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An Assessment of the Pollution and its Impact on the Diversity of Phytoplankton in Tirur River, Malappuram District, Kerala, India

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A B S T R A C T

The present study focuses on the pollution and its impact on the phytoplankton in Tirur River, Malappuram District, Kerala, India. The water quality was investigated for a period of six months from January to June 2015. The surface water samples were collected monthly from the three sites of Tirur River namely Tirur, Thazhepalam and Parapadi of Tirur River, which lies between 75^0 55′ and 75^0 54′ East longitude and 10^0 55′ and 10^0 54′ North latitudes. The physico-chemical parameters analyzed were temperature, pH, acidity, alkalinity, total hardness, calcium hardness, magnesium hardness, chloride, salinity, dissolved oxygen (DO), nitrate, sulphate, biochemical oxygen demand (BOD) and chemical oxygen demand (COD) and their correlations were discussed. The physico-chemical parameters showed distinct seasonal and spatial fluctuations. 57 species of phytoplankton were identified during the period of study from the Tirur River which come under 29 genera belonging to four taxonomic classes namely Cyanophyta, Chlorophyta, Bacillariophyta and Euglenophyta. The salinity was higher in Tirur River during the period of study and the diversity of phytoplankton showed a number of marine diatoms during the pre-monsoon season. The class Bacillariophyceae (Diatoms) was the dominant group of algae in all the three sites of Tirur River throughout the period of study. The present study identified 11 pollution tolerant algal genera namely *Lyngbya, Oscillatoria, Cocconeis, Cyclotella, Cymbella, Melosira, Navicula, Nitzschia, Stauroneis, Synedra* and *Euglena* and it revealed that the quality of the water was deteriorated at all the selected three sites in the Tirur River and are polluted due to human interventions. The analysis of physico-chemical parameters indicated that the water quality of Tirur River was deteriorated at all the three sites studied during the period of study and the contaminants came from fish market and railway station.

Introduction

The phytoplankton helps in the determination of the impact of pollutants on the aquatic environment because any effect on the lower level of the food chain will also have consequence on the higher level organisms. The algae are used for assessing

the degree of pollution and as a water pollution indicator (Palmer, 1969).

Pollution of the major rivers of India through discharge of industrial effluents and domestic sewage are the major threat in recent times (Singh *et al.*, 2007). The biological communities change with the change in the environment in which they occur. The relative proportion of abundance of the species in a community often provides a good indication of pollution (APHA, 1998).

The physico-chemical aspects of river water was reported by Gurumayum *et al.* (2001, 2002), Deshmukh and Ambore (2006), Santhosh (2007), Yazdandoost and Katdare (2001a) and Eknath (2013). A number of scientific papers reported the existing status of Indian rivers and are in a dangerously deteriorated situation due to pollution (Biswas and Konar, 2000; Kumari and Rani, 2008; Singh *et al.*, 2007; Yazdandoost and Katdare, 2001b). Selakoti and Rao (2015) conducted a study on the seasonal fluctuations in physico-chemical variables in Kosi River. The river water resources in Kerala state are subjected to substantial stress due to changes in riverine ecology (Joy *et al.*, 1990; Koshy and Nayar, 2001; Sankar *et al.*, 2002; Harilal *et al.*, 2004; Joseph and Tessy, 2010; Thomas and Paul, 2015). Tirur River, also called Tirur - Ponnani River act as a water resource for the Tirur town, Malappuram District. Tirur River is rising from the Athavanad Village of Tirur Taluk, flows south - west up to Elamkulam in the north western direction, then turns to south west and finally joins Bharathapuzha to reach Arabian Sea near Ponnani. Length of the river is 48 km.

Materials and Methods

The present study was conducted in Tirur River at three sites namely Tirur (S_1), Thazheppalam (S_2) and Parapadi (S_3) between the Tirur railway station and the Parapadi colony. It lies in between 75^0 55′ and 75^0 54′ East longitude and 10^0 55′ and 10^0 54′ North latitudes. The water samples were collected monthly from these selected sites for a period of six months from January to June, 2015.

The surface water samples were collected monthly for a period of six months from January to June 2015. The temperature and pH of water samples were noted by standard methods on the spot at the time of collection. The water for the determination of dissolved oxygen (DO) were collected and fixed on the spot. The physico-chemical parameters namely acidity, alkalinity, calcium hardness, magnesium hardness, total hardness, chloride, salinity, nitrate, sulphate, biochemical oxygen demand (BOD) and chemical oxygen demand (COD) were analyzed by standard methods (APHA, 1998).

One litre water samples were collected for the phytoplankton analyses and were preserved immediately in 4 % formalin solution and brought to the laboratory. The samples were concentrated to 50 ml and the number of phytoplankton per litre was counted. Sedgwick-Rafter (S-R) cell method was used for counting the phytoplankton (APHA, 1998). The data obtained were analyzed season wise as pre-monsoon, monsoon and post-monsoon.

Results and Discussion

The study revealed that the water quality parameters fluctuated with sites and seasons (Table 1 and Fig.1a-n). The growth and reproduction of phytoplankton are influenced by physico-chemical characters of water (APHA, 1998). The analysis of physico - chemical parameters of water indicated that the water of Tirur River was

deteriorated and showed distinct seasonal fluctuations. The pollution was severe during pre-monsoon season (February to May) and the pollution was minimized in June due to the rainfall (Table 1).

The temperature is one of the vital factors that control the abundance of phytoplankton. The increase in water temperature leads to the speeding up of chemical reactions in water, reduces the solubility of gases and amplifies the taste and odours. Temperature is also an important factor in the determination of various other parameters such as pH, conductivity and alkalinity (Trivedy *et al.*, 1998). The wastewater discharge from the industries and settlements and microbial decomposition of organic matter, present in the surface water bodies, are the alkalinity inducing components. High alkalinity in river water indicates high pollution load (Koshy and Nayar, 2001).

The hardness of water was comparatively high and is mainly due to calcium and magnesium salts. According to BIS (2012) the desirable limit of hardness for drinking water was 200 mg/L and permissible limit of hardness was 600 mg/L. The present study revealed that the total hardness of water in three sites were exceeded the desirable limit except during April and June (Table 1 and Fig. 1e). According to Ramachandra and Ahalya (2001) the water hardness up to 60 mg/L is soft, 61 - 120 mg/L is moderately hard, and 121 - 180 mg/L is hard and above 180 mg/L is very hard for drinking water. Here the mean value shows very hard water during the period of study.

The value of nitrate ranged from 0 mg/L to 42.53 mg/L (Table 1 and Fig. 1j). Nitrate is one of the critical nutrients for the growth of algae and help in accelerating eutrophication. The present study showed that the COD values ranged from 25.6 mg/L to 381 mg/L. The BOD determines the level of organic pollution in the river system. The high value of COD indicate the presence of non-biodegradable oxygen demanding pollutants in the water.

The correlation between the different parameters for the three sites were studied. The total hardness showed significant and positive correlation with calcium, magnesium and nitrate in all the three sites studied. The total hardness also showed significant and positive correlation with chloride, salinity and acidity at site 3. The sulphate showed significant negative correlation with pH at site 3. The salinity showed significant positive correlation with total hardness and calcium at site 3 and with magnesium at site 1 and 3.

The COD is positively and significantly correlated with alkalinity at site 1, with calcium and nitrate at site 2, with acidity at site 3 and with total hardness at site 2 and 3. Magnesium showed significant and positive correlation with COD in all the three sites studied.

The chloride at site 1 and 3 and acidity at site 2 and 3 indicated significant positive correlation with Magnesium. The magnesium showed significant positive correlation with alkalinity ate site 1, with calcium at site 2 and with nitrate at site 3. The calcium revealed significant positive correlation with acidity and chloride at site 3. The nitrate showed significant positive correlation with calcium and magnesium at site 2 and with acidity and calcium at site 3.

During the present study 57 species of phytoplankton belonging to 29 genera coming under four taxonomic divisions namely Cyanophyta, Chlorophyta, Bacillariophyta and Euglenophyta were

identified from the Tirur River, Malappuram district, Kerala. Out of the 57 algal taxa recorded, 39 belong to Bacillariophyceae, 14 to Cyanophyceae and 2 each to Chlorophyceae and Euglenophyceae (Table 2).

Bacillariophyceae (diatoms) was the major group comprised 39 taxa (68.4%) belonging to 20 genera followed by Cyanophyceae (blue green algae) represented by 14 taxa (24.6%) belonging to 7 genera. Chlorophyceae (green algae) and Euglenophyceae was represented by 2 taxa (3.5%) each belonging to 1 genera each (Table 2 and Fig. 3).

The abundance of phytoplankton were very less in number at all sites during February (Fig. 2). In the pre-monsoon season especially in May abundance of phytoplankton was high and the highest number of Bacillariophyceae was obtained at the site 2. The quantitative assessment of phytoplankton (Organisms/L) in the study area was recorded in Table 3.

Bacillariophyceae (Diatoms) was the dominant group of algae in Tirur River during the period of study (Fig. 4). The diatoms are ecologically resistant and are highly adapted to riverine environment. The phytoplankton showed fluctuations due to monsoon and more number of phytoplankton was found during pre-monsoon season (Fig. 5-7). The *Euglena* was recorded at site 1 during pre-monsoon (Fig. 6a) and monsoon (Fig. 7a) and it is a pollution indicating organism (Palmer, 1969). At site 2 comparatively more number of Chlorophyceae (17.9%) was recorded during monsoon (Fig. 7b).

Phytoplankton strongly influences certain non-biological aspects of water quality and they are a part of water quality (APHA, 1998). The phytoplankton responsible for the process of primary production in water bodies and also forms a vital source of energy. They serve as a tool for assessing the health of the aquatic ecosystem. The high concentration of nutrients in water resources increases the growth of algae and triggers eutrophication.

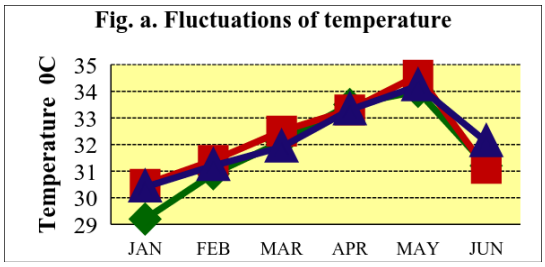
Based on Palmer (1969) eleven pollution tolerant algal genera namely *Lyngbya, Oscillatoria, Cocconeis, Cyclotella, Cymbella, Melosira, Navicula, Nitzschia, Stauroneis, Synedra* and *Euglena* were identified from the study area during the present investigation. The phytoplankton responds quickly to the environmental changes and hence the species composition of phytoplankton indicates the water quality (APHA, 1998). These algal species are the indicators of pollution in Tirur River. The present water quality studies of Tirur River also revealed that the quality of the river water was deteriorated during the period of study.

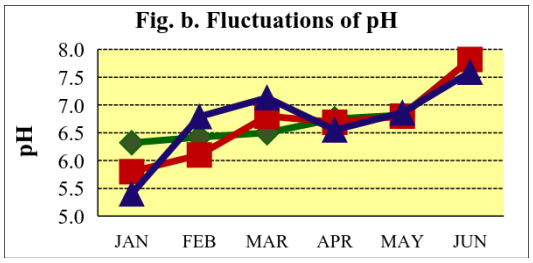
The most dominant phytoplankton genera in Indian River system are *Oscillatoria, Nitzschia, Navicula, Synedra* and *Melosira*. The Ithikkara River in Kerala showed the predominance of diatoms as reported by Sheeba and Ramanujan (2005). The *Nitzschia*, *Navicula* and *Cymbella* were the dominant diatom taxa in Periyar River (Joy *et al.*, 1990). During the period of investigation Bacillariophyceae members were dominant in all the sites followed by Cyanophyceae except in site 2 during June (Fig. 7a).

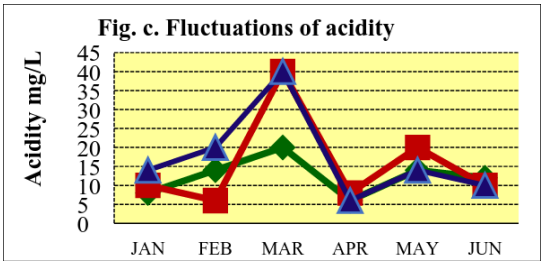
Table.1 Seasonal fluctuations of physico-chemical parameters in Tirur River

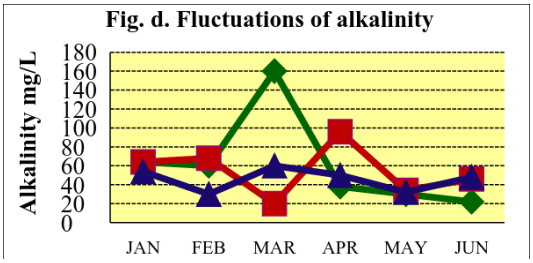
Sl. No:	Parameters	Site No:	Pre-Mon	Mon	Post Mon	MIN	MAX	MEAN	SD	Permissible limit (BIS, 2012)
1	Temperature ^{o}C	1	29.2	32.63	31.2	29.20	34.00	31.82	1.77	-
		2	30.5	32.95	31.1	30.50	34.60	32.23	1.54	
		3	30.4	32.65	32.1	30.40	34.20	32.18	1.38	
2	pH	1	6.32	6.62	7.81	6.32	7.81	6.77	0.54	6.5 - 8.5
		2	5.8	6.60	7.82	5.80	7.82	6.67	0.70	
		3	5.4	6.83	7.59	5.40	7.59	6.72	0.74	
3	Acidity mg/L	1	8	13.50	12	6	20	12.33	4.97	-
		2	10	18.50	10	6	40	15.67	12.86	
		3	14	20.00	10	6	40	17.33	12.04	
4	Alkalinity mg/L	1	64	72.00	22	22	160	62.33	50.62	600
		2	64	54.50	46	20	96	54.67	27.12	
		3	54	43.00	48	30	60	45.67	12.09	
5	Total hardness mg/L	1	710	988.50	50	50	1830	785.67	720.97	600
		2	830	1130.00	36	36	2580	897.67	944.05	
		3	920	1132.50	40	40	2440	915.00	898.44	
6	Calcium mg/L	1	165.13	215.78	8.02	8.02	497.00	172.71	178.42	200
		2	220.22	262.59	7.21	7.21	513.50	212.96	184.56	
		3	238.1	261.57	8.82	8.82	497.00	215.54	180.07	
7	Magnesium mg/L	1	72.41	109.11	7.29	7.29	218.70	86.02	82.05	100
		2	68.04	128.81	7.29	7.29	315.50	98.43	113.79	
		3	79.22	128.18	4.37	4.37	291.60	99.39	104.88	
8	Chloride mg/L	1	4640	4917.00	190	190	7300	4083.00	3009.09	1000
		2	6440	5631.00	120	120	7900	4847.33	3522.15	
		3	5410	7234.50	148	148	10600	5749.33	4562.68	
9	Salinity ppt	1	8.38	8.89	0.34	0.34	13.19	7.38	5.44	-
		2	11.63	10.17	0.22	0.22	14.27	8.76	6.36	
		3	9.77	13.07	0.27	0.27	19.15	10.39	8.24	
10	Nitrate mg/L	1	3.97	12.21	1	0.50	20.65	8.97	8.65	45
		2	1.35	18.95	1	0.00	42.53	13.02	16.97	
		3	1.06	16.87	1.1	0.00	42.31	11.60	16.83	
11	Sulphate mg/L	1	821	33.38	37	12.5	821	165.25	321.67	400
		2	816	71.13	25	25.0	816	187.58	313.81	
		3	842	78.88	33	7.0	842	198.42	325.23	
12	DO mg/L	1	0.1	0.06	0.2	0.03	0.20	0.09	0.06	-
		2	0.03	0.08	0.16	0.02	0.20	0.08	0.08	
		3	0.05	0.05	0.34	0.02	0.34	0.10	0.12	
13	COD mg/L	1	152	167.30	26.4	26.4	367	141.27	126.02	-
		2	136	164.70	25.6	25.6	381.00	136.73	130.45	
		3	116	116.45	27.2	27.00	316.00	101.50	110.01	
14	BOD mg/L	1	0.08	0.03	0.072	0.01	0.08	0.05	0.03	-
		2	0.03	0.05	0.064	0.02	0.13	0.05	0.04	
		3	0.04	0.04	0.021	0.01	0.08	0.04	0.02	

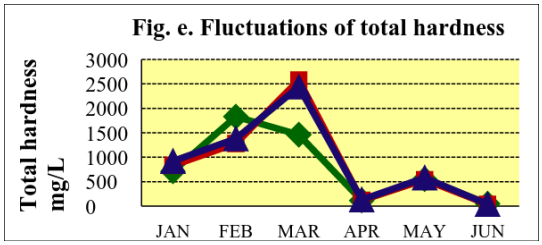
Fig.1 (a - n). Fluctuations of physico-chemical parameters in Tirur River

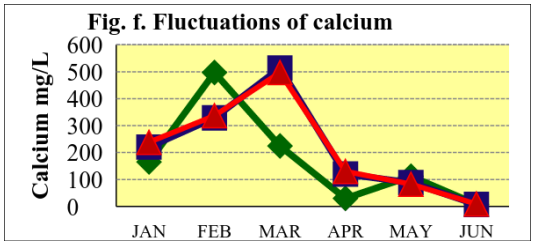


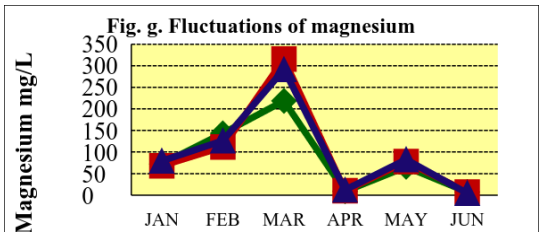


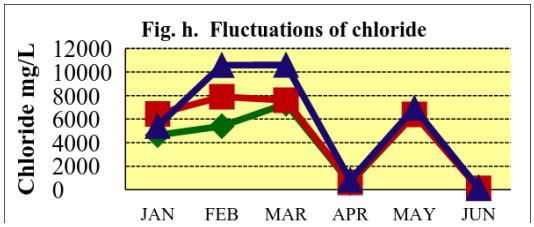


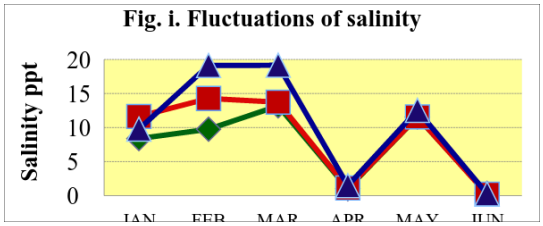


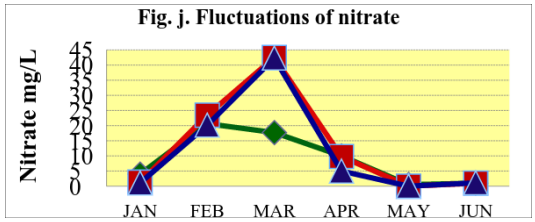


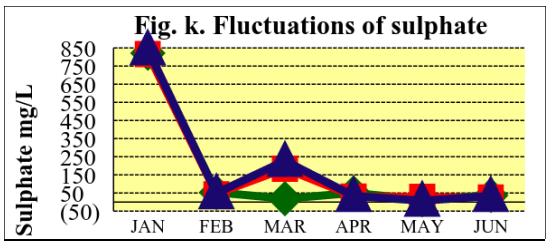


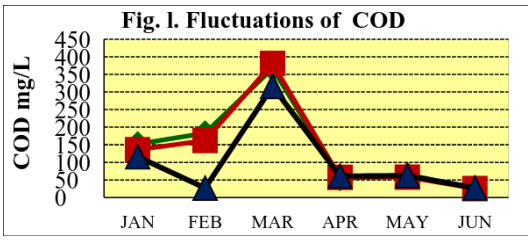












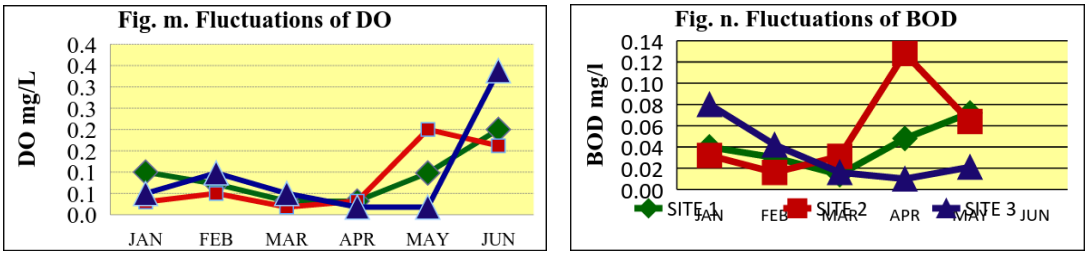


Fig.2 Monthly distribution of total phytoplankton in Tirur River

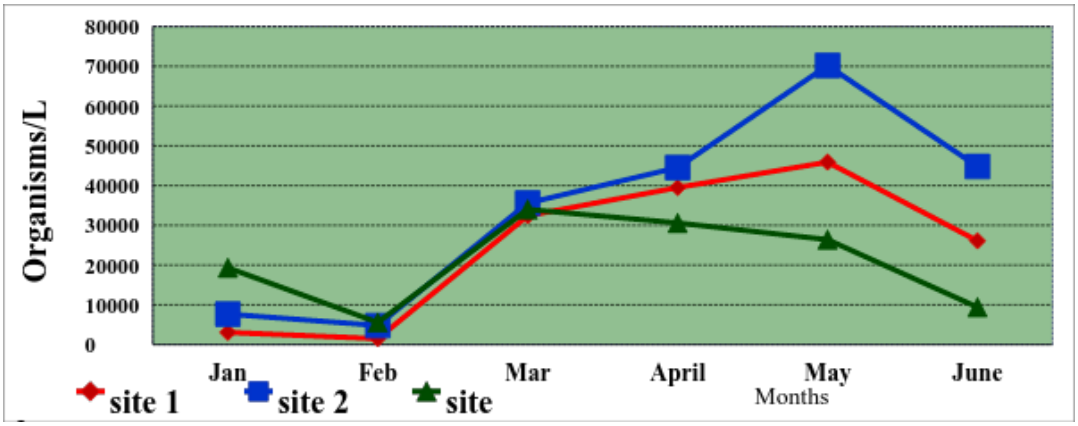


Fig.3 Biodiversity of phytoplankton

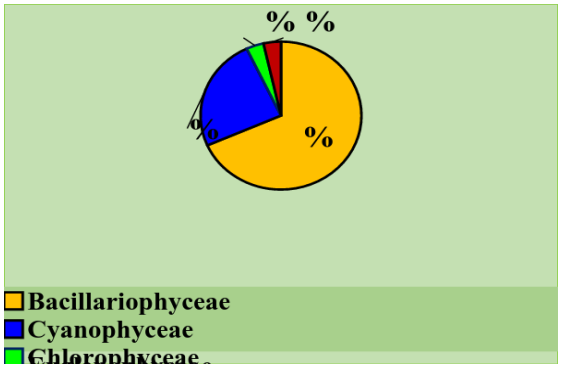


Fig.4 Quantitative assessment of phytoplankton

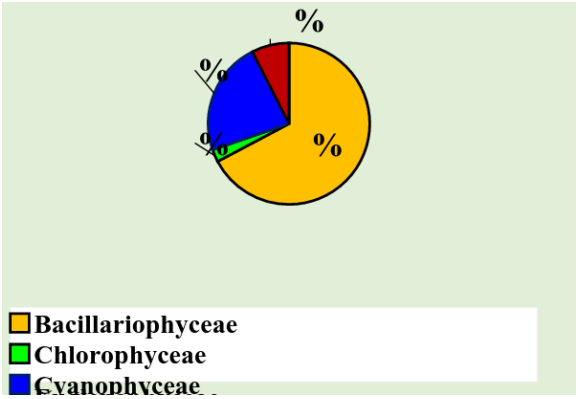


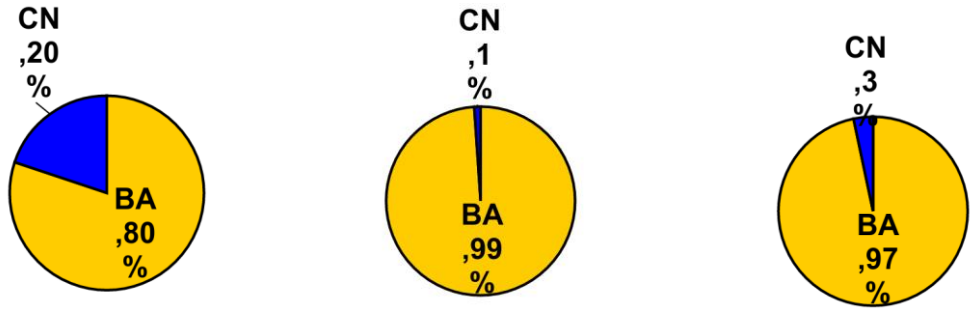
Table.2 Phytoplankton diversity in Tirur River

Sl. No	Algal class	No: of genera	No: of species	%
1	Cyanophyceae	7	14	24.6
2	Chlorophyceae	1	2	3.5
3	Bacillariophyceae	20	39	68.4
4	Euglenophyceae	1	2	3.5
Total		**29**	**57**	**-**

Table.3 Analysis of phytoplankton abundance in Tirur River (Organisms/L)

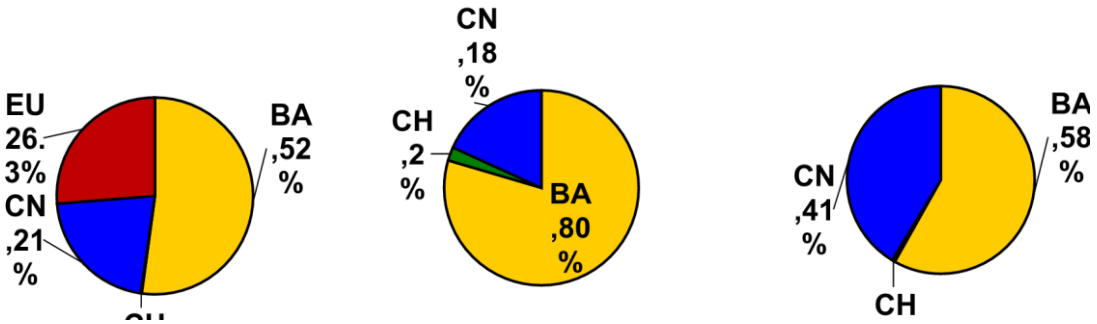
Algal Class	Site No:	Range	Mean	SD	%
Bacillariophyceae	1	960-32700	12520	11528	49.6
	2	4800-55300	27855	18949	80.3
	3	2770-25700	14042	8091	66.9
Chlorophyceae	1	0-200	33	82	0.1
	2	0-8000	1917	3252	5.5
	3	0-500	83	204	0.4
Cyanophyceae	1	520-16600	6647	6802	26.3
	2	83-14900	4897	5773	14.1
	3	400-19500	6873	7340	32.7
Euglenophyceae	1	0-29400	6050	11576	24.0
	2	-	-	-	-
	3	-	-	-	-

Fig.5 Seasonal analysis of phytoplankton during post-monsoon



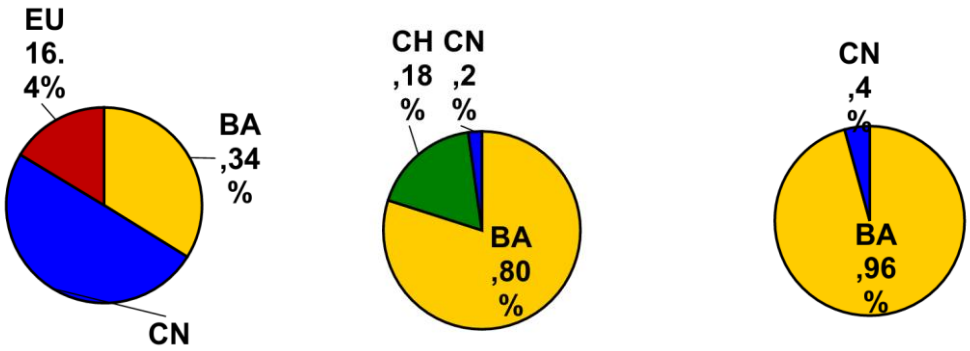
(a) Site 1 **(b) Site 2** **(c) Site 3**

Fig.6 Seasonal analysis of phytoplankton during pre-monsoon



(a) Site 1 **(b) Site 2** **(c) Site 3**

Fig.7 Seasonal analysis of phytoplankton during monsoon



(a) Site 1 **(b) Site 2** **(c) Site 3**

Algae are frequently found in polluted and unpolluted water and due to this behaviour they are generally considered useful to determine the quality of water. Phytoplankton was used for assessing the degree of pollution or as indicator of water pollution of different water bodies (Trivedy, 1986; Sudhaker *et al*., 1994).

Synedra, *Melosira*, and *Nitzschia*, were the diatoms highly resisted to pollution and they dominate depending upon the severity of the pollution level. These diatom genera were reported from the study area. From the investigation it is concluded that all the three sites studied were polluted and the physico-chemical parameters have profound influence on the abundance of phytoplankton in Tirur River.

In conclusion, the present study reveals that the selected three sites in the Tirur River were polluted due to human interventions. The pollution was severe during pre-monsoon and post-monsoon seasons. In the present investigation pH, total hardness, calcium hardness, magnesium hardness, chloride, salinity, sulphate, DO, COD and BOD were not within the permissible limit and desirable limit in all the three sites

studied except nitrate and BOD. The saline content in water was high in all three sites, contaminants came mainly from fish market and railway station.

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