 4th Edition. John Wiley and Sons, Inc, pp: 601.
15. Patil. P. R. S. K. Dhande, A. D. and Pawar, N. S. (2003): Water quality of river Tapi at bhusawal
16. Town. (North Maharashtra Univ. School of Env. And Earth Sciences Jalgaon Indian J. Env. Pro. Vol. 22(6) PP: 620-623.
17. Rajendra MC. (1992). Copepoda species. The freshwater zooplankton of India, S. K. Battish,
18. Oxford and IJIT India, 178-193.
19. Robertson, A.I. and S.J.M. Blabber (1992). Plankton, epibenthos and fish communities. In:
20. „Tropical Mangrove Ecosystems" (A.I. Robertson and D.M. Alongi Eds.). Coastal Estuar. Stud., 41: 173-224.
21. Salve B and Hiware C. (2010). Zooplankton diversity of Wan reservoir, Nagapur (MS) India. Tre. Res. In Sci. and tech. 2(1): 39-48.
22. Stottrup, J.G. (2000). The elusive copepods: Their production and suitability in study on the distribution and ecology of phytoplankton in the Kultanard wetland ecosystem, Kerala. Pollut. Res., 18, 261-269.
23. Tonapi G. T. (1962): Fresh water animals of India an ecological approach. Head Department of Zoology, University of Poona. Ganeshkhind Poona 411007.
24. Welch, P. S. (1952): Limnological methods. Blakiston Co; Philadelphia. Pa.