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***Research Article** (Open Access)*

AN ASSESSMENT OF PLANKTONIC DIVERSITY AND ABUNDANCE IN THE MAN SAGAR LAKE, JAIPUR, INDIA

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ABSTRACT
The composition and diversity of zooplanktons in the studied aquatic ecosystem were investigated. There were 18 planktons in total, including 11 zooplankton and 07 phytoplankton species. Zooplanktons have been identified as Branchiopoda, Hexanauplia, and Crustacea, while phytoplanktons were classified as Trebouxiophyceae and Chlorophyceae. The most abundant plankton was found to be *Coelastrum microporum*. The diversity of planktons was estimated by calculating Simpson index of diversity, Shannon index and Pielou's evenness index which were 0.936, 2.769, and 0.958. Simpsonindex of diversity indicated more than 93 percent chances of capturing different species of planktons while random sampling. Shannon index also represented high diversity in the studied aquatic ecosystem. The value of Pielou's evenness index showed high closeness in the abundance of planktons. Climatic parameters clearly indicated high relation between abiotic factors and the diversity of planktons. This work is very significant in conserving fish fauna in Man Sagar Lake as the planktons are good indicators of environmental pollution.

***Keywords*:** *Diversity, Environment, Phytoplankton, Zooplankton*

INTRODUCTION
Water is a component of the dynamic aquatic life-supporting system that contains a diversity of living species and their interactions, as well as dissolved or suspended organic and inorganic components (Anyinkeng *et al*., 2016). In the Indian desert's freshwater ecosystem, there are numerous faunal species, the majority of which are adapted to the existing conditions. Hundreds of freshwater species from various groups, such as the Protozoa, Annelida, Arthropoda, Mollusca, Pisces, and Amphibia, spend at least part of their lives in freshwater habitats (Srivastava, 2021). Plankton is abundant in aquatic ecosystems. Freshwater planktonic organisms are dominated by rotifers and crustaceans. Phytoplankton and Zooplankton are both types of plankton. Phytoplanktons are microscopic autotrophs that float in water and move in response to the current. While Zooplanktons are a diverse group of minute floating animal forms found in water. They may have locomotory structures but cannot move against the current of water. This latter characteristic distinguishes plankton from nekton, which is a community of actively swimming organisms such as fish, larger cephalopods, and aquatic mammals. There are two types of phytoplankton: (l) Nonmotile, fast-growing diatoms and (ii) motile flagellates and dinoflagellates that can migrate vertically in response to light. Each group has a wide range of cell shapes, many of which have intricate designs and ornamentations (Chavada *et al.,* 2016).

Plankton builds intricate biotic communities that exhibit the same functional diversity and depth of interaction as terrestrial organisms. They are crucial to recycling nutrients and energy in the aquatic environment. These are among the important biotic elements that have an impact on the food chain, food web, and energy exchange in an aquatic ecosystem. It serves as a critical link in aquatic food webs by occupying a pivotal position between autotrophs and other heterotrophs. In transforming plant material into animal food, zooplankton is a significant factor (Nama *et al*., 2019). The fluctuation of abiotic variables, such as temperature, total alkalinity, total nitrogen, phosphate, and pH, can have an impact on plankton growth. Phytoplankton community diversity and abundance is a useful bio-indicator for determining the quality of the water. Due to its unique biogeographic location, extensive climate fluctuations, and different ecosystems, India is blessed with great biodiversity.

India is home to over 89,500 animal species, or slightly more than 7% of all known animal species, despite accounting for less than 2% of the world's total area (Sharma, 2020). A robust plankton ecosystem is characteristic of Indian reservoirs, which can be linked to abiotic causes and nutrient load fluctuation (Goswami *et al.*, 2012). Rajasthan is India's largest state. It is located between latitudes 230 03' N and 300 12' N and longitudes 690 30' E and 780 17' E. Ponds, tanks, dams, naadis, Johra, beri, and bawari, as well as a few perennial lakes, are among the fewer but more diverse bodies of water in the area (Rukasana *et al.*, 2015).

MATERIALS AND METHODS

- ***Study area***- Man Sagar Lake is an artificial lake located in Jaipur, the capital of the Indian state of Rajasthan, with coordinates of 26° 57′ 21.6″ N to 75° 51′ 0″ E. It is surrounded on three sides by the Aravalli hills and has a water spread area of 300 acres (121 ha), while the southern side is heavily populated lowlands.
- The Lake is a shelter for a wide range of migratory birds, enabling aquatic ecosystem species to live sustainably (Fig. 1).

Figure 1: Geographical location of Man Sagar Lake in Rajasthan, India (26° 57′ 21.6″ N to 75° 51′ 0″ E)

- ***Sample collection***-Planktons were collectedusing a planktonic net of 0.2-micron mess size and water samples were collected by using BOD bottles from a depth of 2-3 feet from the surface. Filtered sampleswere collected in the plastic bottle attached to the net. After collection, the sampleswere transferred to a different plastic bottle that contained5% formalin solutionas a preservative.
- ***Identification of planktons***-Planktons were identified by using taxonomic keys and literature.
- ***Quantitative estimation***- It was carried out by using a Sedgwick rafter chamber.
- ***Estimation of Diversity***-It was estimatedbythe Simpson index, Shannon index, and Pielou's evenness index.

(a) *Shannon index (H):* It is a measure of the diversity of the environment that contains the abundance and richness of species in a particular habitat that estimate the uncertainty in a set of data.

Shannon Index (H) $= -\sum_{i=1}^{s} P_i lnP_i$

n = Number of plankton species
N =Total number of planktons in the sample
Pi = (n/N), ln= natural log

(b) *Simpson index (Z):* It is a measure of diversity depending on relative abundance.
Simpson Index (Z)=$\Sigma^{s}{}_{i}Pi^{2}$

n = Number of plankton species
N =Total number of planktons in the sample
Pi = (n/N), ln= natural log

(c) ©*Pielou's evenness index (J)* is defined as the index showing the closeness of the abundance of different species in an ecosystem. Its value is range from 0 to 1.

J = H / ln S

Here, H = Shannon index, lnS = natural log of Species richness

- ***Qualitative estimation of water sample***

Table 1: Ecological parameters of the study area

Sr. No.	Parameters	Unit	Test method
1	PH	------	APHA,23rdEd:4500H+
2	Hardness	mg/l	APHA,23rd Ed: Method: 2340 C
3	Fluoride	mg/l	APHA,23rd Ed: Method: 4500 F-C
4	Total Dissolved Solids (TDS)	mg/l	APHA, 23rd Ed: 2540 C
5	Biochemical Oxygen Demand	mg/l	IS 3025 (Part 44)
6	Alkalinity	mg/l	APHA, 23rd Ed: 2320 B
7	Chemical Oxygen Demand (COD)	mg/l	APHA, 23rd Ed: 5220 B
8	Dissolved Oxygen (DO)	mg/l	ISO 3025 (P-38)
9	Fixed Dissolved Solids	mg/l	APHA, 23rd Ed:2540 E
10	Acidity	mg/l	APHA,23rdEd: 2310 B
11	Conductivity	µmho/cm^2	APHA, 23rdEd: 2510
12	Salinity	gm/kg	APHA, 23rd Ed: 2520

RESULTS AND DISCUSSION

A total of 18 species of planktons were observed in the study area consisting of 11 species of zooplanktons and 7 species of phytoplanktons (Table 2). All zooplanktons belonged to the Arthropoda phylum and all phytoplanktons belonged to the Chlorophyta division. Zooplanktons have been found belonging to three major classes i.e.,Branchiopoda (05), Hexanauplia (05), and Crustacea (01). Phytoplanktons were belonging to Trebouxiophyceae (02), and Chlorophyceae (05) classes. Most of the planktons were belonging to the Ctenopoda order followed by Cyclopoida, and Calamoida (Fig. 2). *Coelastrum microporum* was found as the most abundant plankton (135) followed by *Diaptomus sp* (112), *Stauridium tetras* (112), *Tetraedron lobulatum* (102) (Table 3). All the planktons were observed morphologically distinct from each other (Fig. 3). Diversity of planktons has been estimated by calculating the Simpson index, Shannon index, and Pielou's evenness index. Simpson's index was estimated at 0.064, Simpson's index of diversity was 0.936, Shannon's index was 2.769, and Pielou's evenness index was estimated at 0.958. The value of the Simpson Index of diversity (0.936) is suggesting that more than 93percent of chances of capturing different plankton species while random sampling was carried out in the study area. The value of the Shannon index suggests that a

high diversity of plankton was observed in the studied lake. According to a credible investigation, reservoirs support zooplankton communities with stable physiochemical environments based on Shannon diversity index values between 0.67 and 2.63 (Ferrara *et al*., 2002). The value of Pielou's evenness index (0.958) is suggesting that there was more than 95 percent of closeness in the abundance of planktons showing the equal contribution of planktons in the studied ecosystem. The ecological parameters of the studied lake were measured (Table 4). The temperature has the most profound direct and indirect influence on all life forms (Welch, 1952). It is critical in regulating plankton flora's quality and quantity (Hutchinson, 1957). The lake water temperature ranged between 17ºC and 30ºC.It was suggested that pH 5.0 to 8.5 is ideal for phytoplankton growth (Robert *et al*., 1974). The average pH was measured at 7.44, which was alkaline and favoured for planktonic growth. The amount of dissolved oxygen in water indicated the health of the aquatic ecosystem. The amount of dissolved oxygen increased as the season changed from monsoon to winter. The dissolved oxygen concentration was 4.9 mg/l.Total dissolved solids were measured at 1294 mg/l, which is higher than the standard condition and may be due to low water levels caused by evaporation. Alkalinity was measured at 332 mg/l as a result of water evaporation and a high concentration of bicarbonates. It was reported correlation between alkalinity and primary productivity of aquatic ecosystems (Sulabha *et al*., 2006). Alkalinity affects the primary productivity of an aquatic ecosystem. Phytoplankton flourishes in more alkaline environments because alkaline systems trap atmospheric carbon dioxide (Lopez-Archilla *et al*., 2004). The conductivity of water was estimated at 1922 µmho/ cm^2. It was reported a high positive correlation between primary productivity and the conductivity of water (Das *et al*., 2004). Fixed dissolved solids (FDS) and total dissolved solids (TDS) were measured at 848 mg/l and 1294 mg/l respectively. When FDS and TDS levels exceed the normal range, it indicates that the water is not being used for agriculture or drinking. The hardness was calculated to be 324 mg/l. Water hardness is the final parameter that indicates that the quality of salts in water samples, such as carbonate and many other salts is higher. BOD was reported to be lower in unpolluted waters and higher in polluted water (Hussain *et al*., 2004). The BOD of the studied water sample was estimated 22 mg/l showing slow eutrophication of the lake. The COD of the studied lake was recorded at 134 mg/l. COD is used to determine the amount of oxidizable pollutants in surface water. COD detection can easily determine the amount of organics in water (Davidson, 2001).

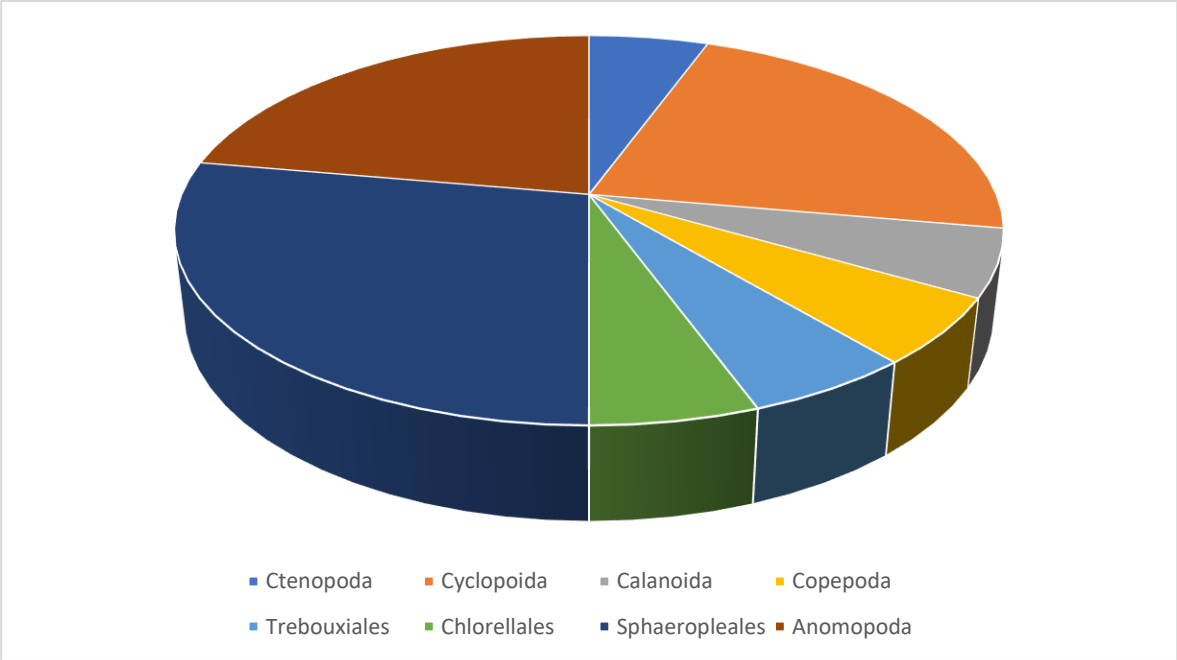


Figure 2: Diversity of Orders of Planktons

Table 2: The planktons and their systematic positions.

SN	Plankton	Division	Class	Order	Family
1.	*Daphnia carinata*	Arthropoda	Branchiopoda	Anomopoda	Daphniidae
2.	*Daphnia pulex*	Arthropoda	Branchiopoda	Anomopoda	Daphniidae
3.	*Diaphanosoma sarsi*	Arthropoda	Branchiopoda	Ctenopoda	Sididae
4.	*Bosmina longispina*	Arthropoda	Branchiopoda	Anomopoda	Bosminidae
5.	*Moina brachiata*	Arthropoda	Branchiopoda	Anomopoda	Moinidae
6.	*Cyclops sternuus*	Arthropoda	Hexanauplia	Cyclopoida	Cyclopidae
7.	*Cyclops leuckarti*	Arthropoda	Hexanauplia	Cyclopoida	Cyclopidae
8.	*Cyclops affinis*	Arthropoda	Hexanauplia	Cyclopoida	Cyclopidae
9.	*Diaptomus sp.*	Arthropoda	Hexanaupia	Calanoida	Diaptomidae
10.	*Macrocyclops albidus*	Arthropoda	Hexanauplia	Cyclopoida	Cyclopidae
11.	*Nauplius larva*	Arthropoda	Crustacea	Decapoda	----------
12.	*Botryococcus braunii*	Chlorophyta	Trebouxiophyceae	Trebouxiales	Botryococcaceae
13.	*Lagerheimia ciliate*	Chlorophyta	Trebouxiophyceae	Chlorellales	Oocystaceae
14.	*Coelastrum microporum*	Chlorophyta	Chlorophyceae	Sphaeropleales	Scenedesmaceae
15.	*Coelastrum cambricum*	Chlorophyta	Chlorophyceae	Sphaeropleales	Scenedesmaceae
16.	*Tetraedron lobulatum*	Chlorophyta	Chlorophyceae	Sphaeropleales	Hydrodictyaceae
17.	*Stauridium tetras*	Chlorophyta	Chlorophyceae	Sphaeropleales	Hydrodictyaceae
18.	*Acutodesmus acuminatum*	Chlorophyta	Chlorophyceae	Sphaeropleales	Scenedesmaceae

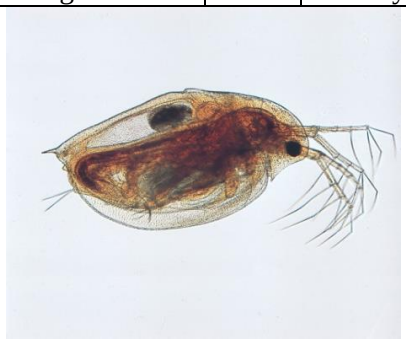
Table 3: Estimation of diversity indices of captured planktons (n= Organism/L)

SN	Planktons	Numbers (n)	Pi= n/N	Pi^2	lnPi	PilnPi
1.	*Daphnia carinata*	57	0.048	0.002	-3.036	-0.146
2.	*Daphnia pulex*	46	0.039	0.001	-3.244	-0.126
3.	*Diaphanosoma sarsi*	61	0.051	0.003	-2.975	-0.152
4.	*Bosmina longispina*	35	0.029	0.0008	-3.540	-0.103
5.	*Moina brachiata*	29	0.024	0.0005	-3.730	-0.089
6.	*Cyclops sternuus*	52	0.043	0.002	-3.146	-0.135
7.	*Cyclops leuckarti*	49	0.041	0.002	-3.194	-0.131
8.	*Cyclops affinis*	60	0.050	0.002	-2.996	-0.150
9.	*Diaptomus sp.*	112	0.094	0.008	-2.364	-0.222
10.	*Macrocyclops albidus*	56	0.047	0.002	-3.058	-0.144
11.	*Nauplius larva*	22	0.018	0.0003	-4.017	-0.072
12.	*Botryococcus braunii*	43	0.036	0.001	-3.324	-0.120
13.	*Lagerheimia ciliate*	59	0.049	0.002	-3.016	-0.148
14.	*Coelastrum microporum*	135	0.113	0.013	-2.017	-0.238
15.	*Coelastrum cambricum*	92	0.077	0.006	-2.563	-0.197
16.	*Tetraedron lobulatum*	102	0.086	0.007	-2.453	-0.211
17.	*Stauridium tetras*	112	0.094	0.008	-2.364	-0.222
18.	*Acutodesmus acuminatum*	68	0.057	0.003	-2.865	-0.163
	Grand total (N)	1190	ΣPi^2 =	0.064	ΣPilnPi=	-2.769
Simpson index of diversity(1-D) = 1-ΣPi^2			1- 0.064 = 0.936			
Shannon index (H)= -(ΣPilnPi)			-(-2.769) = 2.769			
Pielou's index = H/ lnS			2.769/2.890 = 0.958			

Table 4: Climatic Parameters of Man Sagar Lake

SN	Parameters	Result	SN	Parameters	Result
1.	pH	7.44	7.	COD	134mg/l
2.	Total Hardness	324mg/l	8.	Dissolved Oxygen	4.9mg/l
3.	Fluoride	0.254mg/l	9.	Fixed Dissolved Solids	848mg/l
4.	Total Dissolved Solids	1294mg/l	10.	Acidity	BDL
5.	BOD	22mg/l	11.	Conductivity	1922µmho/cm^2
6.	Alkalinity	332mg/l	12.	Salinity	0.71gm/kg

Daphnia carinata



Daphnia pulex

Diaphnosoma sarsi

Bosmina longispina

Moina brachiata

Cyclops sternuus

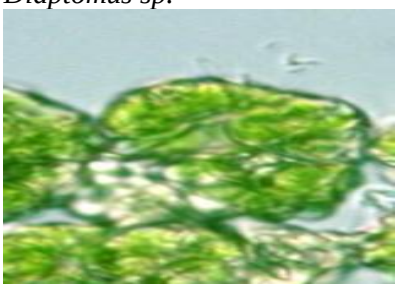
Cyclops leuckarti

Cyclops affinis

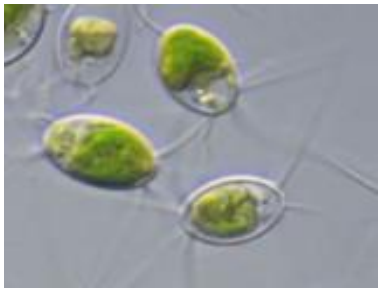
Diaptomus sp.

Macrocyclops albidus

Nauplius larva

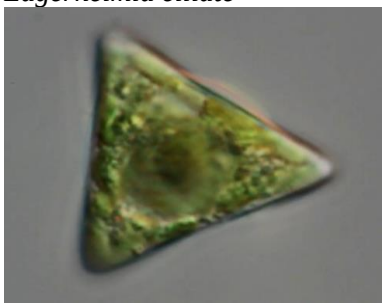


Botryococcus braunii


Lagerheimia ciliate


Coelastrum microporum


Coelastrum cambricum


Tetraedron lobulatum


Stauridium tetras

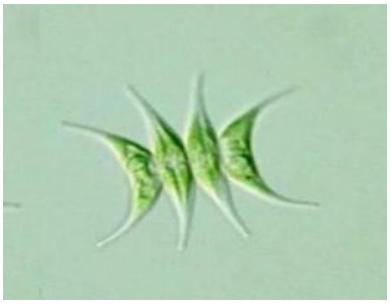

Acutodesmus acuminatum

Figure 3: Reported planktons in the Man Sagar Lake, Jaipur, Rajasthan, India

CONCLUSION

The diversity of plankton varies from season to season. Abiotic factors are primarily responsible for such variation. As a result, the composition and diversity of zooplankton provide information about the water body's characteristics and quality. The analysis of phytoplankton and the estimation of aquatic ecosystem diversity are critical for fish culture management. Phytoplanktons are a good indicator of water pollution. The reservoir at Man Sagar Lake is replenished by rain and in addition it also receives water from the Nagtalai Nala. The water resource is primarily identified for use in irrigation supply. The goal of the zooplankton study was to determine how it related to various indicators of water quality.

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