Original Research Article

Seasonal Abundance and Diversity of Zooplankton Communities along with Physico-Chemical Assessment of a Sacred Temple Tank of Ponda Taluka, Goa

Kunja Priolkar and I. K. Pai*

Department of Zoology, Goa University, Goa-403 206

***Corresponding author:** ikpai@unigoa.ac.in

Received : July 28, 2017; revised : September 20, 2017; accepted: October 20, 2017

Abstract : Zooplankton are heterotrophic (sometimes detritivorous) plankton. Plankton are organisms drifting in oceans, seas, and bodies of freshwater. They are "wanderer" or "drifter". Individual zooplankton are usually microscopic, but some (such as jellyfish) are larger and visible with the naked eye. They are ecologically important and include members from small protozoans and large metazoans, which may be holoplanktonic or meroplanktonic. Further they can be either the nekton or a sessile, benthic existence. Although zooplanktons are primarily transported by ambient water currents, many have locomotion like diel vertical migration. India is synonymous with temples and most of the temples are having sacred temple tanks from where, the water is being used for temple rituals. As there are hardly any ecological studies on these tanks. Goa, the land of sun sand and sea is also known for having several temples and the town of Ponda is known as temple town of Goa. In the present study, physicochemical analysis along with qualitative and quantitative studies of zooplankton of Shri Shantadurga temple tank, Kavalem Ponda, Goa, for two annual cycles was carried out. The results revealed that, there was seasonal variation in most of physico-chemical parameters analysed. Using microscopic taxonomical studies of zooplankton, investigations revealed that, 14 species of Zooplankton belonging to three major groups i.e., Copepoda (seven sps.), Rotifera (four sps.) and Cladocera (three sps.) were present. Among zooplankton, Copepod group was dominant. Zooplankton dominated in dry seasons due to favourable growth conditions.

Key words: Density, Diversity, Physico-chemical parameters, Temple tank, Zooplankton

Introduction

The natural and artificial contaminants affecting the physicochemical properties of aquatic ecosystem impart an indirect effect on the stability of the interacting biological resources, apart from degrading the environmental conditions (Chatterjee *et al.,* 2010). The physicochemical methods are used to detect effects of pollution on the water quality but changes in the trophic conditions in water are reflected in the biotic community structures as shown by occurrence, diversity and abundance pattern of species. (Cairns, 1979). Zooplankton occupy a central position between the autotrophs and other heterotrophs and plays a significant role in transformation of food synthesized by phytoplankton to higher trophic level therefore the study of zooplankton also plays a vital role in knowing biological status of any water body.

Several studies have been made on different types of water bodies in India. However the information is needed with reference to water bodies of small dimensions. In Goa, the ecological study of freshwater bodies is very scanty and on freshwater bodies of small dimensions such as temple tanks is nil. Therefore the present investigation attempts were

made to study physico-chemical parameters along with zooplankton species richness, diversity and seasonal abundance of a sacred temple tank of Ponda taluka in Goa

Materials and methods

The study was conducted for a period of two annual cycles from December to November on sacred temple tank viz; Shri Shantadurga temple tank-Kavalem Ponda. Shri Shantadurga Temple is a large temple complex 33 kms from Panaji at the foothill of Kavalem village in Ponda Taluka, Goa, India. Details of the study site as follows:

Water spread area	Depth (Summer)	Depth (Rainy)	Latitude	Longitude	Altitude AMSL
864 m^2	2.1 m	3.4 m	15°23'46.6" N	73°59'09.8" E	21 m

Grab samples of water for physicochemical studies were collected fortnightly, between 08.00 hrs and 11.00 hrs during the study period i.e., two annual cycles from December to November. Samples were collected in 1 litre plastic bottles and transferred to laboratory immediately for physicochemical analysis, which was carried out using standard methods described in APHA, 1989 and BIS, 1990.

Zooplankton samples were also collected from between 08.00 hrs and 11.00 hrs. Samples were collected by filtering about 20 litres of water through plankton net of mesh size 45 micron. Filtrate was collected in 200 ml bottle and 4% formalin was added to preserve the sample for further studies in lab. The concentrate was examined under microscope and zooplankton were counted using Sedgwick Rafter plankton counting cell according to Welch (1948). Zooplanktons were identified using standard literature (Battish, 1992; Edmondson, 1992; Dhanapathi, 2000).

Results

Table.1 depicts the Physico-chemical data for Site. As seen in the table, maximum surface water temperature of 29.5°C and minimum of 27°C was recorded. The pH ranged between 7.26 and 5.26. Alkalinity was recorded maximum at 41 mg/L and minimum at 30.5 mg/L. A maximum concentration of 50.12 mg/L observed for total hardness, while minimum concentration of 30.13 mg/L was noted. The calcium content in the temple tank water, ranged between 6.41 mg/L and 14.03 mg/L. Chloride was minimum with the concentration being 10.42 mg/L, while maximum concentration of 33.73 mg/L. Magnesium content was in the range of 1.95 mg/L and 4.62 mg/L. Maximum Turbidity was measured at 9.2 NTU and minimum found at 0.6 NTU. The phosphates showed its lowest concentration at 0.008 mg/L, while, its content was maximum at 0.240 mg/L. Sulphates ranged between 1.63 and 8.24 mg/L. A maximum EC was recorded of 166 µS/cm and minimum of 112 µS/cm. TDS ranged between 63 mg/L measured and 105 mg/L. The sodium content ranged between 8.00 mg/L and 19.30 mg/L. Potassium was minimum with concentration being 2.6 mg/L while maximum concentration of 6.10 mg/L. Nitrates ranged between 1.08 mg/L and 0.06 mg/L. The nitrites showed its lowest concentration at 0.001 mg/L. While its content was maximum at 0.020 mg/L. DO ranged between 3.34 mg/L and 10.2034 mg/L. BOD of 0.40 mg/L was observed and maximum of 0.80 mg/L was observed. COD recorded between 5.30 mg/L in and 14.30 mg/L. The zooplankton density was highest during winter with rotifers and copepoda being the major contributing groups. Highest number of zooplankton i.e., 199 individuals/L were encountered and lowest number with the count being 0.15 individuals/L (Table 2).

The zooplankton species encountered during the study period in the temple tank were rotifer, cladocera, cyclopoida, calanoida, copepoda larvae. Table 2 shows zooplankton abundance in Shri Shantadurga Temple tank, Kavalem. The density being low during the wet season of the year, Copepods ranged between 0.15 and 172 individuals/L. Calanoids and cyclopoids were absent during the wet season, but nauplia were present throughout the study period. Copepoda larvae were present in the range of 0.15 - 170 individuals/L and were present throughout the year. The highest density was of Copepods and lowest density was of Cladocera. The percentage of zooplankton occurrence was in the following decreasing order Copepoda (78.55%) > Rotifera (16.92%) > Cladocera (9.53%). Fourteen species encountered during the study period (Table 3).

Table. 1. Physico-chemical Parameters of Shri Shantadurga Temple Tank (Two years data)

Site-1	Temp.	pH	TDS	EC	Turb.	Alkalinity	Chloride	Phosphate	Sulfate	Calcium	Sodium	Potassium	Nitrate	Nitrites	mg	TH	DO	BOD	COD
Months	°C	mg/L	µS/cm	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Dec.	27.0	6.01	100	149	5.0	39.5	23.80	0.040	6.94	13.23	14.00	4.40	0.25	0.005	2.31	42.57	9.30	0.6	9.60
Jan.	27.5	6.63	84	166	2.1	36.5	24.85	0.120	8.24	11.62	16.60	4.80	0.98	0.020	2.19	38.15	6.70	0.4	6.34
Feb.	28.0	6.85	82	147	7.8	38.0	24.85	0.028	5.28	13.63	15.50	5.10	1.08	0.001	2.80	50.12	6.70	0.6	12.80
Mar.	28.5	6.22	81	161	8.3	35.0	24.85	0.036	6.30	14.03	16.00	5.20	0.98	0.002	2.43	45.22	8.40	0.6	6.40
Apr.	29.0	6.10	93	160	7.5	41.0	33.73	0.100	3.64	6.41	19.30	5.20	0.11	0.003	3.40	30.13	9.07	0.4	6.40
May.	29.0	6.90	105	161	2.1	32.0	12.43	0.080	5.86	11.22	12.60	3.80	0.13	0.002	3.89	44.16	9.10	0.5	9.60
Jun.	28.0	7.08	89	147	8.1	41.0	19.53	0.010	3.94	12.02	16.70	5.40	0.09	0.001	3.65	45.29	5.27	0.6	10.60
Jul.	28.0	7.05	78	130	6.9	39.0	15.20	0.020	4.20	10.65	11.20	4.20	0.15	0.006	3.40	40.63	3.60	0.4	11.30
Aug.	27.5	6.01	72	130	2.3	35.0	21.30	0.160	2.37	8.42	11.20	5.00	0.19	0.002	4.62	40.16	5.40	0.7	11.26
Sep.	28.5	5.26	68	142	2.5	30.5	10.42	0.008	1.92	9.26	11.26	3.82	0.16	0.001	3.16	41.26	3.34	0.5	14.30
Oct.	27.5	6.15	78	135	1.6	33.5	18.30	0.010	1.63	11.25	10.30	4.20	0.25	0.001	2.15	42.32	9.20	0.6	5.30
Nov.	27.0	6.94	78	154	2.0	38.0	17.75	0.050	2.94	12.42	12.00	2.80	0.20	0.003	2.68	42.16	6.07	0.6	11.60
Dec.	28.0	6.37	68	134	9.2	40.0	17.75	0.160	3.80	10.42	10.90	2.60	0.80	0.002	3.89	42.15	4.02	0.6	7.63
Jan.	28.0	7.26	70	126	2.8	40.0	17.75	0.078	5.70	12.42	11.20	5.80	0.19	0.002	2.43	41.16	9.23	0.6	13.60
Feb.	28.5	7.10	66	130	0.6	36.0	15.25	0.032	4.60	11.30	10.00	4.60	0.25	0.002	2.16	41.20	7.26	0.7	11.30
Mar.	28.5	5.87	63	137	2.6	32.0	12.43	0.100	3.51	12.02	12.20	4.30	0.17	0.008	1.95	38.15	9.02	0.5	10.26
Apr.	29.0	5.80	70	142	2.6	35.0	11.80	0.009	2.60	11.20	10.30	3.60	0.12	0.002	3.16	38.60	8.36	0.5	12.90
May.	29.5	6.53	75	150	6.8	31.0	17.75	0.150	3.51	10.82	15.90	5.60	0.06	0.008	1.95	35.23	9.20	0.6	11.62
Jun.	28.0	7.03	80	145	1.8	39.0	14.20	0.240	5.89	11.22	8.00	6.10	0.06	0.009	3.16	41.16	10.20	0.5	11.09
Jul.	27.5	6.41	74	135	1.2	40.0	15.98	0.040	3.51	12.42	11.00	5.10	0.06	0.005	2.68	42.13	7.50	0.6	10.25
Aug.	27.0	6.21	75	140	1.2	32.0	15.25	0.060	4.32	10.20	10.30	4.60	0.06	0.008	2.60	33.00	9.30	0.5	11.26
Sep.	27.0	5.90	68	130	2.3	35.0	21.30	0.020	4.75	12.42	11.30	3.60	0.06	0.010	2.19	40.13	4.08	0.7	11.85
Oct.	27.2	6.21	72	140	2.0	32.0	20.00	0.062	5.26	10.20	11.20	2.90	0.06	0.009	3.26	39.20	8.30	0.7	9.36
Nov.	27.5	5.78	65	112	1.2	36.0	12.43	0.015	3.80	12.02	11.20	4.20	0.06	0.004	2.92	42.13	7.62	0.5	11.25

Table. 2. Zooplankton abundance (IND/L).

Site	Shri Shantadurga temple tank			
Months	Copepoda	Rotifera	Cladocera	Total zoo.
Dec.'09	9.15	0.6	9.8	19.55
Jan. '10	101	97.35	0.2	198.55
Feb.	68.85	44	2.95	115.8
Mar.	56.2	7.5	11.8	75.5
Apr.	120	0.55	0.55	121.1
May.	16.4	1.05	0.9	18.35
Jun.	2.3	0.05	0.05	2.4
Jul.	30.8	0.9	0.35	32.05
Aug.	3.4	0.6	0	4
Sep.	0.15	0	0	0.15
Oct.	1.5	0	0	1.5
Nov.	23	4	0	27
Dec.	14	3.8	1.8	19.6
Jan. '11	34.3	15.05	1.4	50.75
Feb.	32.2	7.8	2.2	42.2
Mar.	51.6	3	0.6	55.2
Apr.	70.4	2.2	0	72.6
May.	53.65	1.3	8.15	63.1
Jun.	8.9	0.35	0	9.25
Jul.	1.2	0	0.05	1.25
Aug.	7.55	0.85	0	8.4
Sep.	17.05	0	0.55	17.6
Oct.	60.3	4.2	2.4	66.9
Nov.	172.15	10.8	11.4	194.35
Average	39.84	8.58	2.3	50.71

Table. 3. Zooplankton diversity at Shri Shantadurga temple tank, Kavalem, Ponda,goa

	CALANOIDA:
	Family: Diaptomidae
1	*Diaptomus judayi* (Marsh, 1907)
2	*D. saltillinus* (Brewer, 1898)
3	*D. trybomi* (Lillijeborg, 1889)
	CYCLOPOIDA:
	Family: Cyclopidae
4	*Paracyclops affinis* (Sars, 1863)
5	*P. poppei* (Rehberg, 1880)
6	*Mesocyclops dybowskii* (Lande, 1890)
7	*Haliocyclops christiansis* (Norman, 1936)
	ROTIFERA
	Family: Brachionidae
8	*Brachionus calyciflorus f. amphiceros (Ehrenberg, 1838)*
9	*B. caudatus apsteini* (Fadeev, 1925)
10	*B. forficula* (Wierzejski, 1891)
11	*Keratella tropica* (Apstein, 1907)
	CLADOCERA
	Family: Moinidae
12	*Moinodaphnia macleayi* (King, 1853)
	Family: Macrothricidae
13	*Macrothrix laticornis* (Fisher, 1851)
14	*Llyocryptus spinifer* (Herrick, 1882)

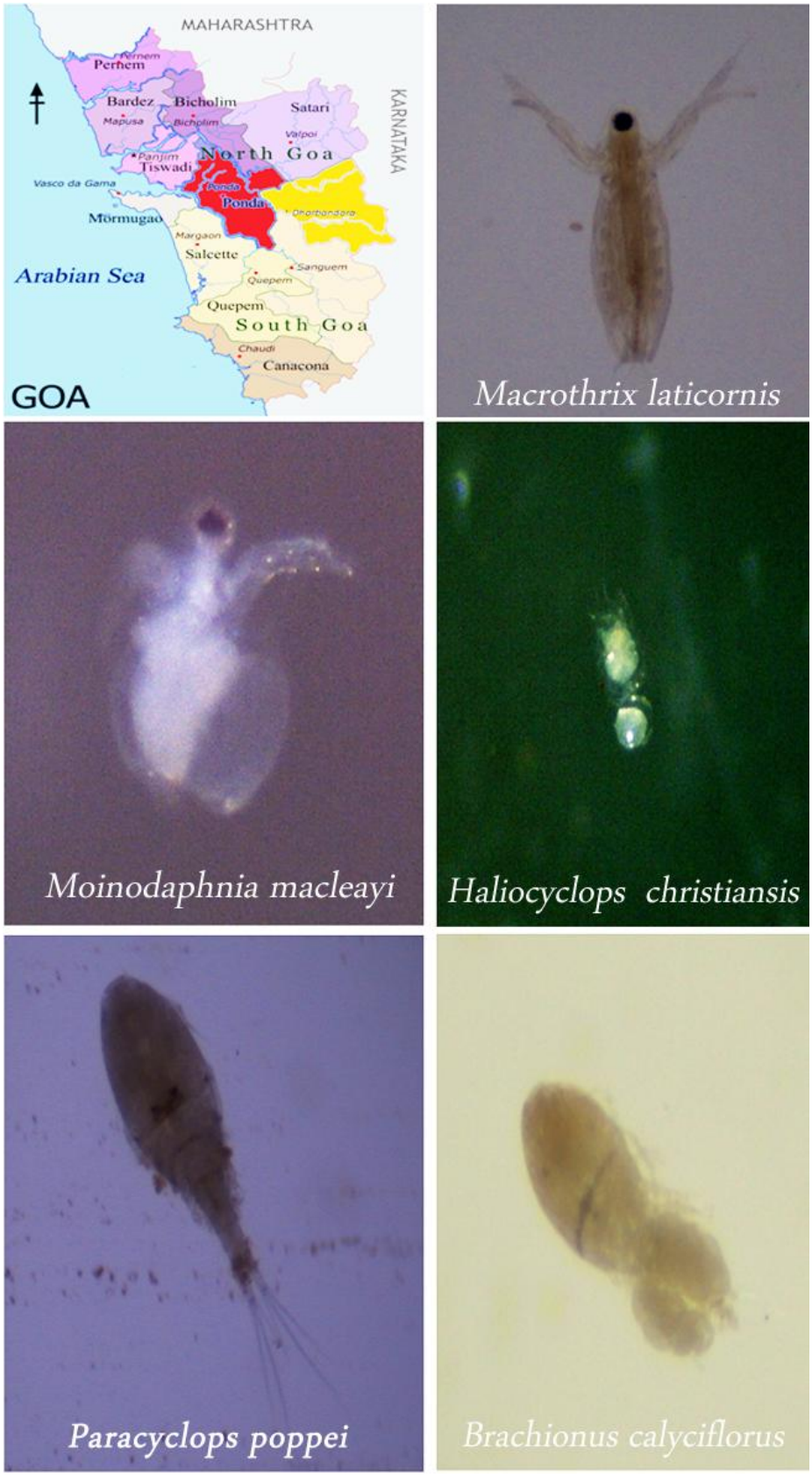

Fig.1. Location and zooplankton specimen encountered during the studies.

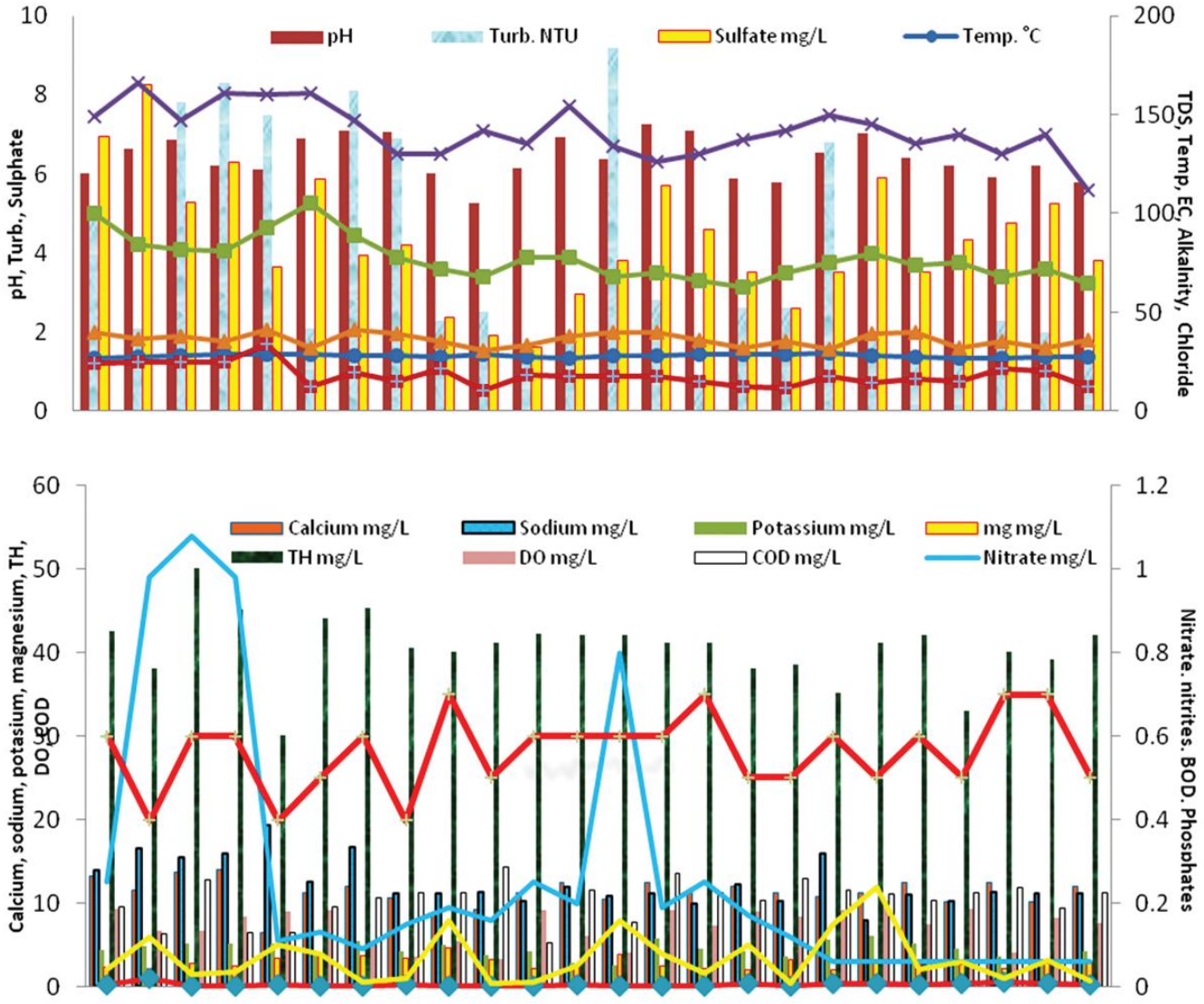

Fig. 1. Physico-chemical parameters of Shri Shantadurga temple tank, Kavalem, Goa.

Discussion

Physico-chemical analyses:

Average temperature 28°C was recorded during study period. Temperature has been considered as one of the primary factors to cause the abundance of zooplankton in freshwaters particularly in shallow waters where bottom exhibit considerable variations in temperature, especially with the progression of the warm season (Moitra and Bhattacharya, 1965, Ahangar *et al.*, 2012). Temperature controls development, growth, reproduction, shape of the body and distribution of the species (Caramujo and Boavida, 1999; Xie and Chen, 2001). According to Kurbatova (2005) and Roychoudhury *et al.* (2013), the pH range from 6.0 to 8.5 indicate medium productive nature of a reservoir; more than 8.5 highly productive; and less than 6.0 low productive nature of a reservoir. In case of the site under study the average pH during different seasons ranged from 5.9 to 6.5, indicating medium productive nature of the water body under study.

In present study average 36 mg/L of alkalinity was observed. The total alkalinity of freshwater lakes is often very low, thus making them poorly buffered and susceptible to acidification (Wetzel, 2001). WHO has prescribed 120 mg/L as the alkalinity level, which shows signs of nutrient richness.

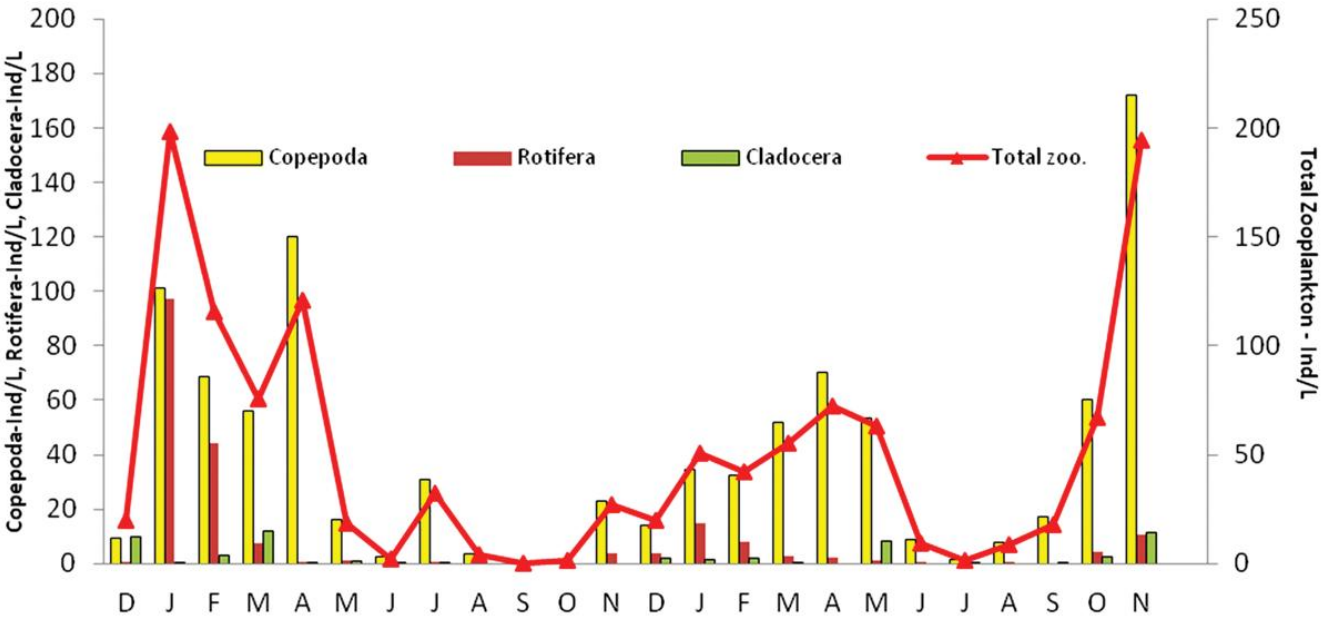

Fig. 2. Zooplankton abundance at Shri Shantadurga temple tank, Kavalem, Goa.

Hardness of water is related to the calcium and magnesium salts. These together with bicarbonates and carbonates give rise to temporary hardness, whereas with sulphates, chlorides and other anions constitute the permanent hardness (Wetzel, 2001). In the present study it was observed that calcium content was higher during winter. High values may be attributed to decomposition of macrophytes and allochthonus supply. Yet another possibility is the contribution of molluscans, in the process of synthesising shells.

Higher concentration of Calcium, Chloride, Sulphate, Nitrate, Sodium etc, during dry seasons, may be attributed to the high temperature and consequent evaporation resulting in less water and concentration of ionic content. Similarly reported by Sharma *et al.*, 2011. High chlorides are taken as an indication of pollution arising from animal origin (Munawar, 1970). Nitrite concentration was very low i.e., below 0.01 mg/L at this site.

Phosphate is an indicator of pollution and involved in the eutrophication process of water bodies (Wetzel, 2001). During the present study, temple tank showed high concentration of phosphates, magnesium and potassium during monsoons, due to washing off nutrients from surrounding into water body. Similar results were reported by Berde (2004). DO levels were always above 3 mg/L throughout study period. Tarzwell (1957) reported that for supporting life, minimum of 3 mg/L DO is required (Devi *et al.*, 2013). Higher DO was recorded in summer season and low in rainy season. The BOD value is well below 1 mg/L. These BOD value does not indicate any pollution in the aquatic system, which adversely affects the water quality and biodiversity. The values of COD indicate good water quality, as water pollution which is related to sewage effluents, industry or agricultural practices is almost nil. The monthly mean variations in EC and TDS followed similar trend, were on higher side during the dry seasons (October to May). Both conductivity and total dissolved solids promoted high zooplankton growth and abundance (Mustapha, 2009).

Zooplankton Assessment

In deciphering trophic status and bio-monitoring of aquatic habitats, zooplankon play a vital role (Raina *et al.*, 2013). The biodiversity and distribution of zooplankton in aquatic ecosystem depend mainly on the physicochemical properties of water. Temperature, light, nutrient levels are usually the influencing factors, with temperature having the greatest effect. The water body studied showed higher abundance in summer

(February to May), followed by winter (October to January). According to Holz *et al.* (1990), increase in temperature and high evaporation, during summer, enhances the rate of decomposition, due to which; the water becomes nutrient rich resulting in increase in population density of zooplankton.

Whereas, low population density during monsoon (June to September) may be attributed to the dilution factor by rain and high water level. Thus seasonally, total zooplankton recorded bimodal peaks during summer and post-monsoon (winter) with trough during monsoon. This bimodal pattern of total zooplanktonic fluctuations is well supported by the findings of Tripathi *et al.*, 2006; Salve and Hiware, 2010; Raina *et al.*, 2013; Sharma *et al.*, 2013; Slathia and Dutta, 2013; Padate *et al.*, 2014 and Tyor *et al.*, 2014.

Copepodes

Copepods were found to be dominant in the freshwater body studied and dominance was seen during all seasons (Table 2, Fig. 2). Copepods reproduce all throughout the year. This was evidenced by the presence of the larval forms, nauplii and copepodite, and the appearance of number of oviparous individuals in all the months during the present study. The results are corroborated with the view of Padate *et al.* (2014).

Eutrophication leads to decrease in the percentage of calanoid copepod, while promotes the development of cyclopoid copepods (Padate *et al.*, 2014). During present studies, calanoid copepods were maximum indicating oligotrophic nature of water bodies studied. Also Kurasawa (1975) reported that, copepods are found to be dominant in oligotrophic lakes (Karuthapandi *et al.*, 2013).

The copepods dominated all the seasons. Copepods showed two peaks, one in the summer and another in winter, higher abundance in winter (Table 2, Fig. 2). Least abundance was seen during rainy season. Dominance of copepods throughout the year has been reported by Ayyapan and Gupta (1980) and Vyas and Adholia (1994). The productivity of lakes generally tends to be very high, particularly in tropical regions, during low water periods (summer and winter). Planktonic crustaceans are commonly abundant during these periods but experience severe decline during high water periods of inundation when inorganic suspended particles are high and phytoplankton production low (Padate *et al.*, 2014).

Similarly Sharma and Saxena (1983); Chauhan (1993); Xie and Chen (2001); Sharma *et al.* (2010) and Sharma and Pachuau (2013) have reported copepod dominance during limnological studies of freshwater bodies. Population rises to higher level in the winter as result of favourable environmental condition including temperature, DO and availability of abundant food in the form of bacteria, nanoplankton and suspended detritus. Edmondson (1965) and Baker (1979) have also confirmed these findings.

Rotifers

The second most abundant zooplankton group was rotifera. Rotifers are prominent group among the zooplankton of a water body irrespective of its trophic status. This may be due to the less specialized feeding, parthenogenetic reproduction and high fecundity (Rajshekhar *et al.*, 2009). They increase in large quantity rapidly under favourable environments conditions (Thirupathaiah, 2011). Rotifers dominance was seen in winter and least number of rotifers in rainy season (Table 2, Fig. 2). Low population density during monsoon and post monsoon may be attributed to the dilution factor by rain and high water level (Akbulut, 2004 and Mulani *et al.,* 2009).

Cladocerans

Cladocerans were the third abundant group. Cladocerans showed its peak abundance during dry seasons (Table 2, Fig. 2). Food supply plays a vital role in the density of cladocera (Singh, 2000). In summer, the rising temperature increases the density of algae, detritus as well as bacteria, the major food for cladocerans that ultimately leads to increase in overall density of cladocerans (Padate *et al.*, 2014).

Low densities during the other periods may be due to predation by copepod (Hessen, 2003). Another reason may be the positive phototactic swarming from littoral areas to pelagic zone (Kairesalo and Pentilla, 1990).

Harpacticoids and ostracods were detected once or twice with 1-2/20 L, during the study period. Most of the freshwater ostracods are bottom dwellers, although some appear occasionally in plankton samples (Ansari and Khan, 2014).

Thus from this study we can conclude that, the overall ionic concentrations were higher for most of the parameters, indicating the most nutrient-rich water body. All the physico-chemical parameters studied from site are well within permissible limits prescribed by Indian Standards (IS) and Indian Council for Medical Research (ICMR) for drinking water. The diversity and density of zooplankton exhibited by three major groups (copepoda, rotifera, cladocera) with 14 species showed seasonal variability in density due to different physicochemical parameters which impact upon them. It can be inferred that the copepoda group adapts well to the changes occurring throughout the year in the water bodies and thus found during all seasons indicating oligotrophic nature of water body. Seasonal abundance of zooplankton is more during dry seasons (summer and winter) due to favorable growth conditions in comparison with rainy season.

References

Ahangar I. A., Mir M. F., Saksena D. N. and Ahangar, M. A. 2012. Zooplankton diversity of Anchar lake with relation to trophic status, Srinagar, Kashmir. Glo J of Env Res. 6(1): 17-21.

Akbulut, E. N. 2004. The determination of relationship between zooplankton and abiotic factors using canonical correspondence analysis (CCA), in the Ova Stream (Ankara / Turkey). Acta Hydrochimica, Hydrobiologica. 32(6): 434-441.

Ansari S. and Khan, A. A. 2014. Diversity and distribution of zooplankton in a freshwater body of Aligarh region. Ind J Sci Res and Tech. 2(1): 73-82.

APHA, 1989. Standard methods for analysis of water and wastewater.American public health Association, 17th edition Washington, D.C.

Ayyapan, S. and Gupta, T. R. C. 1980. Limnology of Ramasamudra Tank. J Inland Fish Soc India. 12: 1-12.

Baker, R. L. 1979. Specific character of *Keratella cochlearis* (Gosse) and *K. earlinare* Ahlastrom (Rotifera: Brachionidae): Morphological and ecological consideration. Can J Zool. 57(9): 1719-1722.

Battish, S. K. 1992. Freshwater Zooplankton of India. Oxford and IBH Publishing Co. Pvt. Ltd., Delhi.

Berde, V. B. 2004. Comparative studies on physical, chemical and biological components of some freshwater bodies in Goa and Maharastra. Ph.D. thesis, Goa University.

BIS, 1990. Drinking water specifications, IS 10500, Bureau of Indian Standards, New Delhi.

Cairns, 1979. Studies on pollution in river Chambal: Zooplankton in relation to water quality. Asian J Water Env. Poll. 8(3): 83-87.

Caramujo, M. and Boavida M. 1999. Characteristics of the reproductive cycles and development times of *Copidodiatomus numinidus* (Copepoda: Calanoida) and *Acanthocyclopes robustus* (Copepoda: Cyclopoida). J. Plankton Res. 21: 1765-1778.

Chatterjee, S. K., Bhattacharjee I. and Chandra, G. 2010. Water quality assessment near an industrial site of Damodar river, India. Environ Monit. Assess.161:177-189.

Chauhan, R. 1993. Zooplankton species and their dominance in Rewalsar lake, Himachal Pradesh. Uttar Pradesh J. Zool. 13: 143-147.

Chaurasia, S. K. and Adoni, A. D. 1987. Planktonic fauna of Sagar lake and some reservoirs. Geobios new reports. 6: 77-78.

Devi, A. V., Baskaran, S. and Kumar, R. S. 2013. Physico-chemical parameters and zooplankton diversity of a temple pond in Virudhnagar, Tamil Nadu. Int. J. of Sci,. Env.and Tec. 2(2): 250 – 257.

Dhanapathi, M. V. S. S. S. 2000. Indian Association of Aquatic Biologists. Hyderabad.

Edmondson, W. T. 1965. Freshwater Biology. John Wiley and sons, New York.

Edmondson, W. T. 1992. Freshwater Biology 2nd Edition. International books and periodicals supply service, New Delhi.

Hessen, D. O. 2003. Phytoplankton contribution to seston mass and elemental ratio in Lakes. Implication for Zooplankton nutrition. Limnol. Oceonogr. 48:1289-1296.

Holz, 1990. (Cf: Tyor A. K., Chopra G. and S. Kumari, 2014) Zooplankton diversity in shallow lake of Sultanpur National park, Gurgaon (Haryana).I.J.A.B.P.T. 5(1): 35-40.

Kairesalo, T. and Penttila, S. 1990. Effecr of light and water flow on the spatial distribution of littoral *Bosmina longispina* Leydig (Cladocera). Verh. Internat. Verein. Limnol. 24: 682-687.

Karuthapandi M., Rao D. V., Xavier I. B. And Deepa, J. 2013. Zooplankton diversity andtrophic status of Safilguda tank, Hyderabad. I.J.A.L.S. 6(1):44-50.

Kurasawa, 1975. (Cf: Karuthapandi M., Rao D. V., Xavier I. B. and J. Deepa, 2013. Zooplankton diversity and trophic status of Safilguda tank, Hyderabad. I.J.A.L.S. 6(1): 44-50.

Kurbatova S. A. 2005. Response of microcosm zooplankton to acidification. Izv. Akad. Nauk. Ser. Biol. 1:100-108.

Moitra S. K. and Bhattacharya, B. K.1965. Some hydrological factors affecting plankton production in a fresh pond in Kalyani, West Bengal, India. Ichthyologica. 4:8-12.

Mulani S. K., Mule M. B. and Patil, S. U. 2009. Studies on water quality and zooplankton community of the Panchganga River in Kolhapur city. J. Environ. Biol. 30:455-459.

Munavar, M. 1970. Limnological studies of freshwater ponds of Hyderabad, India-II: The biocoenose, distribution of unicellular and colonial phytoplankton in polluted and unpolluted enviornments. Hydrobiologia. 36: 105-128.

Mustapha, M. K. 2009. Zooplankton assemblage of Oyun Reservoir, Offa, Nigeria. Int. J Trop. Biol. 57(4): 1027-1047.

Padate, G. S., Ekhande, A. P. and Patil, J. V. 2014. Seasonal variations in density and species richness of microcrustacea of high altitude Lotus Lake, Toranmal (M.S.) India. Weekly Sci. Res. J. 1(30): 1-9.

Raina R., Kumar P., Sonaullah F. and Wanganeo, A. 2013.Limnological study on a Samrat Ashok Sagar with special reference to zooplankton population.Int. J. Biodivers. Conserv. 5(6):317-332.

Rajashekhar, M., Vijaykumar K. and Zeba, P. 2009.Zooplankton diversity of three freshwater lakes with relation to trophic status, Gulbarga district, North-East Karnataka, South India. Int. Jr. of Sys.Bio. 1(2): 32-37.

Roychoudhury S., Palit D. and Banerjee, A. 2013. Assesment of zooplankton diversity in relation to physico-chemical parameters of water in selected waterbodies of Durgapur industrial region, West Bengal, India. Asian Jl. of water, Env. and Poll. 10(4):99-115.

Salve, B. and Hiware, C. 2010. Zooplankton Diversity of Wan Reservoir, Nagpur (MS) India. Trends Res in Sci and Tech. 2(1): 39-48.

Sharma B. K. and Pachuau, L. 2013. Zooplankton diversity of a sub-tropical reservoir of Mizoram, Northeast India. Opusc Zool Budapest. 44(1): 47-60.

Sharma B. K. and Saksena, D. N. 1983. Seasonal variation of copepod component ofzooplankton in a perennial tank, Janaktal, Gwalior (India). Acta Hydrochhim. Et hydrobiol. 11: 479-484.

Sharma R., Sharma V., Sharma M. S., Verma B. K., Modi R., and Gaur, K. S. 2011. Studies on limnological characteristics, planktonic diversity. Uni J Env Res Tech 1(3): 274-285.

Sharma S., Siddique A., Singh K., Chouhan M., Vyas A., Solnki C. M., Sharma D., Nair S. and Sengupta, T. 2010. Population dynamics and seasonal abundance of zooplankton community in Narmada River (India). Researcher, 2(9): 1-9.

Sharma S., Solanki C. M., Sharma D. and Pir, Z. 2013. Distribution and diversity of zooplankton in Madhya Pradesh, India. Int J Adv Res. 1(1): 16-21.

Singh D. N. 2000. Seasonal variation of zooplankton in a tropical lake. Geobios. 27(2-3): 97-100.

Slathia D. and Dutta, S. P. S. 2013. Hydrobiological study of a Subtropical Shiwalik lake, Jammu, J&K (India). Int J Sci Res Pub. 3(8): 143-149.

Thirupathiah M., Samantha C. And Sammaiah, C. 2011. Diversity of zooplankton in freshwater lake of Kamalapur, Karimnagar district (A.P.). India. The Ecoscan. 5(1&2): 85-87.

Tripathi R. B., Singh I. and Tiwari, D. D. 2006. Qualitative and quantitative study of zooplankton in Seetawar Lake of Shravasti, U.P, India. Flora and Fauna. 12(1): 37-40.

Tyor A. K., Chopra G. and Kumari, S. 2014. Zooplankton diversity in shallow lake of Sultanpur National park, Gurgaon (Haryana). IJABPT. 5(1): 35-40.

Vyas, A. and Adholia. U. N. 1994. Energy and biomass studies of the Mansarovar reservoir, Bhopal, with reference to zooplankton. Int J Environ Stud. 46: 143-148.

Welch, P. S. 1948. Limnology. McGraw-Hill, New York.

Wetzel, R. G. 2001. Limnology: Lake and river ecosystems. 3rd Edition. Academic Press, USA.

Xie, P. and Chen, X. 2001. Experimental and field studies of *Mesocyclops notius* (Copepoda: Cyclopoida) from a subtropical Chinese lake, Lake Donghu. J Plankton Res. 23: 585-596.