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Deciphering The Interplay Of Hydrological Parameters, Plankton Community, And Icthyofauna In Patela Pond, A Southern Rajasthan Ecosystem

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Abstract

Freshwater ecosystems are areas with high levels of biodiversity. Gaining a comprehensive understanding of the complex interconnections among hydrological factors, plankton communities, and fish variety is essential for developing and implementing effective conservation programmes. This study examines the distinctive environment of Patela Pond, southern Rajasthan, India. Our goal is to understand the complex relationship between these ecological elements and how they impact the diversity of fish in the pond. Our analysis will examine the simultaneous composition and abundance of the plankton community, with a specific emphasis on the phytoplankton and zooplankton groups and the relationship between water quality, plankton quantity, and the diversity richness of fish species. During the survey 37 different forms of phytoplankton were identified; (out of these, the genus of Chlorophyceae and Cyanophyceae predominate over the genus of Bacillariophyceae and Desmidiaceae); 28 different forms of zooplanktons were identified; (these forms belong to the phylum Copepods, Rotifers, Cladocerans, and Protozoa). The value of physico-chemical parameter observed between November 2022 to October 2023 including water temperature (17.75℃ to 42.15℃), pH (7.8 to 8.6), free CO_2 (1.09 ppm to 3.48 ppm), DO (5.1 to 5.7 mg/l), nitrate (0.38ppm to 0.95 ppm) and alkalinity (0.87 to 0.92).

Keywords: Physico-chemical parameters, Planktonic diversity, Phytoplankton's, Zooplanktons, Icthyofauna.

1. Introduction

The development of inland fisheries has enormous potential in the state of Rajasthan. Numerous lakes, tanks, rivers, streams, and seasonal ponds can be found. Numerous water ecosystems of varying sizes are abundant in southern Rajasthan. The freshwater ecosystem provides humanity with dynamic resources and is the only home for a remarkable diversity of unique species and vulnerable biota [1]. The major role that hydro biological factors perform in the waterbody is highly correlated with the diversity richness of aquatic ecosystem. Fluctuation in the physicochemical parameters of water lead to variation in distribution and abundance of zooplankton and phytoplankton [2]. The hydrological parameters that assist the growth of phytoplankton are temperature, alkalinity, phosphate, and nitrates. Different physical factors straightway or discursively impact the phytoplankton diversity. The fundamental details of the phytoplankton distribution and abundance would form a useful tool for further ecological assessment of pond [3]. Productivity of an aquatic ecosystem directly linked with physicochemical state, which can be exclusively used to determine potential for fisheries and tropical status [4]. The size of the prey species dictates the growth and mortality rate of the predator species. Research scholars have suggested that higher fish numbers are the cause of increased zooplankton [5]. The presence of plankton community is essential in regulating the fish population as it aids in determining the seasons and locations of spawning, adult spawners' biomass, annual variations in biomass, adult migrations, growth performance, survival rates of larval stages, environmental correlations, trophic relationships, and interactions among species during the larval stage that may affect the overall stock size [6]. The physical and chemical characteristics of the water have a major role in determining the amount and quality of phytoplankton as well as its seasonal dispersion. Their sensitivity and wide species composition alterations are frequently indicators of major changes in the ambient conditions within aquatic ecosystems [7]. The trophic dynamics of freshwater ecosystems have long acknowledged the significance of zooplanktonic components. In aquatic biotopes, zooplankton is a key component of the secondary energy transfer network. Examining zooplankton is essential to assess the ecological and fisheries conditions of freshwater reservoirs [8]. The growth, reproduction, and performance of fishes are influenced by various physical and chemical parameters of water, which collectively determine its quality. These parameters encompass dissolved oxygen, other gases, suspended solids, temperature, pH, mineral contents, and pollutants [9]. The primary goal of this study is to deciphering the interplay of plankton community, hydrological factors and Ichthyodiversity in the Patela pond. The study has set out specific objectives to analyse zooplankton diversity, phytoplankton diversity and physic-chemical parameters different seasons from November 2022 to October 2023.

2. Materials and methods

2.1 Study area

During the period from November 2022 to October 2023, water samples were collected monthly from the two different areas of Patela pond surrounding the Shree Somnath Mahadev temple and the adjacent Govardhan Gaushala Talwara, Southern Rajasthan. The Patela pond is located at latitude of 23.033’43.13’’N and longitude of 74.019’20.31’’E in Talwara tehsil.

Fig. 1. Study Area

2.2 Methodology

Water samples were collected on a monthly basis from two designated locations during the time frame of 6 AM to 10 AM. The temperatures were quickly recorded using thermometers, and the pH levels were measured with digital pH meters. Water samples were expeditiously transported to the laboratory in an ice box to prevent any variations in the samples, ensuring their integrity for further study. The hydrological parameters of the water and the diversity of plankton in the pond were determined using the standardized method outlined in APHA (1998) [10]. In order to measure the biological oxygen demand and dissolved oxygen levels using Wrinkler's method, great caution was exercised while collecting water samples in BOD bottles to ensure the absence of any air bubbles. The presence of Carbon dioxide in the water sample will be assessed by introducing 4-5 drops of phenolphthalein indicator solution to 50 ml of the sample. If there is no pink coloration observed, the solution will undergo titration with N/44 NaOH solution. The analysis Alkalinity of the water sample involves the addition of four drops of phenolphthalein solution and Bromocresol green to 50 ml of the sample. This solution will then be titrated using a standard sulphuric acid solution (0.02N). The determination of nitrate will involve the measurement of absorbance at 220 nm in a sample comprising 1 ml of hydrochloric acid (1N) within a 100 ml sample.

The plankton samples were obtained from two stations using Hensen's Standard Plankton net composed of bolting silk no. 25. To quantify, 50 liters of surface water were passed through small plankton net. Small amounts (10 ml) were extracted as sub samples, and plankton counting was conducted in a counting chamber using a C.Z. inverted microscope. After collection, the plankton, comprising both phytoplankton and zooplankton, were preserved by immersing them in a solution containing 70% alcohol. A qualitative assessment was performed on the plankton samples in accordance with Needham & Needham, (1962) [11], Alfred et al., (1973) [12], APHA, (1989) [13] and Edmondson, (1992) [14].

3. Result and discussion

The results of our research will provide significant relation of planktonic diversity and the hydrological parameters with icthyofaunal diversity. The productivity and diversity both are important in shaping of an ecosystem are greatly influenced by its habitat and producers. Human activities can have detrimental effects on the delicate balance of the freshwater pond ecosystem, leading to habitat destruction through industrial development, overconsumption of water, contamination from chemicals, pollution, sewage overflow, and other unfortunate events. The survival of the human population is heavily reliant on freshwater ecosystems in numerous aspects; however, their impact on these aquatic environments can be devastating. Anthropogenic activities, rapid urbanization, and industrialization have contributed to the development of ecological pressure on the aquatic environment in recent decades. As a result, human health has been directly or indirectly affected by these factors. The analysis conducted in the above study focused on a range of hydrological parameters and the diversity of plankton in pond water. The water temperature stands out as a paramount variable in evaluating water quality due to its profound impact on essential water quality factors and the overall vitality of aquatic organisms. Furthermore, it plays a pivotal role in governing the physiological activities of these organisms. The temperature range is linked to the photoperiod, leading to higher temperatures in summer and lower temperatures in winter. The surface water temperature of the pond observed during the study ranged from 17.75◦C to 42.15◦C. The pH is a numerical representation of the acidity or alkalinity of a liquid solution, indicating the level of hydrogen ions present in the solution. The current research demonstrates a pH range of 7.8 to 8.6, indicating an alkaline environment. The pH undergoes a shift from slightly acidic to slightly alkaline during the months of January to march.

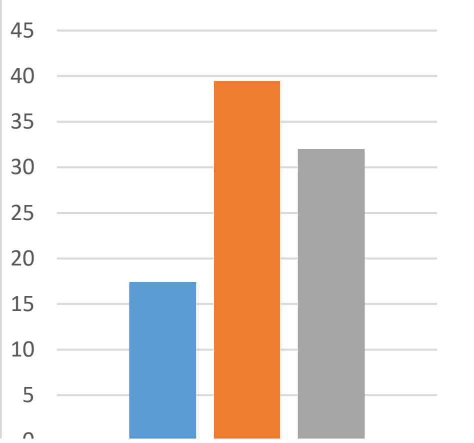

Fig. 2. Water temperature (°C)

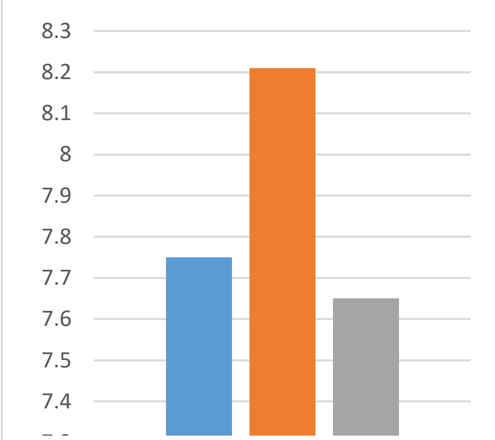

Fig. 3. Water pH

Dissolved oxygen (DO) is a metric that indicates the level of oxygen accessible to living organisms or the quantity of oxygen present in water through dissolution. The oxygen content in water is a result of various biological and physical processes that occur within the aquatic ecosystem. This balance is carefully managed by the presence of aquatic vegetation and the population of plankton. The DO is another essential element that upholds the existence of aquatic organisms. Elevated Biological oxygen demand refers to the quantity of oxygen consumed by microorganisms found in water. An increase in BOD leads to a decrease in DO levels within water.

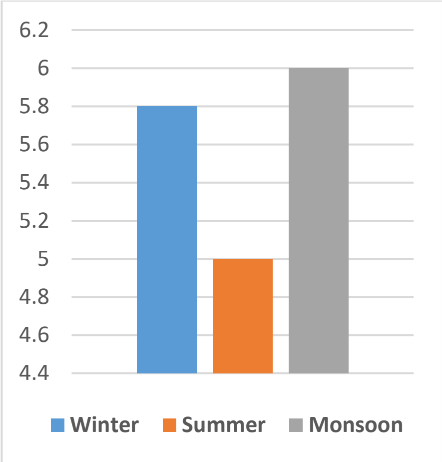

Fig.4. Dissolved oxygen (mg/l)

A high BOD serves as an indicator of a substantial amount of microbial pollution present in the water, which in turn has a direct or indirect influence on the diversity of fish. Dissolved oxygen levels exhibit seasonal fluctuations and also vary throughout a 24-hour cycle. These levels are influenced by changes in water temperature, as cold water has the capacity to hold more oxygen compared to warm water. The results of the present study demonstrated that the dissolved oxygen (DO) concentrations in Patela pond fluctuated between 5.1 and 5.7 mg. /linterestingly; these fluctuations followed a pattern of increasing DO levels from morning to evening, followed by a decrease from evening to the subsequent morning.

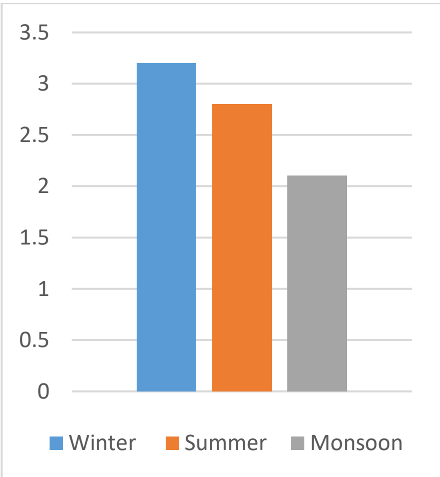

Fig. 5. Free Carbon dioxide (ppm)

Carbon dioxide is extremely soluble in water. Free carbon dioxide is a minor component of the atmosphere and plays a pivotal role in regulating various chemical parameters of water. The primary origin of free CO_2 is primarily the decomposition of organic matter and the respiration of plants and animals. During the study CO_2 ranges between 1.09 to 3.48 ppm.
Nitrate represents the extensively oxidized version of nitrogen compounds found in natural bodies of water, resulting from the aerobic breakdown of organic nitrogen waste. Typically present in minimal amounts, nitrate is necessary for numerous photosynthetic autotrophs and can sometimes act as a nutrient that restricts growth.
Additionally, it serves as a deciding nutrient for the growth of algae, and when present in high levels alongside phosphates, it leads to eutrophication. A nitrate concentration exceeding 40 ppm is deemed toxic. Water alkalinity signifies it's potential to neutralize a powerful acid, primarily caused by the existence of calcium, sodium, and potassium bicarbonate, carbonate, and hydroxide compounds. In addition, alkalinity functions as an indicator for productivity assessment. The total alkalinity of natural water bodies in tropical regions tends to vary significantly due to the fluctuation of pollution. These fluctuations are influenced by factors such as geography and season. The current investigation examined the levels of free CO2, alkalinity, and nitrate, which ranged from 1.30 to 2.80 ppm, 140 to 143 ppm, and 0.87 to 0.92 ppm,

respectively. The research being conducted affirms the importance of physiochemical parameters in influencing species distribution [15]. Patela Pond is an uncontaminated body of water with high diversity, according to data from the current study.

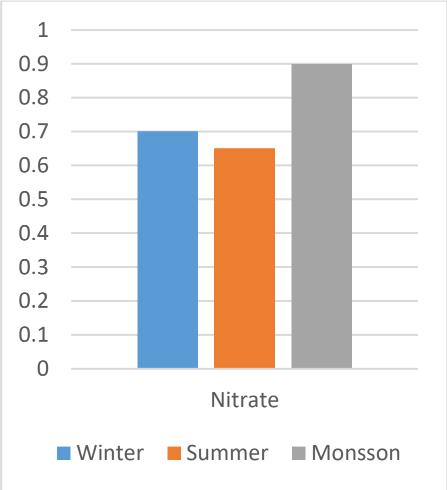

Fig. 6. Nitrate (ppm)

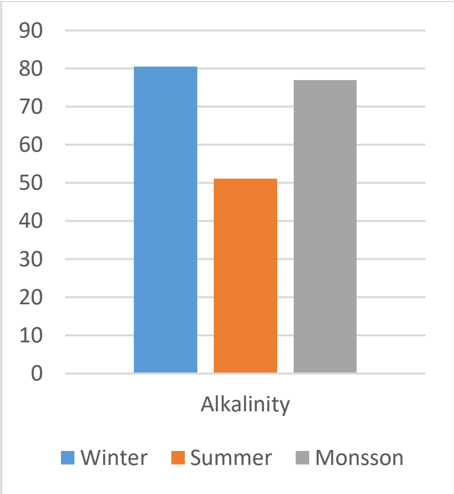

Fig. 7. Alkalinity (ppm)

The outcomes of the study's quantitative and qualitative examinations of the phytoplankton and zooplankton in Patela Pond, Banswara. Chlorophyceae, Desmidaceae, Bacillariophyceae, and Cyanophyceae are the only four groups of planktonic algae that have been identified from the region. The survey yielded the identification of 37 distinct phytoplankton forms, with the Chlorophyceae and Cyanophyceae genera predominating over the Bacillariophyceae and Desmidiaceae genera (Table 1 and 2). 12 of them (33.33%) belonged to the family Cyanophyceae, 9 to the Bacillariophyceae (25.00%), 12 to the Chlorophyceae (33.33%), and 4 to the Desmidiaceae (8.33%). The planktonic community at site 1 (Near the Shree Somnath Mahadev temple) and site 2 (adjacent to Govardhan Gaushala) shown in Table 1 and table 2. *Bacillaria sp.*, *Pediastrum sp.*, *Microcystis sp.*, *Agmenellum sp.*, *Anabaena sp.*, *Navicula sp.*, and *Spirulina sp*. were the predominant forms that were found at both sites. The site 1 of pond is probably polluted because pollution indicator species like *Microcystis sp.*, *Oscillatoria sp.*, and *Anabaena sp.* are present abundantly at site 1. The predominance of blue green algae in the rivers and lakes of Udaipur was also noted by Sharma (1980) [15], Solomon (1994) [16], and Shekhawat (1997) [17]. A study by Goldman & Horne (1983) [18] found that the predominance of blue green algae is an indicator of eutrophication. Within the Chlorophyceae family, Chlorella was the most abundant genera. The dispersion of algae is influenced by the nutrients and other organic and inorganic materials present in the water as well as the relative adaptability of various species. The factors for water quality have a direct impact on phytoplankton ecology and dispersal. The organization of the phytoplankton community is significantly impacted by the rise in phosphate concentration as well as the relationship between phosphorus and nitrogen. High photosynthetic activity is shown by the negative relationship between plankton abundance and dissolve oxygen. Algae may be useful as markers of the many anthropogenic activities in the surrounding land region, which have a significant impact on the phytoplankton communities in the two stations analysed. In the current study, total phytoplankton exhibited a positive relationship with pH, alkalinity, and water temperature at all sites, but a negative correlation with DO, free CO_2, and nitrate.

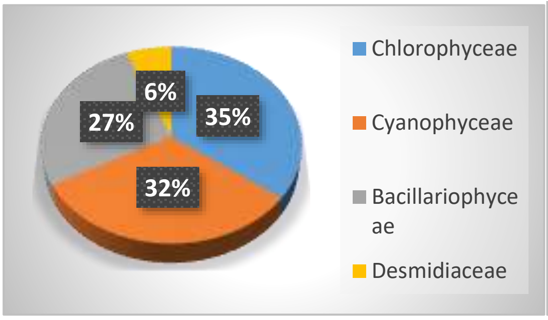

Fig. 8. Relative % of Phytoplankton's at site 1

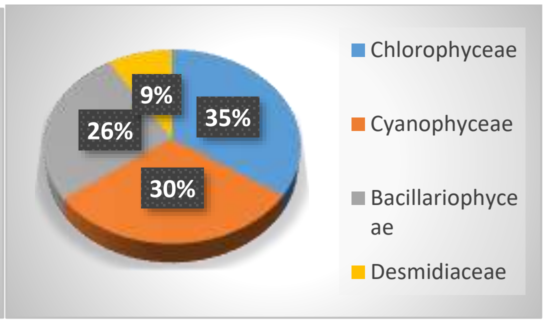

Fig. 9. Relative % of Phytoplankton's at site 2

Identification of zooplanktons was done up to the generic level. 32 genera of zooplankton, representing the four major families Copepoda, Rotifera, Cladocera, and Protozoa, were identified in two locations of the Patela Pond in Banswara during the study period (Table 1 and 2). 32 genera were identified: 11 from the Rotifera (34.37%), 9 from the Cladocera (28.12%), 7 from the Copepoda (21.87%), and 5 from the Protozoa (15.62%). Protozoa, Rotifera, Cladocera, and Copepods have been found to make up the zooplankton population. The second most prominent form of cladocera is *Moina sp.*, whereas *Daphnia* was the most dominant genus. Copepod's most dominating genus was *Diaptomas sp.*, while its second most prominent form was *Cyclops sp. Amoeba sp.* and *Vorticella sp.* ranked second and third among protozoa, with *Paramecium* being the most abundant genus. Along with protozoa, the most common forms like as *Brachionus sp., Keratella sp., Asplanchna sp., Cyclops sp.,* and *Daphnia sp.* show that the reservoir has become eutrophic. The Rotifers have gained international recognition as water quality markers. Rotifers are among the most sensitive zooplankton indicators of water parameters; hence, the presence of a particular species can serve as a reference for the physical and chemical properties of the water. The predominance of rotifers among zooplankton suggests that the pond's water is contaminated. Increased interspecific interaction, stability within the lake zooplanktonic population, and a wider food chain are all indicators of a diverse ecosystem (Shanthala et al., 2008) [19]. Rotifers are thought to be the most sensitive indicators of water qualities, meaning that the presence of a particular species can serve as an indication for the hydrological features of the water. There isn't much significant pollution at site 2, though. Result specified that site 1 having slightly polluted water due to more anthropogenic activities which indicate low diversity as compared to site 2 showing high diversity due to relatively less polluted water.

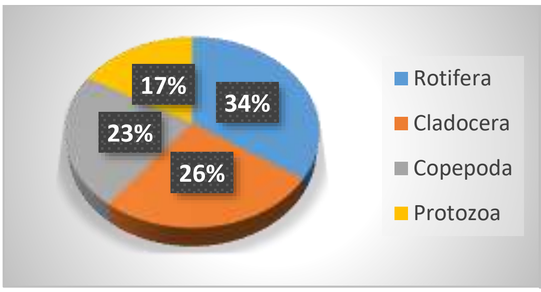

Fig. 10. Relative % of Zooplanktons at site 1

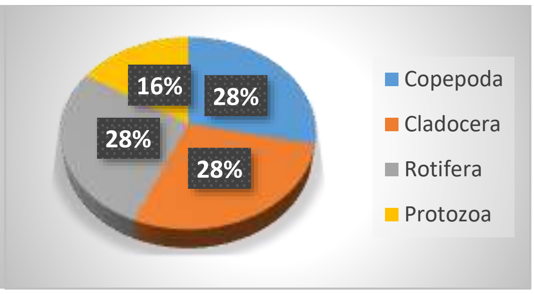

Fig. 11. Relative % of Zooplanktons at site 2

The Shannon wiener's index for phytoplankton at site 1 and site 2 is 1.252 and 1.294 respectively, while Shannon wiener's index for zooplankton at site 1 and site 2 is 1.353 and 1.362 respectively. Present study revealed that site 2 showing more value of Shannon wiener's index as compared to site 2. If value of H' is between 2-3 i.e. light pollution level and between 1-2 show moderate pollution level. Malhotra et al. (2014) [20] noted that intermittent increases in industrial pollution and sewage discharge led to a decline in the zooplankton diversity of the Yamuna River.

S. No.	Phytoplankton Family	Number of individuals (p)	Shannon wiener's index (H')
1	Chlorophyceae	668	-0.36761
2	Cyanophyceae	602	-0.36446
3	Bacillariophyceae	506	-0.3529
4	Desmidiaceae	112	-0.16757
	Total	**1888**	**H'= 1.252532**
Zooplankton			
	Phylum of zooplankton	P	H'
1	Rotifera	155	-0.36712
2	Cladocera	117	-0.35024
3	Copepoda	103	-0.3375
4	Protozoa	80	-0.29863
	Total	**450**	**H'= 1.353483**

Table 1. Diversity of Planktonic Community at site 1

S. No.	Phytoplankton Family	Number of individuals (p)	Shannon wiener's index (H')
1	Chlorophyceae	663	-0.36721
2	Cyanophyceae	580	-0.3617
3	Bacillariophyceae	504	-0.35123
4	Desmidiaceae	170	-0.21485
	Total	**1917**	**H'= 1.294989**
Zooplankton			
	Phylum of zooplankton	P	H'
1	Copepoda	145	-0.35743
2	Cladocera	143	-0.35639
3	Rotifera	141	-0.35529
4	Protozoa	82	-0.2936
	Total	**511**	**H'= 1.362711**

Table 2. Diversity of Planktonic Community at site 2

List of Plankton community observed during study at both sites		
Phytoplankton		
1. Chlorophyceae	Site 1	Site 2
Chlamydomonas sp.	+ +	+ + +
Chlorella sp.	+ + +	+ + +
Pediastrum sp.	+ +	+ +
Protococcus sp.	+	+ +
Spirogyra sp.	+ +	+ + +
Tetraspora sp.	+	+ +
Ulothrix sp.	+ + +	+ +
Volvox sp.	+ + +	+ + +
2. Cyanophyceae		
Agmenellum sp.	+ +	+ + +
Anabaena sp.	+ + +	+
Arthrospira sp.	+	++
Coelosparium sp.	+	+
Meriosmopedia sp.	+	+ +
Microcystis sp.	+ + +	+
Nostoc sp.	+ +	+ + +
Oscillatoria sp.	+ + +	+ +
Polycystis sp.	+	+
Sphanocapsa sp.	+	+ +
Spirulina sp.	+ +	+ + +

Synechocystis sp.	+	+ +
3. Bacillariophyceae		
Asterionella sp.	+	+ +
Bracillaria sp.	+ +	+ + +
Cyclotella sp.	+ + +	+
Diatoma sp.	+ + +	+ +
Fragilaria sp.	+	+ +
Navicula sp.	+ +	+ + +
Nitzchia sp.	+ + +	+ + +
Pinnularia sp.	+	++
Synedra sp.	+	+
Tabullaria sp.	+	+ +
4. Desmidiaceae		
Closterium sp.	+ +	+ ++
Eustrum sp.	+ +	+ + +
Netrium sp.	+ +	+ + +
Staurastrum sp.	+ + +	+ +

Zooplankton		
1. Cladophora	Site 1	Site 2
Alonella sp.	+ +	+ + +
Bosmina sp.	+ + +	+
Chydorus sp.	+	+ + +
Daphnia sp.	+ + +	+ +
Diphanosoma sp.	+ +	+ + +
Macrothrix sp.	+ +	+ + +
Moina sp.	+ + +	+ + +
Sida sp.	+ + +	+ + +
Simocephalus sp.	+	+ +
2. Copepoda		
Canthocampus sp.	+	+ +
Cyclops sp.	+ + +	+ +
Diaptomas sp.	+ + +	+ + +
Halicyclops sp.	+	+
Mesocyclops sp.	+	+ +
Nauplius larva	+ +	+ +
3. Rotifera		
Aslanchna sp.	+ + +	+
Branchionus sp.	+ + +	+
Filinia sp.	+ +	+ + +
Hexathra sp.	+ +	+
Keratella sp.	+ + +	+
Monostyla sp.	+ +	+ + +
Notholca sp.	+ + +	+
Platyias sp.	+ +	+ + +
Polyarthra sp.	+ + +	+
Rotaria sp.	+ +	+
Testudinella sp.	+ +	+ + +
Trichocera sp.	+ +	++
4. Protozoa		
Amoeba sp.	+ + +	+ +
Paramecium sp.	+ +	+ +
Vorticella sp.	+ + +	+ +

Most abundant; + + +, Abundant; + +, less abundant; +

Table 3. List of Common genera of Plankton found in Patela Pond, Banswara

4. Conclusion

By clarifying the relationship between hydrological factors, plankton communities, and fish variety, we may detect possible dangers and direct the creation of focused conservation efforts. This knowledge can guarantee the enduring well-being and viability of Patela Pond's distinctive biodiversity. The interdependence and complex interactions between biological communities and abiotic environmental factors, along with the availability of resources in their specific location, highlight the sensitivity of these communities to anthropogenic activities. Consequently, these communities have the ability to undergo transformations in response to environmental changes.

The nature of fish is characterized by their ectothermic properties, which means their body temperature is dependent on the surrounding environment. Temperature plays a decisive role in shaping their physiology, particularly by influencing their metabolic rate. As a result, variations in temperature have a profound impact on their feeding and locomotory behaviour. Juvenile fish and fry exhibit high sensitivity to low pH levels (below 5), which can result in mortality. Elevated pH levels (pH 9-14) have the potential to harm the internal structure of fish, such as the cellular membrane. Imbalanced pH of pond indicates the unclear pond water. Water that is considered healthy typically contains a dissolved oxygen concentration of at least 6.5-8 mg/l.

In Patela Pond, Chlorophyceae have taken up the primary dominant position. Surprisingly, the small rotifers and Cladocera larvae have emerged as the most dominant species in pond, despite the presence of larger organisms in the primary food source. Consequently, the abundance of zooplankton and phytoplankton has been observed to have a strong correlation with both fish production and the diversity of fish species in the Patela pond. By analysing the diversity and population of planktonic species in relation to abiotic factors, this study may offer valuable information for the future planning and regulation of fish culture in these water bodies.

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