Journal of Environmental Biology **May 2008,** 29(3) 303-308 (2008)
©Triveni Enterprises, Lucknow (India) For personal use only
Free paper downloaded from: www.jeb.co.in Commercial distribution of this copy is illegal

Impact of domestic sewage on fresh water body

N. Shiddamallayya*[1] and M. Pratima[2]

[1]Regional Research Institute (Ay.), Ashoka Pillar, Jayanagar, Bangalore - 560 011, India
[2]Dept. of P.G. Studies and Research in Botany, Gulbarga University, Gulbarga - 585 104, India

(Received: February 02, 2006 ; Revised received: July 10, 2006 ; Accepted: August 29, 2006)

Abstract: *In the present study, various (physico-chemical) factors were assessed over a period of two years (from February 2002 to January 2004) to note the chemistry and quality of tank water in Bhalki town of Bidar. Physico-chemical factors like pH, dissolved oxygen, magnesium, chlorine, nitrite, sulphates and chemical oxygen demand were found with maximum concentration during summer season. Similarly, during monsoon season free carbon dioxide, alkalinity, hardness, calcium, phosphate, silicon, total solids and biological oxygen demand; and in winter season organic matter were recorded. The concentrations viz., pH, hardness and nitrite were more compared to the potable water standard of WHO. The correlation matrix and dendrogram of physico-chemical factors have been computed and analysed. The positive co-relation coefficient observed between pH and magnesium, dissolved oxygen and hardness, free carbondioxide and calcium, alkalinity and nitrite, alkalinity and phosphate, alkalinity and biological oxygen demand, hardness and calcium, hardness and magnesium, magnesium and chlorine, nitrate and phosphate, nitrite and biological oxygen demand, phosphate and organic matter; and silicon and chemical oxygen demand. The dendrogram confirms chlorine, pH, hardness, silicon, total solids and sulphates are the key factors of the change in the chemistry of water body.*

Key words: *Physico-chemical properties, Fresh water, Sewage, Pollution*
PDF of full length paper is available with author ***(*siddamallayya_matapati@rediffmail.com)***

Introduction

Water pollution is the biggest menace of urbanisation, industrialisation and modern agricultural practices. It leads to alteration in physical, chemical and biochemical properties of water bodies as well as that of the environment. It directly or indirectly affects the life processes of flora and fauna of the water body, surrounded by chemical toxicants (Kumari *et al.*, 2006; Indira and Sivaji, 2006; Krishnan *et al.,* 2007). Study of pollution in water bodies of Karnataka state have been carried out by Bharati and Hosmani (1975), Hosmani and Bharati (1987), Hegde (1988), Vijay Kumar and Paul (1990), Angadi *et al.* (1999), Nagarathna and Hosmani (2002), Raghavendra and Hosmani (2002) and Sachidanadamurthy and Yajurvedi (2004). However, no such works were reported from the Bhalki town and Bidar district except the report of Angadi *et al.* (2005). Therefore, the present work is an attempt to study the impact of influx of domestic sewage on chemistry and quality of water in Bhalki tank. The main objectives of this study are to assess seasonal changes in chemistry, quality and potability of water during February 2002 to January 2004. Water samples were collected periodically from tank over two years and analysed. The data of samples were statistically analysed, result and inferences are presented in this article.

Materials and Methods

Study area: Bhalki is one of the towns in Bidar district, is located in the northeastern region of the Karnataka state and lies at 18° 03' north latitude and 77° 12' east longitude, located 590 m above mean sea level. The selected water tank is situated at the north-western side of the city and covers an area of 3.18 square kilometers. The maximum water storage area and shoreline of the tank is covered with *Ipomea fistula* Mart. The water level is ranged from 1.2 m in summer to 4.35 m during monsoon season. The tank has three inlets; Railway bridge canal (carries runoff during rainy season from the surrounding fields), Birude and Dhanagargalli sewage canals (city canals supplying the pollutants to the water body). The water tank is the main source for the potable water. Further, tank water is used for the agriculture, fisheries and other domestic activities *viz.* bathing of cattle, washing of clothes, disposing of anthropogenic wastes and cleaning of vehicles. All these undesirable activities are changing the chemistry of water and making it unfit for drinking, irrigation and domestic activities.

Sampling and analysis: The surface water samples from two stations were collected once in a month using wide mouthed clean Iodine treated poly vinyl chloride container. All collections were made between 8.30 to 10.00 am for the period from February 2002 to January 2004. The collected water samples were analysed by following standard methods out lined by Trivedy and Goel (1986), Aneja (1996), Gupta (2001) and APHA (2005), to estimate various factors such as, temperature, pH, dissolved oxygen, free carbondioxide (CO_2), alkalinity, hardness, calcium (Ca), magnesium (Mg), chlorine (Cl), salinity, nitrate, phosphate, silicon, sulphates (SO_4), total solids, organic matter, biological oxygen demand (BOD) and chemical oxygen demand (COD).

Statistical analysis: The data collected were subjected to Pearson's correlation matrix to study the significant level at 0.05 and 0.01 (2 tailed) to note the positive and negative correlation among the physico-chemical factors. Similarly, Hierarchical cluster analysis

was applied to construct a dendrogram of percentage of similarity in physico-chemical factors to identify relative homogenous clusters of factors and to measure the distance or similarity in relation to aquatic condition. The SPSS ver. 10.5 statistical program was used for all statistical analysis throughout this research.

Results and Discussion

The quantitative analysis of various physico-chemical factors of Bhalki tank is presented in Table 1. Atmospheric and water temperature varied with the variation of seasons as lowest in winter and highest in summer. Similar findings were also recorded by Shastri and Pendse (2001) and Eshwaralal and Angadi (2002). The lowest pH value was found during the winter season due to heavy rainfall and dilution effect, similar observation was also made by Agarkar and Garode (2001). The highest pH was recorded in all the seasons this is in agreement with the work of Mali and Gajaria (2004). Less amount of dissolved oxygen was recorded during the monsoon and the highest in the of summer season due to increased photosynthetic activity in the water body. Simon (2002) had also recorded the similar finding in Lang reach hole, Australia. The complete absence of free CO_2 was recorded in all the seasons due to luxuriant growth of algae and the maximum in monsoon due to heavy rain and increase in number of overgrazing

Table - 1: Physico-chemical factors of Bhalki tank (February 2002 to January 2004)

Parameters	Summer (Feb. 02 to May 02)	Monsoon (June 02 to Sep. 02)	Winter (Oct. 02 to Jan.03)	Summer (Feb.03 to May 03)	Monsoon (June 03 to Sep. 03)	Winter (Oct. 03 to Jan. 04)
Atmospheric temp. (^{0}C)	26.5-35 (30.3)	24-28.8 (26.5)	23.8-28 (26)	29-38.5 (34)	26.5-27 (26.9)	25-31.8 (29.1)
Water temperature (^{0}C)	27-26.5 (25)	21-28.8 (25.5)	20.8-26.3 (23)	24-29.3 (26.4)	25.3-26.3 (25.5)	20.3-28 (24.3)
pH	7.7-7.9 (7.8)	7.2-7.9 (7.5)	7.1-7.9 (7.4)	7.8-8 (7.9)	7.2-7.8 (7.4)	7.3-7.5 (7.4)
Dissolved oxygen	7.9-12.3 (9.9)	4.9-10.8 (8.8)	5.9-12 (9.5)	8.9-9.7 (9.3)	7.7-10.1 (8.9)	7.9-11.5 (9.8)
Carbondioxide	7.7-11 (9.5)	6.6-20.9 (10.7)	00-6.6 (3.9)	00-00 (00)	00-21.7 (14)	12.7-18.7 (15.5)
Alkalinity	128-155 (143)	110-215 (148)	113-140 (122)	118-150 (130)	115-130 (123)	178-130 (121)
Hardness	122-162 (143)	89-131 (114)	107-128 (119)	120-149 (132)	109-193 (136)	145-170 (156)
Calcium	24-31 (28)	18-30 (25)	21-29 (26)	18-31 (23)	31-51 (37)	38-45 (42)
Magnesium	15-21 (18)	11-15 (13)	9-16 (13)	15-21 (18)	8-16 (11)	10-17 (13)
Chlorine	19-41 (28)	29-49 (38)	38-47 (42)	47-72 (60)	27-43 (35)	24-35 (32)
Salinity	35-73 (51)	53-89 (69)	69-85 (76)	85-130 (109)	49-77 (67)	42-77 (57)
Nitrite	0.012-0.084 (0.042)	0.005-0.377 (0.126)	0.003-0.022 (0.009)	0.036-0.448 (0.196)	0.012-0.202 (0.07)	0.029-0.066 (0.043)
Phosphate	0.003-0.092 (0.035)	0.045-0.288 (0.118)	0.006-0.031 (0.019)	0.012-0.069 (0.044)	0.023-0.057 (0.044)	0.013-0.021 (0.018)
Silicon	7.1-17.9 (12.5)	4.4-25.7 (14.8)	8.3-20.5 (13.3)	6.8-11.6 (9.6)	7.9-10.8 (8.8)	3.3-13.3 (10.2)
Sulphate	2.2-12.5 (5.2)	2.9-6.7 (4.5)	3.6-7 (5.6)	6.7-11.7 (8.3)	2.9-10.8 (5.8)	3.3-10.5 (6.8)
Total solids	13-161 (88)	27-109 (74)	73-94 (80)	53-88 (72)	70-205 (122)	60-93 (71)
Organic matter	0.32-1.68 (0.81)	0.63-2.65 (1.46)	0.66-1.39 (1.09)	0.24-2.13 (1.42)	2-3.02 (2.38)	0.29-10.5 (0.56)
BOD	1.22-6.28 (3.80)	2.43-7.29 (4.31)	1.02-5.47 (2.79)	1.42-4.66 (3.34)	1.83-3.04 (2.49)	0.64-4.87 (2.24)
COD	6.6-12.8 (9.2)	00-8.8 (4.6)	5.4-12.2 (9.3)	6.4-11.4 (9.1)	6.4-9.6 (8)	00-9.6 (4.8)

All the values are expressed in mgl^{-1} except pH, atmospheric temperature and water temperature
The values in bracket are mean values of months of two sites of a season (n = 8)

Online Copy

Table - 2: Pearson's correlation coefficients of physico-chemical factors of Bhalki tank, Bhalki (February 2002 to January 2004)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
A	+1.000																		
B	+0.521**	+1.000																	
C	+0.414*	+0.183	+1.000																
D	+0.248	+0.151	+0.171	01.000															
E	-0.221	+0.086	-0.564**	-0.016	+1.000														
F	+0.184	+0.173	+0.220	+0.164	+0.076	+1.000													
G	+0.231	-0.029	+0.091	+0.424*	+0.365	+0.101	+1.000												
H	-0.186	-0.249	-0.455*	+0.125	+0.625**	-0.333	+0.578**	+1.000											
I	+0.487*	+0.075	+0.478*	+0.170	-0.250	+0.207	+0.546**	-0.235	+1.000										
J	+0.481*	+0.004	+0.328	+0.200	-0.464*	+0.143	-0.043	-0.398	+0.414*	+1.000									
K	+0.481*	+0.004	+0.327	+0.200	-0.463*	+0.143	-0.043	-0.398	+0.413*	+1.000**	+1.000								
L	-0.142	+0.029	+0.374	+0.004	-0.334	+0.546**	-0.237	-0.476*	+0.084	+0.017	+0.016	+1.000							
M	-0.202	+0.168	+0.206	+0.050	+0.012	+0.686**	-0.193	-0.356	-0.073	+0.061	+0.061	+0.818**	+1.000						
N	-0.154	+0.055	-0.031	-0.171	-0.023	-0.445*	-0.075	+0.082	+0.049	-0.127	-0.126	-0.217	-0.251	+1.000					
O	-0.155	-0.005	-0.208	-0.022	-0.048	-0.145	-0.304	-0.138	-0.120	-0.134	-0.134	-0.004	+0.029	+0.136	+1.000				
P	-0.114	+0.084	+0.053	+0.096	-0.003	-0.198	-0.135	+0.046	-0.153	-0.103	-0.103	-0.171	-0.072	+0.121	+0.082	+1.000			
Q	-0.176	+0.473*	-0.022	-0.077	-0.003	+0.389	-0.295	-0.226	-0.307	+0.027	+0.027	+0.247	+0.594**	-0.127	+0.010	+0.103	+1.000		
R	-0.013	-0.174	+0.213	+0.123	-0.078	+0.576**	+0.181	-0.120	+0.243	+0.068	+0.068	+0.486*	+0.344	-0.220	-0.176	-0.400	-0.084	+1.000	
S	-0.039	-0.003	+0.267	-0.085	-0.483*	-0.311	-0.194	-0.196	+0.135	+0.010	+0.010	-0.087	-0.264	+0.523**	+0.251	+0.341	-0.118	-0.115	+1.000

* = is significant at the 0.05 level (2-tailed)

** = is significant at the 0.01 level (2-tailed)

A = Atmospheric temperature, B = Water temperature, C = pH, D = Dissolved oxygen, E = Carbondioxide, F = Alkalinity, G = Hardness, H = Calcium, I = Magnesium, J = Chlorine, K = Salinity, L = Nitrite, M = Phosphate, N = Silicon, O = Sulphates, P = Total solids, Q = Organic matter, R = Biological oxygen demand, S = Chemical oxygen demand

Online Copy

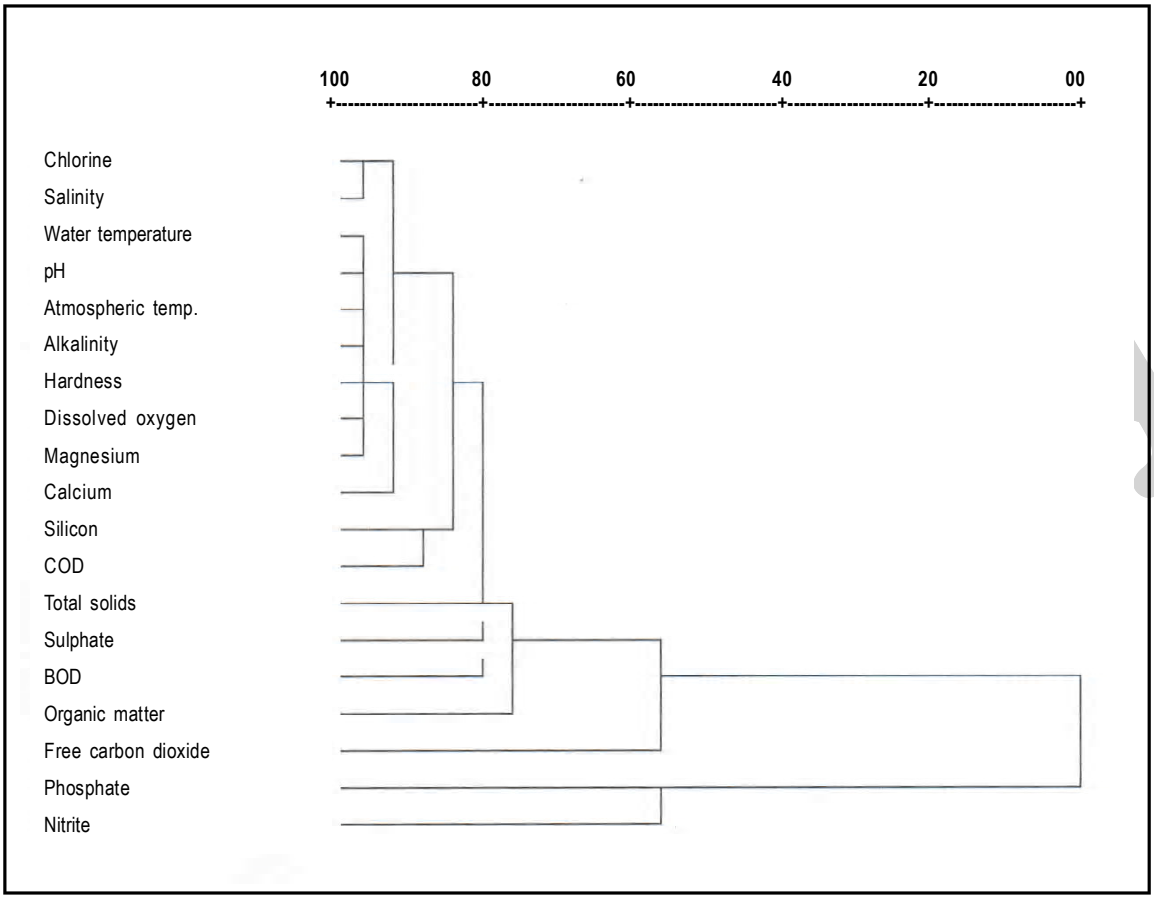

Fig. 1: The dendrogram of percentage similarity in physico-chemical factors in Bhalki tank Bhalki

micro-organisms. Similar observation was also made by Shastri and Pendse (2001) in Dahikuta reservoir, Nasik.

The lowest alkalinity was observed during winter and the highest in monsoon due to decomposition of organic matter in the water body. The minimum hardness was found during the monsoon due to utilization of carbonates as a source of carbon by phytoplankton. Swarnalatha and Rao (1998) have also recorded similar observation in Banjara lake, Hyderabad. The maximum hardness was in the monsoon due to run off carried from the surrounding areas. The lowest content of calcium was during the winter due to luxuriant growth of phytoplankton in the water body. The highest content was in the monsoon due to carry of Ca along with run off. Similarly Das (2002) has also recorded an increase of Ca in reservoirs of Andra Paradesh. The lowest Mg concentration was noticed during monsoon and the highest was in the summer. It was due to evaporation by high atmospheric temperature. The lowest and highest content of Cl and salinity were noticed during the summer. Similarly the highest concentration of Cl has been also observed by Raghavendra and Hosmani (2002), Das (2002) and salinity by Govindasamy *et. al.* (2000).

The least concentration of nitrite was found during winter due to increase of primary productivity of phytoplankton and utilization of nitrite as nutrient. The highest concentration of nitrite was recorded in the summer season. The lowest concentration of phosphate was assessed during the summer due to uptake of phosphate by algal bloom. The minimum concentration of silicon was found during winter. The highest content was during the monsoon due to death and decomposition of diatom. Similarly Govindasamy *et al.* (2000) have also recorded similar finding in their study. Both lowest and highest concentrations of sulphates were recorded during the summer months. Similar findings are also observed in the work of Agarkar and Garode (2000).

The lowest total solids content was estimated during the summer due to utilization of minerals for luxuriant growth of phytoplankton. The maximum concentration was recorded during the monsoon due to addition of solids by runoff. Similar observations were also found by Sachidanandamurthy and Yajurvedi (2004). The minimum content of organic matter was recorded in the summer and the maximum during the winter. The minimum BOD was noticed during the winter due to decrease in temperature which leads to decrease in microbial activity and algal bloom. Similar observation has also been made by Raghavendra and Hosmani (2002) and Sachidanandamurthy and Yajurvedi (2004). The highest BOD was recorded during the monsoon due to eutrophication in the water body. The total absence of COD was observed during monsoon and winter and the highest was in the summer season.

The statistical analysis of Pearson's correlation coefficient is presented in Table 2. The study of correlation coefficient between various physico-chemical factors indicated that water temperature varied with the variation of atmospheric temperature. Increase of temperature caused the high evaporation in the water body and leads to increase in concentrations of Mg and salinity. The rise of carbonate and bicarbonate concentrations increased the level of pH with an increase of temperature. Increase of Cl concentration was due to high evaporation in the water body (Raghavendra and Hosmani, 2002). The reaction between free CO_2 and water molecule gives carbonate and bicarbonate and are also dependent on other elements. Such process might use Mg content to produce $MgCO_3$ and enhance pH (Shastri and Pendse, 2001) and decrease CO_2 content (Naresh and Nama, 1991; Mukhopadhyay, 1996). Alkalinity enhances the decomposition of organic matter, which inturn increases concentrations of nitrite, phosphate and BOD. The abundant Ca and Mg are responsible for an increase of hardness (Prasad and Manjula, 1980; Das, 2002) and a negative relation of pH with the former is also evident. Mg, Cl and salinity were fluctuated together in the studied water body (Kumar, 1994). Significant positive correlation coefficients between phosphate and nitrate (Katiyar and Belsare, 1997) and also with organic matter were found. The BOD with nitrite (Rao *et al.*, 1993) and silicon with COD have shown very close positive relationship with one another. Ca and silicon have shown negative relation with nitrite and alkalinity respectively and similar relation was also found between COD and CO_2 in the water body during the study period.

The dendrogram of percentage similarity of physico-chemical factors is presented in Fig. 1. The study of similarity of physico-chemical factors from 75 to 95% is carried out to note close relation in fluctuation of factors as cluster. The Cl, salinity, water temperature, pH, alkalinity, hardness, dissolved oxygen, Mg have shown highest similarity and considered as dominant factors of the water body. Factors at 92% similarity cluster *viz.* hardness with calcium as a dependent factors and Cl as an independent factor, at 88% similarity cluster by silicon with COD as dependent factors, at 84% similarity cluster by silicon with pH as dependent factors, at 80% similarity cluster by hardness with total solids as dependent factors and sulphate and BOD as independent factors and at 76% similarity cluster by total solids with organic matter as dependent factors in the water body. The factors like Cl, pH, hardness, silicon, total solids and sulphate are inter linked factors with one cluster to the other are considered as key factors to bring any changes in the water body.

The concentrations of pH, hardness, Ca, Cl, salinity, nitrate, phosphate, total solids and organic matter were increased during consecutive year compared to first year of the study period. This is an indication of increase in pollution load by influx of domestic sewage in the water body. The study reveals that concentrations of pH, hardness and nitrite were more compared to the standard of drinking water quality of WHO and directly affect on the quality of life. It also indicates that the oligotrophic water body is slowly changing as mesotrophic and in future may change as eutrophic. There is an urgent need to control the discharge of domestic sewage and other domestic activities to restore the potability and also having high aqua-cultural potentials in the water body for the benefit of mankind of Bhalki town.

Acknowledgments

The authors are indebted to late Dr. S.B. Angadi, Reader, Dept. of Botany, for his valuable guidance. We also thank The Head of the Dept. of Botany, Gulbarga University, Gulbarga, Karnataka for providing the facilities.

References

Agarkar, S.V. and A.M. Garode: Evalution of physico-chemical and microbiological parameters of Vyazadi reservoir water. *Indial Hydrobiol.*, **3**, 3-5 (2000).

Agarkar, S.V. and A.M. Garode: Physcio-chemical and microbiological aspects of Sakegaon reservoir water. *Indian Hydrobiol.,* **4**, 65-69 (2001).

Aneja, K.R.: Experiments, in Microbiology, Plant pathology, Tissue culture and Mushroom cultivation. 2nd Edn. Wishwa Prakashan, New Delhi (1996).

Angadi, S.B., B. Lingannaiah and S. Eshwarlal: Limnological studies of Jagat tank, Gulbarga. Fresh water ecosystem of India, Daya Pub., New Delhi. pp. 133-159 (1999).

Angadi, S.B., N. Shiddamallayya and P.C. Patil: Limnological studies of Papnash pond, Bidar (Karnataka). *J. Environ. Biol.,* **26**, 213-216 (2005).

APHA.: Standard methods for the estimation of water and waste water. American public health association. American Wastewater Association and Water Pollution Control Federation. 21st Edn., Washington DC (2005).

Bharati, S.G. and S.P. Hosmani: Limnological studies in ponds and lakes of Dharwad, Part-III. Occurance of two Englenoid blooms. *IBID*, **20**, 151-156 (1975).

Das, A.K.: Phytoplankton primary production in some selected reservoirs of Andra Pradesh. *Geobios.*, **29**, 52-57 (2002).

Eshwaralal, S. and S.B. Angadi: Primary productivity of two freshwater bodies of Gulbarga, India. *Nat. Environ. Pollut. Tech.,* **1**, 151-157 (2002).

Govindasamy, C., L. Kannan and J. Azariah: Seasonal variation in physico-chemical properties and primary production in the coastal water biotopes of Coromandel coast, India. *J. Environ. Biol.,* **21**, 1-7 (2000).

Gupta, P.K.: Methods in Environmental Analysis Water, Soil and Air. AGROBIOS (India) (2001).

Hegde, G.R.: Limnological studies of temple ponds of Dharwad, Karnataka state. Proc. Nat. Symp. Past, present and future of Bhopal lakes.Bhopal University, Bhopal. pp. 247-252 (1988).

Hosmani, S.P. and S.G. Bharati: Composit trophy index (CTI) as a measure of water pollution. *Comp. Physiol. Ecol.,* **12**, 71-73 (1987).

Indra, V. and S. Sivaji: Metals and organic compounds of sewage and sludges. *J. Environ. Biol.*, **27**, 723-725 (2006).

Katiyar, S.K. and D.K. Belsare: Limnological studies on Bhopal lakes: Freshwater protozoan communities as indicators of organic pollution. *J. Environ. Biol.,* **18**, 271-282 (1997).

Krishnan, R. Radha, K. Dharmaraj and B.D. Ranjitha Kumari: A comparative study on the physicochemical and bacterial analysis of drinking borewell and sewage water in the three different places of Sivakasi. *J. Environ. Biol.*, **28**, 105-108 (2007).

Kumar, A.: Periodicity and abundance of Rotifers in relation to certain physico-chemical characteristics of two ecologically different ponds of Santhal, Paraganas (Bihar). *Ind. J. Ecol.,* **21**, 54-59 (1994).

Kumari, S. Binu, A. Kavitha Kirubavathy and Rajammal Thirumalnesan: Suitability and water quality criteria of as open drainage municipal sewage water at coimbatore, used for irrigation. *J. Environ. Biol.*, **27**, 709-712 (2006).

Online Copy

Mali, K.N. and S.C. Gajaria: Assessment of primary productivity and hydrobiological characterization of a fish culture pond, Gujarat. *Indian Hydrobiol*., **7**, 113-119 (2004).

Mukhopadhyay, S.K.: Limnological investigations in lotic and lentic freshwater bodies in and around Darjeeling, West Bengal, India.*Geobios*., **23**, 101-106 (1996).

Nagarathna and S.P. Hosmani: Factors influencing the bloom of *Nitzschia obtusa* in a polluted lake. *India J. Environ. Ecoplan.,* **6**, 223-227 (2002).

Naresh, V. and H.S. Nama: Pollution ecology of fresh water reservoir at Jodhpur, with special reference to microorganisms. *Geobios.,* **18**, 33-37 (1991).

Prasad, B.N. and S. Manjula: Ecological study of blue-green algae in river Gomati. *Indian. J. Environ. Hlth.,* **22**, 151-168 (1980).

Raghavendra and S.P. Hosmani: Hydrobioloical study of Mandakally lake, A polluted waterbody at Mysore. *Nature Environ. Pollut. Tech.,* **1**, 291-293 (2002).

Rao, V.N.R., R. Mohan, V. Hariprasad and R. Ramasubramanian: Seasonal dynamics of physico-chemical factors in a tropical high altitude lake: An assessment in relation to phytoplankton. *J. Environ. Biol.,* **14**, 63-75 (1993).

Sachidanandamurthy, K.L. and H.N. Yajurvedi: Monthly variations in water quality parameters (physico-chemical) of a Perennial lake in Mysore city. *Indian Hydrobiol*., **7**, 217-228 (2004).

Shastri, Y. and D.C. Pendse: Hydrobiological study of Dahikhuta reservoir. *J. Environ. Biol.,* **22**, 67-70 (2001).

Simon, A.T.: Seasonal evaporative concentration of an extremely turbid water-body in the semiarid tropics of Australia. *Lakes Reserv. Res. Manage.,* **7**, 103-107 (2002).

Swarnalatha, P. and A.N. Rao: Ecological studies of Banjara lake with reference to water pollution. *J. Environ. Biol.,* **19**, 179-186 (1998).

Trivedy, R.K. and P.K. Goel: Chemical and biological methods for water pollution studies. Environmental Publication, Karad. India (1986).

Vijay Kumar, K. and R. Paul: Physico-chemical studies of the Bhosga reservoir in Gulbarga, Karnataka. *J. Ecobiol.,* **2**, 320-335 (1990).

Online Copy