SEASONAL DISSIMILARITIES IN COMPOSITION AND DIVERSITY OF ZOOPLANKTON IN KAMALAPURA WATER TANK, HOSAPETE TALUK, NEWLY BORN VIJAYANAGARA DISTRICT, KARNATAKA (INDIA)

G. Mallanagoud[1], Vijaya S Gulalakayi[2], L. R. Dindalkoppa[3], S. Manjappa[4] and Suresh B[5]

[1]Department of Zoology, Veerashiva College Ballari- 583104, Karnataka, India
[2]Department of Zoology, Vijayanagar College, Hosapete. 583201, Karnataka, India
[3]Department of Zoology, KRCES GGD Arts BMP Com & SVS Science College Bailhongal, Belgavi- 591102, Karnataka, India
[4]Depaertment of Chemistry, University BDT College of Engineering, Davangere – 577005, Karnataka, India.
[5]Department of Civil Engineering, Bapuji Institute of Engineering & Technology, Davangere – 577 004, Karnataka, India

***Abstract*: The present work focusses on the general ecological investigation on zooplankton population dynamics in terms of species composition and density in Kamalapaura water tank in Hospet city, newly born Vijayanagar district, Karnataka state. A total of 36 zooplankton taxa were identified and five classes namely Rotifera (14), Copepoda (6), Cladocera (7), Ostracoda (6) and Protozoa (4). The same trends were observed in terms of percentage with decreasing order Rotifera contributing 38.8%, followed by Cladocera (19.5%), Copepod, (16.8%), Ostrocoda (16.7%) and Protooa (11.2%). Maximum species richness was recorded 7.73 Margalef's index (R1) at station D1 during pre-monsoon season and 1.16 Menhinick index (R2) at station K-3 during post-monsoon season, minimum Species richness was recorded 7.24 Margalef's index (R1) at station K-2 during pre-monsoon season and 1.09 Menhinick index (R2) at station D3 during pre-monsoon season. Maximum species diversity was recorded 0.05 Simpson's index (λ) at station D1 during the entire study, minimum species diversity was recorded 0.03 Simpson's index (λ) at station K-3 during the study period. Maximum of 2.86 Shannon - Weiner index (H') at station D2 during post monsoon season and minimum of 2.42 Shannon - Weiner index (H') at station D2 during pre-monsoon season. Maximum species evenness was recorded at stations K-1 and K-3 during post-monsoon season, minimum species evenness was recorded at station K-1 during pre-monsoon season. The study also indicates Kamalapura water tank is subjected to pollution due to addition of vehicular pollution and fertilizers from agricultural lands including domestic waste from the human habitation. This indicates the enrichment of water with nutrients leads to production of species, which in turn leads to the increased productivity and other undesirable biotic changes.**

***Keywords*: zooplankton, seasonal, species, population, diversity and water tanks**

Introduction:

In the present says, pollution from organic substances in the water bodies is one of the most important. Due to population explosion and developmental activities in and around the lentic water bodies are putting pressure on almost all the freshwater bodies. Increasing in the nutrient load into the lentic water tanks may leading into the deterioration of water quality of those lentic water bodies (Smitha, *et al.,* 1999 and Dhrubajyoti Bordoloi and Baruah, 2014). Physico-chemical variables are the good indicators of any water body and quality, that alone does not reflect the existence condition of the ecological factors of the water body due to lack of proper incorporation with ecological environment (Karr, *et al.,* 2000). Since a species community is the outcome of the integration and interaction of different physical, chemical and geo-morphological characteristics of any water body, biological assessment is a useful alternative in assessing those systems (Stevenson and Pan, 1999).

Planktons succession is depend upon the ecology of the lentic water body and several studies have described the patterns and underlying phenomenon of the seasonal dissimilarities (Rothhaupt, 2000). However, the knowledge of the species composition and dynamics of plankton followed by zooplankton spices creates a crucial feature for the analysis of the trophic level in lentic water bodies for the evaluation of the possible and optimal application of different water resources.

Food chain is depends upon the phytoplankton species composition since they the called as primary producers in the lentic water bodies and in open water resources. Zooplankton are also acts as an indicator of the polluted quality of water. In the food chain, due to the interdependence existing between phytoplankton and zooplankton species which systems are composed, these dynamics in the plankton populations convert to changes in the trophic level of food chain and the productivity of the lakes.

The biological spectrum of the lentic fresh water bodies is multidimensional where zooplankton are useful in bio-monitoring the ecological disturbance caused by a number of physico-chemical factors, sewage pollutants and other anthropogenic factors Although, voluminous literature is available on the plankton population of freshwater habitats of valley (Pandit, 1998), scanty

literature is available on lentic water body. The objective of this study was to assess the seasonal changes in zooplankton composition, species diversity species richness and species evenness in the Kamalapura water tank, Hospet city, Bellary district, Karnataka, India.

Materials and methods

Topography of the study area

Hospet is a town head quarter situated 327 Kms away from Vijayanagar district of Karnataka state, India. Hospet-Shimoga Highway (SH-25) passes through the study area. Almost all the villages of the area are connected by unmetalled and metalled roads and regular bus facility exits from Hospet to different villages. The study area falls in the survey of India topo map numbers 57 B/6 on 1:50000 scale. The area is bounded by 14.74° to 14.88° N latitude and 75.88° to 76° E longitude. The location map of the study area is represented in Figure. 1. Topography of the study area is generally undulating to rolling topography with frequent mound like structures. Soils of the area are affected by erosion. Isolated hills and hill ranges are also seen. The geology (rock) of the study area consists of metamorphic rocks like gray wacke, argillite and granodiorite and tonalitic gneisss. The study area received a maximum rainfall of 742 mm in the year 2005 and a minimum of 361.9 mm in the year 2003. The normal rainfall of the study area is 656.70 mm.

Kamalapura water tank: Kamalapura tank is a perennial artificial water body situated 14 Kms away from Hospet to north-eastern region. The colour of the water body is slight reddish. The area of the tank is 26 acres and depth is about 12 feet. The water body is irregular in shape. It is located at 15^0.30`N latitude and $76^0$.47`E longitude. Rainwater, sewage and seepage from hilly regions is the main source of water to this tank. The water is used for agricultural practices and domestic activities. During the study area the catchment area received an average rainfall of 567 mm. The tank is rectangular in shape and it receives water from rainfall. The water is used for irrigation and pisci culture purposes. The colour of the tank is pale reddish. Anthropogenic activities are practiced in the vicinity of the tank. The water is used to grow paddy, sugarcane jutes and vegetables. The catchment area received an average rainfall of 656.70 mm (Irrigation Department, 2019-20).

In the present investigation, three sampling locations were selected, viz. Hanuman Tempel North side of the water tank (K-1), Kamalapura village south (K-2) and Kamapalura village west (K-3). Surface water samples were collected from these study sites for collection of hydgro-graphical chemical and other metrological features. Temperature and pH were measured with a thermometer and portable pH meter respectively; transparency was estimated by the Secchi disc.

Methods

Both surface and subsurface samples of zooplankton were collected by using plankton net and preserved in Lugol's solution. Identification was done by consulting standard literature and monographs of Adesalu (2010), Das, et al., (2009), Tiwari (2006) and Balasingh (2007). In this present endeavor only the pollution tolerant genera (Palmer, 1969) with 50 and above individual per ml of water sample were considered for observation following Panigrahi, *et al.*, (2001). The numbers scored by each pollution tolerant genera as per Palmer (1969) were added and algal pollution index of the pond was thus evaluated. Density of pollution tolerant zooplankton genera (hereafter used as PTPG) of the pond was determined by Sedgwick-Rafter cell method (Okogwu, 2010, Neves, 2003 and Avinash, 2014)

The water samples for zooplankton analysis were collected at monthly interval for a year from August 2020 to July 2021 randomly at Kampli water tank. The data thus generated were summed up as average data on the basis of seasons viz. summer (April to July), monsoon (August to October) and winter (November to March).

The total number of zooplankton present in one l water sample was calculated using the formula N= (n x v) / V where N = total number of phytoplankton cells in 1 L water (cells/l); n = average number of zooplankton cells in 1 ml plankton sample; v = volume of plankton concentrate (ml); and V = volume of total water filtered (L). Taxonomic guides and descriptions proposed by previous studies (Tomas et al., 1996, Horner, 2002, HASLE, G. R. 1978, Hoppenrath et al., 2009) were adopted.

Shannon–Wiener diversity index (Shannon CE, Wiener, 1963), where it is calculated using the formula: *H* = -S*p* diversity measure, whereas *pii* ln/*pi*, Lacdan, et al., 2014). *H* represents the proportion of total species belonging to the *ith* species. Three indices were used to obtain estimation of species diversity, species richness and species evenness (Shannon, 1949 and Simpson, 1949). Species richness (R1 and R2) obtained using equation by Margalef, 1958 and Menhinick, 1964. Species evenness was determined by using the following expression. Shannon's equitability (EH) can be calculated by dividing H by HMAX (here HMAX =lnS). Equitability assumes a value between 0 and 1 with 1 being complete evenness.

Result and Discussion

Physico-chemical features of the Kamalapaura water tank was presented in the Table.1. Surface water temperature of this aquatic ecosystem was varied seasonally with maximum water temperature (26˚C) and minimum (18˚C) were reported.

Figure 1 Location map of the study area

Table 1. Physicochemical parameters of Kamalapaura water tank during study period

Chemical Parameters	Unit	Kamalapaura water Tank					
		Station K-1		Station K-2		Station K-3	
		Max	Min	Max	Min	Max	Min
Temperature	^{O}C	28.60	20.21	27.90	19.89	27.89	19.20
Transparency	cm	27.00	8.00	26.00	9.00	28.00	8.00
Salinity	ppt	0	0	0	0	2.5	0
pH	-	7.5	6.8	7.4	6.9	7.3	6.4
DO	mg/L	7.9	6.4	7.6	6.5	7.7	6.2
Total Alkalinity	mg/L	445.0	246.0	472.0	291.0	458.0	292.0

Temperature indicating highly significant inverse relationship with dissolved oxygen. Such an inverse relationship was noticed by many researchers (Sumitra, et al., 2007). The pH ranges from 7.5 at stations K-1 in September to 6.4 at station K-3 in November (Table-1). From the current study indicates that the pH values of all the lantic water tank samples are acceptable as per the drinking, irrigation and aquaculture guidelines. Dissolved oxygen varied from 7.9 mg/l at station K-1 in March to 6.2 mg/l at station K-3 in May. These values are in well agreement with the findings of some researchers (Shukla, et al., 1989). During the

study period, the negative correlation of DO with temperature at all sampling locations are in agreement with researchers (Rajashekhar, et al., 2007; Reddy Radha Krishna, et al., 2012 and Bhanu Prakash, et al., 2014). Alkalinity ranges from 472 mg/l at stations K-2 in June to 246 mg/l in March at station K-1. This alkalinity limit is not harmful to human beings and other living organisms (Venkateswarulu, et a., 1990). It has also been concluded that high alkalinity indicates pollution (Da, et al., 2009). Alkalinity showed significant negative relationship with dissolved oxygen (r= -0.65). (Table 2).

Table 2. Correlation Coefficient (r) among the physico-chemical properties and phytoplankton of Daroji tank during April 2015- March 2016

	Temperature	Transparency	Salinity	pH	DO	Total Alkalinity
Temperature	1.000					
Transparency	0.200	1.000				
Salinity	0.471	0.000	1.000			
pH	-0.692	-0.086	0.472	1.000		
D.O	-0.396	0.263	0.243	0.316	1.000	
Total Alkalinity	0.252	0.530	0.000	-0.172	-0.672	1.000

Correlation significance

In the present study, temperature showed negative correlation with pH (p=<0.01, r=-0.692) and DO (p=<0.01, r=-0.396). Total alkalinity revealed highly significant positive correlation with transparency (p=<0.01, r=0.530) and negative correlation with DO (p=<0.01, r=-0.672). It was proved and evident from the present work DO and pH was proved statistically. In the present study, a total of seventy (36) zooplankton species representing 5 major classes were documented which indicate diverse nature of zooplankton. Among 36 taxa of phytoplankton, 14 belonged to Rotifera, 6 to Copepoda, 7 to Ostrocoda and 4 to protozoan. Thus, the order of dominance was: Rotifera > Cladocera > Copepoda > Ostracoda > protozoan (Figure 2).

The zooplankton identified were: Temperature is the most important factors that govern the zooplankton community composition. Number of Rotifera, Copepoda, Cladocera, Ostracoda and protozoan are more in water samples in pre and post monsoon season. Other factors are also influential either negatively or positively (Table 2 and 3). In pre-monsoon season water is found in patchy places with almost greenish appearance. The accumulation of pollutants in small quantity of water justifies the increased number of Brachionus forficula, Brachionus quadridentatus, Brachionus angularis and Trichocerca species Rotifera species. Similar observations were made by other researchers (Tiwari and Chauhan, 2006; Balasingh and Shamal, 2007; Laskar and Gupta, 2009; Adesalu, 2010; Bhanu Prakash, et al., 2014).

Species diversity indices can serve as a good indicator of the overall pollution of lentic water tanks. Indices of species diversity can be derived from counting of species and are of three main categories: species richness (Margalef index), species evenness/dominance (Simpson index), and a combination of richness and dominance (Shannon–Wiener index). The diversity indices have been developed by taking into account of the number of species diversity and their relative dynamics, which means the higher the values of these diversity indices, the more the oligotrophic state of lentic water bodies (Sigee, 2004).

Table 1 Phytoplankton Diversity in Kamalapaura Water Tank in Hosapete city

	Station D1	**Station D2**	**Station D3**
Zooplankton diversity	Rotifera *Brachionus calyciflorus,* *Brachionus caudatus,* *Brachionus forficula* *Keratella tropica* *Lecane bulla* *Euchlanis dilatata* *Filinia spp* *Testudinella sp.* *Rotaria spp* Copepoda *Mesocyclop sps* *Paracyclops spp.* *Cyclops viridis* Cladocera *Alona rectangula* *Daphnia sp*	Rotifera *Brachionus calyciflorus,* *Brachionus falcatus,* *Brachionus angularis,* *Keratella tropica* *Lecane bulla* *Monostyella sp.* *Euchlanis dilatata* *Filinia spp* *Testudinella sp.* *Trichocerca tigris* *Rotaria spp* Copepoda *Mesocyclop sps* *Diaptamus spp* *Paracyclops spp.* *Mesocyclops leuckarti*	Rotifera *Brachionus calyciflorus,* *Brachionus forficula* *Keratella tropica* *Lecane bulla* *Monostyella sp.* *Notholca acuminata* *Euchlanis dilatata* *Rotaria spp* Copepoda *Mesocyclop sps* *Mesocyclops leuckarti* Cladocera *Moina mircura spp* *Bosmina* *Ceriodaphnia pulchella Sars* Ostracoda

	Ceriodaphnia pulchella Sars Ostracoda *Candocypris spp.* *Metacypris* protozoan *Amoeba* *Diffluga spp.* *Euglena*	Cladocera Alona spp Moina mircura spp Bosmina Ceriodaphnia pulchella Sars Ostracoda *Candocypris spp.* *Centrocypris* *Stenocypris spp.* Protozoan *Amoeba* *Diffluga spp.* *Paramoecium* Euglena	*Candocypris spp.* *Centrocypris* *Cypris spp* Protozoan *Diffluga spp.* *Paramoecium* *Euglena*
Shannon–Wiener diversity index (*H*)	2.288	3.485	2.824

Table 2. Number of Phytoplankton Taxa during Pre and Post-Monsoon Season

Group	Pre monsoon	Post Monsoon	Monsoon
Rotifera	31	26	20
Copepoda	9	8	6
Cladocera	6	5	4
Ostrocoda	4	5	2
Protozoa	3	3	1

Table 3. Seasonal variations of zooplankton, biodiversity indices at Kamalapura water tank during the study period

	Pre Monsoon				Post Monsoon				Monsoon			
Indices	Index	K-1	K-2	K-3	Index	K-1	K-2	K-3	Index	K-1	K-2	K-3
Species Richness	N_0	57	62	58	N_0	56	61	59	N_0	44	51	49
	R_1	8.73	8.21	8.61	R_1	7.64	7.68	7.71	R_1	5.62	5.71	5.21
	R_2	1.12	1.18	1.08	R_2	1.15	1.19	1.15	R_2	1.06	1.15	1.18
Species Diversity	λ	0.06	0.05	0.04	Λ	0.05	0.05	0.04	Λ	0.02	0.03	0.02
	H^1	2.29	2.52	2.61	H^1	2.82	2.84	2.88	H^1	2.69	2.56	2.52
	E	0.91	0.92	0.88	E	0.93	0.91	0.90	E	0.82	0.72	0.71

(N_0 = No of all species) R_1 = Margalef's index R_2 = Menhinick index
λ = Simpson's index H^1 = Shannon – Weiner index E = Evenness index

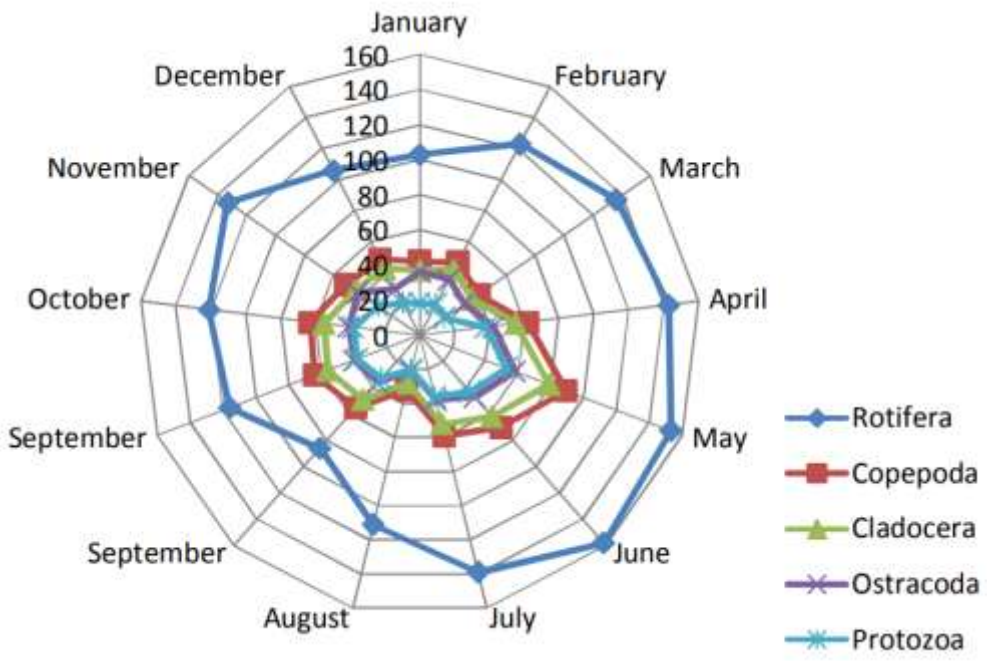

Figure 2. Average zooplankton abundance during the study period

Figure 3. Abundance of zooplankton during three seasons

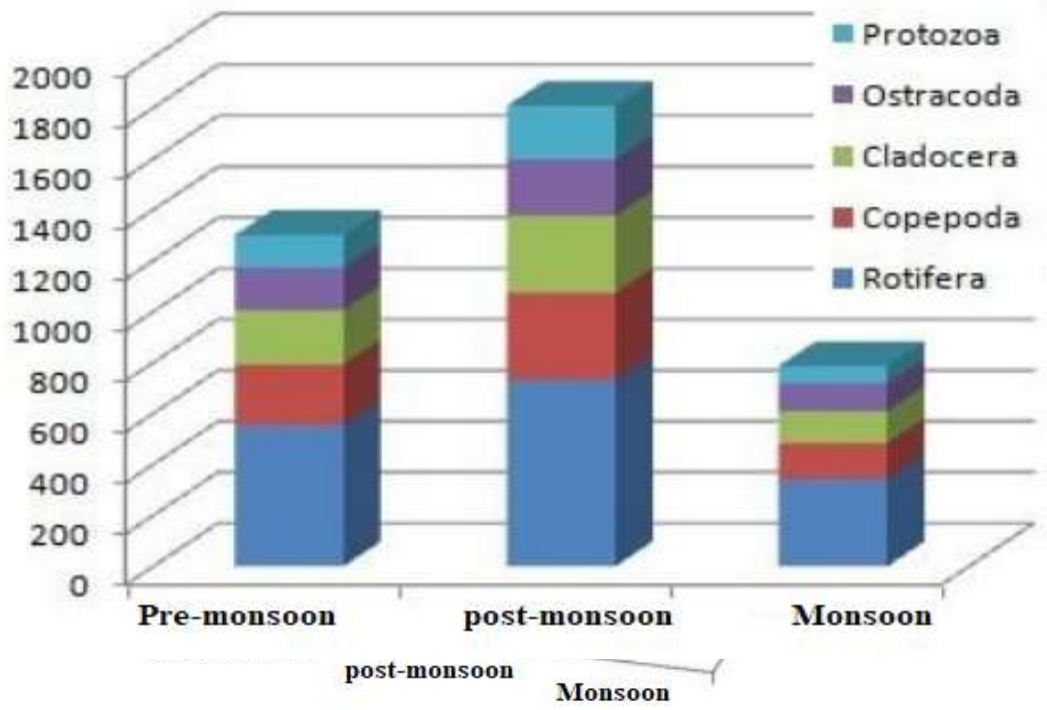

Figure 4. Percentage of composition of zooplankton during three seasons

Maximum species richness was recorded 8.73 Margalef's index (R_1) at station K-1 during pre-monsoon season and 1.19 Menhinick index (R_2) at station K-2 during post-monsoon season, minimum Species richness was recorded 5.21 Margalef's index (R1) at station K-3 during pre-monsoon season and 1.06 Menhinick index (R_2) at station K-1 during pre-monsoon season. Maximum species diversity was recorded 0.06 Simpson's index (λ) at station K-1 during the entire study, minimum species diversity was recorded 0.02 Simpson's index (λ) at station K-3 during the study period. Maximum of 2.88 Shannon - Weiner index (H') at station K-3 during post monsoon season and minimum of 2.29 Shannon - Weiner index (H') at station K-1 during pre-monsoon season. Maximum species evenness was recorded at stations K-1 and K-2 during post-monsoon season, minimum species evenness was recorded at station K-3 during monsoon season (Table. 3).

A comparison of the biodiversity indices in the Kamalapura water tank water suggested that the diversity indices were higher. Such relationship is well documented in the previous researchers and is related to the exciting preventive environmental conditions associated with the eutrophication process (Sladecek, 1983). Seasonal variations in abundance and composition of lentic water tank zooplankton are usually affected by the manmade activity, discharge, hydrology, trophic level and availability of light (Shiddamallayya, N., and Pratima, M, 2008 and Kolayli and Sachin, 2009). From the study reveals that the diversity indices of the lentic water tank is dynamic nature and lentic aquatic ecosystem balanced zooplankton community are enjoying and representing in the water tank.

Conclusions

The study reveals that counting of zooplankton species is present the basic information of species diversity, abundance and dynamics of the diversity indices. Hence ecological assessment through indices is the useful tool for further assessment and monitoring of lentic aquatic ecosystem which are suffering from pollution. The study also indicates Kamalapaura water tank is subjected to pollution due to addition of vehicular pollution and fertilizers from agricultural lands including domestic waste from the human habitation. This indicates the enrichment of water with nutrients leads to production of species, which in turn leads to the increased productivity and other undesirable biotic changes. The findings of this investigation clearly revealed that in respect to domestic waste and human activity the pollution, zooplankton perhaps were more tolerant to pollution.

Acknowledgement

No conflict for interest

References

Adesalu, T. A... Phytoplankton dynamics of river Oli in Kainjii lake National Park, Nigeria during dry season. International Journal of Botany, 2010, 6:112-116.

Avinash B. Gholap 2014 Species diversity indices of zooplankton from Sadatpur reservoir, Ahmednagar, Maharashtra Annals of Biological Research, 2014, 5 (4):58-61

Balasingh, G.S.R. and Shamal, V.P.S, Phytoplankton diversity of a perennial pond in Kanyakumari District. J. Basic and Appl.Biol., 2007, 1: 23-26.

Bhanu Prakash. M, Jyothi Kaparapu and Narasimha Rao G. M. Seasonal variations of phytoplankton community structure in relation to Physico-chemical factors in Lake Kolleru, Andhra Pradesh, India. J. Algal Biomass Utln. 2014, 5 (3): 1 – 7.

Das, S. K., Biswas, D., and Roy, S. Study of hydrophytes in some lentic water bodies in West Bengal, India. Ecoprint, 2009, 16, 9–13.

Dhrubajyoti Bordoloi and P. P. Baruah. Water quality assessment using phytoplankton in a historical pond of Upper Assam. J. Algal Biomass Utln. 2014, 5 (2): 1 – 7.

Hasle, G. R. 1978. The inverted microscope method, p. 88-96. In A. Sournia (ed.), Phymplankmn Manual. Monographs of Oceanographic Methodology 6. UNESCO, Paris, France.

Hoppenrath M., Elbr¨achter M., Drebes G., 2009, Marine phytoplankton. Selected micro phytoplankton from the North Sea around Helgoland and Sylt,E. Schweizerbartsche Verlagsbuchhandlung, Stuttgart, 264 pp

Horner, R. A. 2002. A Taxonomic Guide to Some Common Marine Phytoplankton. Biopress Ltd., Bristol, U.K.

Karr, J .R., J D. Allen and A. C. Benke 2000 River conservation in the United States and Canada. In P. J. Boon, Davies and B. R. Petts, G E (Ed.), Global perspectives on River conservation, pp 3–39 Science, Policy, and Practice. Wiley, New York.

Kolayli, S., Sahin, B., Species composition and diversity of epipelic algae in Balikli dam reservoir, Turkey. J Environ, Biol, 2009, 30:939-944.

Laskar, H.S., and S. Gupta., Phytoplankton diversity and dynamics of Chatla floodplain lake, Barak Valley, Assam, Northeast India – A seasonal study. J. Environ. Biol., 2009, 30: 1007-1012.

Margalef, R., Information theory in ecology. General Systhematic, 1958, 3:36-71. 26.

Menhinick, E.P., A Comparison of some species - Individuals diversity indices applied to samples of field insects. Ecol 1964, 45: 859-881.

Neves I F, Rocha O, Roche KF, Pinto AA. 2003 Zooplankton community structure of two marginal lakes of the River Cuiabá (Mato Grosso, Brazil) with analysis of Rotifera and Cladocera diversity. Braz J Biol. 2003 May; 63(2):329-43. Epub August 2003.

Okogwu OI1, 2010 Seasonal variations of species composition and abundance of zooplankton in Ehoma Lake, a floodplain lake in Nigeria. Rev Biol Trop. 2010 Mar; 58(1):171-82

Pandit, A K (1998) Plankton dynamics in freshwater wetlands of Kashmir. Ecology of polluted waters and toxicology. Techno science publication, Jaipur, India.

Rajashekhar, A.V., A. Lingaiah, Satyanarayana Rao and Ravi Shankar Piska., The studies on water quality parameters of a minor reservoir, Nadergul, Rangareddy district andhra Pradesh. J. Aqua. Biol., 2007, 22:118-122.

Reddy Radha Krishna, M., Mastan, S.A., and Srilakshmi, D., Studies on physico-chemical parameters and zooplankton abundence in Kolleru lake, Andhra Pradesh, India, J. Environ. Res. Develop. 2012, 7(2), 964-972.

Rothhaupt, K O (2000) Plankton population dynamics: Food web interactions and abiotic constraints. Freshwater Biology 45: 105-109.

Shannon, C.E., Weaver, W., The mathematical theory of communication. University of Illinois Pres, Urbana. 1949. 24.

Shiddamallayya, N., and Pratima, M., Impact of domestic sewage on fresh water body. J Environ Biol, 2008, 29:303- 308.

Shukla, Rajanikanth ,C.S and Thirupathi, B.D.,Ecological investigation on physic chemical characteristics and phytoplankton productivity of river Ganga at Varanas, ,Geobios. 1989, 16:20-27

Sigee, D. C., Freshwater microbiology: diversity and dynamic interactions of microorganisms in the aquatic environment. Chichester, UK: Wiley, 2004

Simpson, E.H., Measurement of diversity. 1949, Nature 163:688.

Sladecek, V., Rotifera as indicators of water quality. Hydrobiologia, 1983, 133, 127–141.

Smitha, V.H., G.D. Tilmanb and J.C. Nekolac 1999 Eutrophication: impacts of excess nutrient inputs on freshwater, marine, and terrestrial ecosystems. Environmental Pollution. 100:179-196.

Stevenson, R. J and Y. Pan 1999 Assessing environmental conditions in Rivers and streams using diatoms. In E. F. Stoermer and J. P. Smol, (Ed.), The diatoms, Applications for the environmental and earth sciences, pp. 11–40 Cambridge University Press, Cambridge.

Sumitra, M., Sharma, R., Sharma, V and Sharma. M. S., Trophic status of Lake Pichhola in relation to physico- chemical characteristics of its Water. National Symposium on Limnology, 2007, 244-248.

Tiwari, A., and Chauhan, S.V., Seasonal phytoplanktonic diversity of Kitham lake, Agra. J. Environ Biol., 2006, 27(1); 35-38.

Tomas, C.R. (Ed.) (1997). Identifying marine phytoplankton. Academic Press: San Diego. ISBN 0-12-693018-X. XV, 858 pp.

Venkateswarulu, V., Sampathkumar, P.T and Nirmal Kumar. J., An ecological study of the algeae of river Moosi, Hyderabad. A Comprehensive study. J.Environ . Biol., 1990, 11: 79-82.