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Influence of physico-chemical parameters on the diversity of plankton species in wetlands of Tiptur taluk, Tumkur dist, Karnataka State, India.

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ABSTRACT

Plankton diversity and physic-chemical parameters are an important criterion for evaluating the suitability of water for drinking and other purposes. The present study is conducted to assess the relationship between physic-chemical parameters and phytoplankton assemblages which in turn can serve as a suitable method to assess the quality of wetland ecosystem, for a period of two years during June 2010 to May 2012. Water quality parameters like temperature, pH, EC,DO, ,BOD,COD, free carbon dioxide, , total alkalinity, total hardness, calcium and magnesium hardness, chloride, phosphate, sulphate and nitrate and plankton composition were investigated during the study period. Results have shown an increased concentration in physic-chemical parameters and plankton diversity is more in pre monsoon compared to post monsoon and monsoon season. The results of the present investigations are compared with literature values and investigation reveals that there is a fluctuation in the physic-chemical characters of the water; this will be due to entry of rain water and change in the temperature and salinity as season changes.

INTRODUCTION: Wetland ecosystems are among the most productive ecosystems in the biosphere. They receive surface water inputs from streams (surface run off), precipitation, and overland flow and subsurface water inputs from surface infiltration and ground water. These different inputs are important to wetland productivity because they contain markedly different quantities of transported nutrients Stanley and Ward, (1997) and organic matter Mann and Wetzel, (1995). Wetlands are recognized as ecosystems that harbor high biological diversity, provide sustenance for millions of people and face ongoing threats as results of human activities throughout the world Gopal and Chauhan, (2001). As ecosystems, wetlands are highly volatile being particularly vulnerable to environmental fluctuations. Although wetland biodiversity constitutes a significant portion (e.g., 15-20%), of the total biodiversity of the Indian Subcontinent Gopal and Chauhan, (2001), studies of wetland ecosystems are limited Tsai and Ali, (1997); Gopal and Zutshi, (1998); de Graaf and Marttin, (2003).

The physic-chemical parameters are very important in study of any environment especially aquatic environment apart from the general interest in understanding the condition of water and its impact on the aquatic biota, observation on the short term changes on the physic-chemical parameter may also have practical implication in pollution studies. Sediments form a natural buffer and filter system in the material cycles of waters. Sediment in our rivers and wetlands is an important habitat as well as a main nutrient source for aquatic organisms. Furthermore, sediments have an impact on ecological quality because of their quality, or their quantity, or both Stronkhorst *et al*.,(2004).

Another important aspect of biological water quality assessment is that the biotic community represents “the results of summation of the prevailing conditions”, Hynes (1971). Intermittent or single discharges of toxic wastes will be manifested in the composition of the local biotic community, whereas, unless sampled during the actual discharge, intermittent discharges may not be detected by chemical sampling. Furthermore, the source of intermittent or single discharge may be detected biologically by sampling progressively further upstream until the effects of pollutant discharge are not longer found. Obviously, neither biological nor chemical methods should be employed to the exclusion of the other. The two approaches complement each other, and biological methods are not currently used to their full potential.

It is recognized that wetlands alone cannot solve all of our water pollution problems since every wetland has a finite capacity to assimilate pollutants and overloading it will reduce its ability to perform this and other functions. Nevertheless, wetlands have a key role to play in integrated catchment-based strategies to address water quality issues.In Gujarat state; Nandan (1983) studied the algal flora of polluted waters. Shaji (1989) and Jose (1990) evaluated the algae as pollution indicators in running waters. Rana and Nirmal Kumar (1992) and Nirmal Kumar et al.(2005, 2008) also studied physico-chemical characteristics of water and sediments, diversity of macrophytes and planktons of certain wetlands of Central Gujarat. Nirmal Kumar (1992) also prepared indices based on chemical properties in relation to planktons.

Biological diversity provides the basis for life on earth. The fundamental, social, ethical, cultural and economic values. These resources have recognized in the region and literature from the earliest days recorded history (Dutta et al., 2001).Adequate knowledge of zooplankton communities and their population dynamic is a major requirement for better understanding of processes in a fresh water body since eutrophication influences both composition and productivity of zooplankton (Bhora and Kumar, 2004). The physical and chemical characters of the wetlands water can be used to assess the ecological nature of the wetlands. Several studies have been conducted to understand the physical and chemical properties of lakes, wetlands and reservoirs RajaseKara et al.,(2005).

Phytoplankton constitutes the very basis of nutrient cycle of an aquatic ecosystem. They play a crucial role in maintaining proper equilibrium between the biotic and a biotic component of an aquatic ecosystem. The quality of water is identified in terms of its physical, chemical and biological characteristics. The algae are purifiers of environment on one hand and polluting organisms on the other. The phytoplankton diversity with the seasonal fluctuation indicates the diversity of ecological niches.

In the tropical country like India, highly seasonal rainfall and heavy discharge of water during monsoons results in high flushing rate of phytoplankton in the most of the reservoirs. Therefore, the consistency and productiveness of biotic component is variable. Plankton by virtue of drifting habit and short turnover period constitutes major link in the trophic structure and events in the reservoir ecosystem. A rich plankton community is the hallmark of Indian reservoirs that can be attributed to abiotic factors and nutrient load variability Goswami *et al.*, (2012).

Materials and methods:

The present study was carried out in four wetlands of Tiptur taluk, from June 2010 to May 2012. Samples were collected on the basis of seasonal wise i.e. pre-monsoon (February-May), monsoon (June-September), post monsoon (October-January). The surface water samples were collected from selected sites during morning hours in two liters polythene bottles for physico-chemical parameters between 7:00 A.M. to 11:00 A.M. Atmospheric and water temperature, pH, turbidity, electrical conductivity, were determined on the sampling sites. BOD and DO were fixed on the site, while TDS, CL, TH, Ca, Mg, Alkalinity, Acidity, NO_3, PO_4, Fe, Si, CO_2, SO_4, COD and DOM were analyzed in the laboratory by using standard methods of APHA, (2005). For the plankton analysis, the samples were collected by filtering 10 liters of water filtered through plankton net of 20µ pore size filtering cloth and concentrated up to 100 ml. The concentrated plankton samples were preserved immediately with the help of 4% formalin. The samples were observed under the microscope and identified phytoplankton and zooplanktons using standard keys and published literature. The phytoplankton species have been identified by using keys - Edmondson, W.T.(1959), Subrahmanyan, R.(1968) and. Subrahmanyan, R.(1971), Adoni, A. D., et al., (1985). The zooplankton species have been identified with the help of standard keys of Needham, J. G. and Needham, P. R. (1972). The quantitative estimation was done by using Sedge wick – Rafter Cell and expressed as numbers per liter.

Study Sites

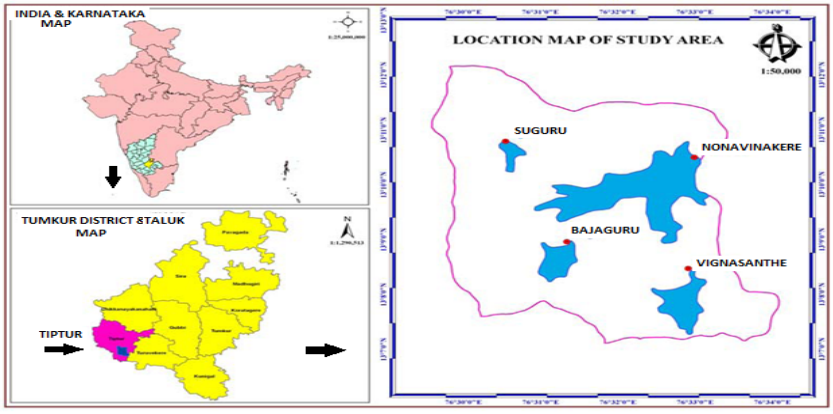

Fig.1.Mapped wetland bodies

Results and Discussion

The plankton studies were noticed that a total of 114 species of phytoplankton belonging to 31 genera and 21 families under the 3 classes (Table -1). Among these Chlorophyceae comprised of 62 species (belonging to 19 genera, 12 family), followed by Cyanophyceae 17 species (12 genera, 5 family), Bacillariophyceae 27 species (16 genera, 4 family), Euglenophyceae 8 species, 2 genera has been recorded(Table-1). A total of 32 species of zooplankton belonging to 28 genera and 15 families under the 3 classes were recorded; 14 species of rotifera were belonging to 11 genera and 9 family, 6 species of copepod belonging to 6 genera and 3 families and 8 species of Cladocera belonging to 7 genera and 3 families, 4 species of Protozoans were recorded during the study period from the 4 study sites (Table-2).

Table.1. Seasonal variation of phytoplankton (Org/L) in the wetlands of Tiptur during 2010-12 .

Sl. No.	Parameters	June 2010 to May 2011			June 2011 to May 2012		
		Monsoon	Post Monsoon	Pre Monsoon	Monsoon	Post Monsoon	Pre Monsoon
Station-1	Cyanophyceae	2945.25	4460.75	9619.75	3114.5	4829.75	9754.5
	Chlorophyceae	3032.25	4858	5951.5	3232.75	4965.5	6438
	Baciliariophyceae	1487.75	2239	7688	2000.75	2277.75	8527.5
	Euglenophyceae	15.75	75.25	2569	8	69.5	2551.25
Station-2	Cyanophyceae	885.5	1212.5	2784	726.5	1523.5	3739.5
	Chlorophyceae	5402.5	8439.5	9021.5	6203.5	8855	9236
	Baciliariophyceae	4086.75	3687.25	8644.5	4366.5	4185.75	8815.5
	Euglenophyceae	0.75	1.75	11.75	4	1.5	13.75
Station-3	Cyanophyceae	1278.25	2899.5	4576.5	1741	2819.5	5096.5
	Chlorophyceae	4096.5	8107.25	8542.25	4458	8836.75	8088.5
	Baciliariophyceae	2980.75	4583.5	9990.5	3259.75	5018.25	10037.25
	Euglenophyceae	0.75	3.75	20	3	5.5	26.75
Station-4	Cyanophyceae	3177.25	3992.75	7645.5	3456.25	4111.25	8205
	Chlorophyceae	2365.25	7472.25	5349.5	2675.75	10128	6755
	Baciliariophyceae	1711	425.75	3569.25	1910.25	517.5	4129.5
	Euglenophyceae	6.75	43	2624.75	10.25	40.5	2652.25

Table .2. Seasonal variation of zooplankton(Org/L) in the wetlands of Tiptur during 2010-12

Sl. No.	Para meters	June 2010 to May 2011			June 2011 to May 2012		
		Monsoon	Post Monsoon	Pre Monsoon	Monsoon	Post Monsoon	Pre Monsoon
Station-1	Rotiferies	106.25	45	135.25	97.75	54.75	142.25
	Protozoan	34	4	94	49	11	109.25
	Copepoda	16.25	38.5	100.5	20.75	46	114.5
	Clodocera	86.25	186.5	285	93.5	141.5	291.25
Station-2	Rotiferies	31	7.5	92.5	36.25	8.5	100
	Protozoan	22	4.75	71	31.75	15.75	91.75
	Copepoda	9	28.75	72.5	14.25	31.25	83.75
	Clodocera	50.75	156.25	242.5	54.75	149.25	238.5
Station-3	Rotiferies	39.5	50.75	267.5	50	44	344.75
	Protozoan	30.75	10	83	40.5	21.25	93
	Copepoda	13.5	34.5	69.5	18.75	38	84
	Clodocera	68.75	143.25	238.75	57.75	144.5	241.5
Station-4	Rotiferies	69	53.75	100	69.5	64.5	55.75
	Protozoan	35	12.5	87.75	49.5	26.75	103
	Copepoda	14.25	35.75	84.5	21.5	43.5	95.75
	Clodocera	65.5	112.5	279	77.25	134.25	284.75

Table.3. Average of physico-chemical characteristics of wetland water of Tiptur during 2010-2012.

Sl. No.	Parameters	Station-1	Station-2	Station-3	Station-4
1	Air temperature	26.96	26.82	26.45	27.14
2	Water temperature	25.31	24.53	24.31	25.03
3	PH	7.68	7.77	7.75	7.63
4	Turbidity	30.19	47.92	43.48	35.58
5	EC	276.42	496.04	520.25	265.96
6	TDS	122.37	302.21	304.54	154.42
7	Chloride	25.64	21.10	28.96	65.34
8	Total hardness	112.38	153.23	178.75	125.29
9	Calcium	21.79	32.80	37.79	22.17
10	Magnesium	18.11	27.20	31.65	19.37
11	Alkalinity	69.00	152.04	174.37	134.42
12	Acidity	16.96	43.81	11.90	14.58
13	Nitrate	0.22	0.14	0.13	0.21
14	Phoshate	0.26	0.20	0.18	0.25
15	Iron	0.20	0.17	0.14	0.11
16	Silicon	0.20	0.44	0.68	0.22
17	DO	5.07	6.13	5.63	5.17
18	BOD	5.05	3.37	4.03	4.71
19	Carbon dioxide	2.03	1.45	1.74	1.64
20	Sulphate	129.75	87.46	109.87	137.75
21	COD	40.34	22.62	28.45	29.85
22	DOM	1.27	1.05	1.30	1.76

Note: All the parameters are expressed in Mg/l, except pH, Water tempreture, Air tempreture (degree celcius), Electrical conductivity (micromhos per centimeter).

Table.4.The status of identified phytoplankton and zooplankton during June 2010 to May 2012 .

1	Cyanophyceace	12	17	1	Rotifers	11	14
2	Chlorophyceace	19	62	2	Protozoans	4	4
3	Bacillirophyceace	16	27	3	Copepoda	6	6
4	Euglenophyceace	2	8	4	Cladocera	7	8
	Total	**49**	**114**		**Total**	**28**	**32**

Cyanophyceace : Cyanophyceace can be classified as primeval pioneer organisms. Phytoplankton studies and monitoring are useful for control of the physico-chemical and biological conditions of the water. Therefore, certain divisions of phytoplankton especially blue green or cyanophyta ,can degraded re-creationally value of surface water, particularly thick surface scum, which reduces the use of amenities for contact spoprts,or large concentrations which causes deoxygenating of the water leading to fish

death Whitton and Patts, (2000). The seasonal occurrences of cyanophyceace ranged from a maximum and minimum of 9619.75- 2945.25(Org/L), 3739.5-726.5(Org/L), 5096.5 -1278.25(Org/L) and 8205-3177.25(Org/L), in Pre Mansson and Mansoon of 2011 at station1,3 and in 2012 at 2 and 4 respectively.In the present investigation, the density of cyanophyceace in all the four water bodies was found to be maximum during summer seasons. It may be due to higher water temperature. Nirmal Kumar – Cini Oommen (2011), Zafar, (1967); Hegde and Bharati,(1985) and Swarnalatha and Narasinga Rao, 1993 were of the opinion that high temperature favours the luxuriant growth of blue-greens.

Chlorophyceae : Chlorophyceace are free living and planktonic, mostly confined to shallow water and are attached to the submerged plants or found on moist soil Huisman *et al*.,(2005). The seasonal density of chlorophyceae in station-1and 2 ranges a maximum of 6438 (Org/L) to minmum 3032.25, 9236-5402.5 (Org/L) in pre mansoon 2011-12 and mansoon 2010-11 respectively. In station 3and 4 it ranges 8836.75to 4096.4(Org/L) and 10128-2365.25 (Org/L) in post mansoon 2011-12 and mansoon 2010-11 respectively. Huisman et al., (2005) ; James G.N. and Paul R.N., (1992). Hegde and Bharati,(1985), pointed that alkaline pH is one of the important factors that regulate the presence of chlorophyceae in aquatic medium. In the present study all the stations are fairly alkaline pH in nature.

Bacillariophyceae : Diatoms are a major group of algae and one of the most common types of phytoplankton, belong to member of Bacillariophyceae. Diatoms are microscopic single celled photosynthetic aquatic organisms contained within distinctive silica frustules that can remain preserved in sediments for thousands of years. Seasonally the density was found to be highest of 8527.5 (Org/L), 8815.5 (Org/L), 10037.3 (Org/L) and 4129.5 (Org/L) during pre-mansoon 2011-12 in all stations. Lowest of 1487.75 (Org/L) in mansoon 2010-2011at station -1, but at station -2, 3687.25 (Org/L) in post mansoon in 2010-11, in station-3, it was 2980.75 (Org/L) in mansoon 2010-11 and 425.75 (Org/L) in post mansoon in 2010-11.Verma and Mohanty, (1995) ; Swarnalatha and Rao, (1998) and Harikrishnan et al.,(1999) stated that alkaline pH favours the abundance of diatomic population. It is true in case of Station 1 and 4.

Euglenophyceae : Just like blue greens, euglenoids also prefer to grow in polluted water. In fact they grow luxuriantly and often develop in to water blooms in water, which are originally rich. Season wise variation in the present investigation indicated that the highest density of 2624.75 (Org/L) and 2569 (Org/L) in pre-mansoon 2010-11 at station-4 and 1, respectively and lowest density 1 (Org/L) at station 2 and 3 during mansoon 2010-11. Researchers like Munawar,(1974); Hegde and Bharathi, (1985) and Puttaiah and Somashekar (1987) have considered that free carbon dioxide, dissolved oxygen, phosphate are the chief factors that regulate the distribution of Euglenoids in the fresh water bodies. Verma *et al.,* (2001) and Milind S. Hujare, (2008) were also reported phytoplankton density in different seasons in order of summer > winter > monsoon.

Zooplankton diversity:

Rotifera : Rotifers are the most important soft-bodied metazoans (invertebrates) having a very short life cycle among the plankton. Only 100 widely spread rotifer species are planktonic and their life cycles are influenced by temperature, food and photoperiod, Dhanapathi 2000. Seasonally, the highest average of 344.75 (Org/L) in pre-mansoon 2011-12 at station 3,while lowest average of 7.5 (Org/L) at station 2 in post mansoon 2010-11, Singh et al. (2002) reported that higher rotifer population occur during summer and winter might be dominant due to hyper tropical condition of the river at high temperature and low level of water.. Several researchers such as Bhagat and Meshram (2007), have studied the dynamics of rotifers in Ansadi dam of

Maharashtra and opined that alkalinity in the range of 8.5 to 9.5 mg/l is congenial for the proper development of rotifers and their abundance was in order of copepods> rotifers> cladocerans>protozoans.

Protozoans : A protozoan is what we call a eukaryotic organism because it is a cell that contains a true nucleus and is bounded by a nuclear membrane. It consists of only a single cell and is so small that we usually can't see it without using a microscope. Seasonally, a more density was found 109.25, 91.75 , 93.0 and 103 (Org/L), in pre-mansoon 2011-12 at station 1, 2, 3 and 4 respectively. All stations have shown a minimum of 4 (Org/L), 4.75 (Org/L), 10.0 (Org/L) and 12.5 (Org/L) in post-mansoon 2010-11.Similar results were reported Annalakshmi G and Amsath.A.2012. The densities of protozoans were more at station -1, this may be due to more organically polluted water.

Copepoda : Copepods are a group of small crustaceans found in the sea and nearly every freshwater habitat. Some species are planktonic , some are benthic , and some continental species may live in limno-terrestrial habitats and other wet terrestrial places, such as swamps, under leaf fall in wet forests, bogs, springs, ephemeral ponds and puddles, damp moss, or water-filled recesses (phytotelmata) of plants such as bromeliads and pitcher plants. Seasonally, the higher population densities of copepodes found 114.5, 83.75, 84.0 and 95.75 Org/L at station-1, 2, 3 and 4 respectively in pre-mansoon 2011-12. Minimum of 16.25, 9, 13.5 and 14.25 Org/L was found at station- 1, 2, 3 and 4 in mansoon 2010-11Similar result was found Lakshmi Ganesan and R.A Khan, (2007). If the regularity is accounted for, it is observed that higher density of Copepoda in station-1, with high BOD and low DO are important parameters that appear to regulate the population of copepods. However it is rather difficult to point out a particular factor responsible for the distribution, a similar opinion has been represented Sehgal, (1980). Most analyses have identified ancient lakes as hotspots for freshwater biodiversity. For copepods, Lake Baikal with over 120 species, the majority of which are endemic Boxshall and Evstigneeva, (1994), and Lake Tanganyika with 69 species, of which 34 (49%) are endemic Coulter, (1991); Boxshall and Strong, (2006), constitute prime hotspots. In both the copepod fauna comprises several species flocks, defined as monophyletic clades endemic to the lake and presumed to have originated via intralacustrine speciation.

Clodocera : Cladocera is an order of small crustaceans commonly called water fleas. Around 620 species have been recognized so far, with many more undescribed. In the current studies the seasonal occurrences of Cladocera numerical density varied from 285 Org/L in pre-mansoon 2010-11 at station-1 to lowest of 50.75 Org/L at station-2 in mansoon 2010-11. Many zooplankton, particularly the Cladocera, exhibit marked diurnal vertical migrations.The seasonal fluctuation of zooplankton population is a well known phenomenon; Welch (1952) mentioned that the fluctuation in zooplankton population is greatly influenced by the variation of temperature along with many other factors. Benarjee *et al.(*2008). Studied the climatic influence on zooplankton population in historical Lake of Warangal, Andhra Pradesh. Manjare *et al.* (2010) worked on zooplankton population in Vadgaen tank, Kolhapur, Maharashtra.

Conclusion: From the forgoing account it is clear that the wetland harbours have a large number of population density of planton and data compare well with similar work carried out in India and elsewhere. This indicated that the diversity and density of the different group of phytoplankton and zooplankton were more in the pre monsoon and decreased during the monsoon period. Since the wetlands are under the semi-arid region, the prevailing temperature and nutrient loads by various factors enhances the population abundance of plankton.It is in case of Tiptur Taluk wetlands , the over-exploitation of pollution free water for various domestic and agriculture purpose, it enhances the considerable reduce of diversity of these organisms. Therefore fluctuation of

planktonic communities occurs seasonally and indicated that wetlands of Tiptur are similar like other tropical fresh water wetlands.

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References:

1. Annalakshmi .G and Amsathi . A. (2012). Studies on the hydrobiology of river cauvery and its tributaries arasalar from kumbakonam region (tamilnadu, india) with reference to zooplankton.International journal of applied biology and Pharmaceutical Technology. Volume: 3(1).
2. Benarjee G, K Srikanth, G Ramu, K Narasimha Ramulu and B Ravinder (2008). "The Climatic Influence on Zooplanktonic Population in Historical lake of Kakatiya Dynasty", Proc. of 8th Indian Fisheries Forum, pp. 22-26, Kolkata.
3. Bhagat, V.B. and C.B. Meshram (2007). Zooplankton dynamics of Ambadi dam, near Akot, dist. Akola, Maharashtra. Journal of Aquatic Biology Volume: 22(1):19-20.
4. Bhora Chandan and Aravind Kumar (2004). Plankton diversity in the wetlands of Jharkand.A.P.H publishing Corp .New Delhi: 91-123.
5. Boxshall, G. A. and T. D. Evstigneeva, (1994). The evolution of species flocks of copepods in Lake Baikal: a preliminary analysis. In: Martens, K., B. Goddeeris & G. Coulter (eds), Speciation in Ancient Lakes. Archiv fu¨r Hydrobiologie, Ergebn Limnology 44: 235–245.
6. Boxshall, G. A. and E. E. Strong, (2006). An extraordinary shift in life habit in a genus of cyclopid copepods from Lake Tanganyika. Zoological Journal of the Linnean Society 146: 275–285.
7. Coulter, G., (1991). Lake Tanganyika and its Life. Oxford University Press, Oxford.
8. De Graaf G.J., Marttin F. (2003). Mechanisms behind changes in fish biodiversity in the floodplains of Bangladesh. – Wetlands Ecol Manage 11: 273-280.
9. Dhanapathi, M.V., (2000). Taxonomic notes on the rotifers from India (from 1889-2000). Indian Association of Aquatic Biologists (IAAB), Hyderabad.
10. Dutta S.P.S,H.Kaur and I.D.Sharma (2001). Hydrobiological studies on river Basantar samba (Jammu and Kashmir). J.Aqua.bio.16,41-44
11. Eshwarlad, S. and Angadi, S.B. (2003). Physico-chemical parameters of two fresh water bodies of Gulbarga India with special reference to phytoplankton. *Poll. Res.*, 22(3): 411-422.
12. Gopal B., Chauhan M. (2001). South Asian wetlands and their diversity: the role ofmonsoons. - In: Gopal B, Junk WJ, Davis JA (eds) Biodiversity in wetlands: assessment, function and conservation, vol 2., Backhuys Publishers, Leiden, pp 257-276.
13. Gopal B., Zutshi D.P (1998). Fifty years of hydrobiological research in India. – Hydrobiologia 384:267-290.
14. Goswami A.P (2012). Department of Biology, M.V.M. Science and Home Science College, Rajkot, Gujarat, INDIA. ISCA Journal of Biological Sciences Vol.1 (1), 30-34.
15. Huisman, J., Matthijs, H.C.P. and Visser, P.M(2005). Harmful Cyanobacteria. *Berlin, Springer*, p. 243.
16. Hujare M S (2008). "Seasonal Variation of Physico-Chemical Parameters in the Perennial Tank of Talsande, Maharashtra" *Ecotoxical. Environ. Monit.*, Vol. 18, No. 3,pp. 233-242.16.
17. Hynes, H.B.N (1971). *The Biology of Polluted Water*. Univ. Toranto Press, Canada pp. 202.

18. Lakshmi Ganesan and R.A Khan (2007).Studies on the ecological of zooplankton in a flood plain wetland of West Bengal, India. Proceedings of Taal .The 12th World Lake Conference: 67-73.
19. Manjare S A, Vhanalakar S A and D V Muley (2010). "Water Quality Assesment of Vadgaon tank of Kolhapur (Maharastra), with Special Reference to Zooplankton", *International J. of Advanced Biotechnology and Research*, Vol. 1, No. 2, pp. 91-95.
20. Mann C.J., Wetzel R.G. (1995). Dissolved organic carbon and its utilization in a riverine wetland ecosystem. – Biogeochemistry 31: 99-120.
21. Nandan S.N. (1983). Algal flora of polluted waters of Gujarat state Biodiversity Scenario. Discovery Publication House, New Delhi. Pp. 152-170.
22. Nirmal Kumar – Cini Oommen. (2011). Phytoplankton composition in relation to hydrochemical properties of tropical community wetland. Applied ecology and environmental research 9(3): 279-292.(on line)
23. Nirmal Kumar J.I., Kumar, R.N., Bhatt, I. (2005). Study of Cultural Eutrophication in relation to the plant diversity of Wetland Rathreshwar in central Gujarat. – In: Aquatic
24. Rana B.C., Nirmal Kumar J.I. (1992). Macrophytes and Nutrient study of two wetlands of Guajrat, India. – International Journal Ecology and Environmental Science.18: 195-202.
25. Shaji C. (1990). Studies in algal flora and ecology of some polluted waters in Gujarat Stanley E.H., Ward A.K. (1997). Inorganic nitrogen regimes in an Albama wetland. – Journal of the North American Benthological Society 16:820-832.
26. Singh, S. P., Pathak, D. and Singh, R., (2002) Eco. Environ. Cons 8: 289.
27. Stronkhorst J., Brils J., Batty J., Coquery M., Gardner M., Mannio J., O'Donnell C., Steenwijk J.and Frintrop P. (2004). Discussion document on Sediment Monitoring Guidance for the EU.
28. Tsai C., Ali Y. (1997). Openwater fisheries of Bangladesh. – The University Press Limited, Dhaka
29. Verma M C, Singh S and Thakur P (2001)."Ecology of a Perennial Wetland. An Overview of Limnobiotic Status", *J. Environ.Poll.*, Vol. 8(1): 53-59.
30. Welch P (1952). "Limnological methods.The Blankston Co., Philadelphia. Toronta, Wuhrmann, K 1938, Lake", Eutrophication and its Control. In Proc. Shiga Conference on Conservation and Management of World Environment: 26-37.
31. Whitton, B.A. and Patts, M. (2000). The Ecology of Cyanobacteria. Kluwer Academic Publishers, Netherlands.