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RESEARCH ARTICLE

DISTRIBUTION OF PHYTOPLANKTON IN RELATION WITH WATER QUALITY OF ALAPPUZHA – CHANGANASSERRY CANAL OF KUTTAND WETLAND ECOSYSTEM, SOUTHERN INDIA

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ABSTRACT

The distribution and diversity of phytoplankton in relation with the water quality of Alappuzha – Changanasserry canal in the Kuttanad wetland ecosystem, part of Vembanad Kol Ramsar site in Kerala was assessed in the present study. The results showed that in total, 78 species were recorded from the whole stretch of the canal. Out of these, 39 species belonged to *Chlorophyceae,* 1 species of *Chrysophyceae,* 15 species of *Bacillariophyceae,* 10 species of *Eugleninae* and 15 species of *Myxophyceae* were recorded. *Anabaena utermohli* (47992/l organisms) *Anabaenopsis arnoldii var. indica* (46680 organisms/l) of *Myxophyceae* were abundant followed by *Melosira granulata* (13032 organisms) of *Bacilariophyceae.* Nitrate nitrogen showed high positive correlation with all phytoplankton group which indicates that nitrate is one of the major controlling parameter of the phytoplankton standing biomass. Phosphate is the most important controlling factor responsible for the growth of *Euglenophyceae* and *Cyanophyceae* members resulting in Euglenoid blooms. *Dinobryon sociale* is an indicator of clean water algae which is present only at the pollution free sites of the canal.

INTRODUCTION

Water is the elixir of life, as there can be no life without water. It is an important natural resource which is abundant in nature and covers about two thirds of the earth's surface. Fresh water is a finite source, essential for agriculture, industry and even human existence. Without fresh water of adequate quantity and quality sustainable development will not be possible. But the world's water resources are under pressure and in danger because of potential pollution and contamination risks due to over use and misuse of the resources. Many natural water bodies in India receive millions of litres of wastewater and agricultural run off, with different concentrations of pollutants in varying forms. Pollution results in the degradation of physico –chemical as well as biological quality of water. The presence of plants and animals, or lack of them is used as biological indicators of pollution (Palmer, 1980). Phytoplanktons, which include green algae, blue green algae, diatoms, desmids, euglenoids etc., are important among aquatic flora. They are ecologically significant as they form the basic link in the food chain of all aquatic animals (Misra *et al.,* 2001). When in large numbers they make the water greenish. Kuttanad, '*the rice bowl of Kerala'* is the deltaic formation of five major river systems like Achenkovil, Pamba, Manimala, Meenachil and Muvattupuzha. It is a highly complex and dynamic wetland ecosystem frequently flooded during monsoon periods. Rice cultivation is the major agricultural activity in this system. Kuttanad is polluted due to excessive use of fertilizers, pesticides and other chemicals and stagnation and flow reduction during summer. Alappuzha Changanassery (AC) canal - a manmade canal in Kuttanad wetland ecosystem forms a part of the Vemband - Kol Ramsar site. It was constructed without vision hindering the free water flow in the deltaic system. It is considered as a major engineering venture to connect several villages of Kuttanad to the highland. Now the canal and the road running along with it is a major cause for the inundation and flood in this part of Kuttanad. AC canal system originated during the road construction through the paddy fields. The canal was formed by the excavation of the mud all along the length to fill the road.

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The present study intends to understand the relation between physico-chemical properties and the distribution of phytoplankton communities in AC canal.

MATERIALS AND METHODS

The AC canal is a continuous mostly stagnant stretch of water body having a length of 11 km between Alappuzha and

Changanassery parellel to Alappuzha – Changanassery state highway (SH – 11). Both sides of the canal possess dense human habitation and the canal is used by the local people for their day-to-day activities. The canal is mainly fed by Manimala and Pamba rivers, besides a number of small canals carrying discharge from the agricultural fields join this main canal at its downstream sites. The mats of Eichhornia and other aquatic plants undergo periodic decomposition and the interspersed space and substrate support the periphytic and phytoplankton populations time to time.

Samples for the present investigation were collected from six different sites of AC canal during the period from February to June 2012. The sites were selected based on the characteristics of the area like the aquatic macrophytes community, degree of stagnation, and place of joining of side canals (Fig. 1).

Water samples were collected separately for physico-chemical and phytoplankton analysis. Physico-chemical parameters like water temperature, turbidity, pH, TDS, hardness, chloride, dissolved oxygen, sulphate, nitrate and phosphate were carried out as per standard methods (APHA, 1998). One litre of water sample was collected and fixed in Lugol's solution followed by 4% formalin as preservative.

The concentrated the sample were made into 20 ml by centrifugation and both qualitative and quantitative analysis was carried out under microscope. Drop count method (Adoni, 1985) was employed for quantitative estimation.

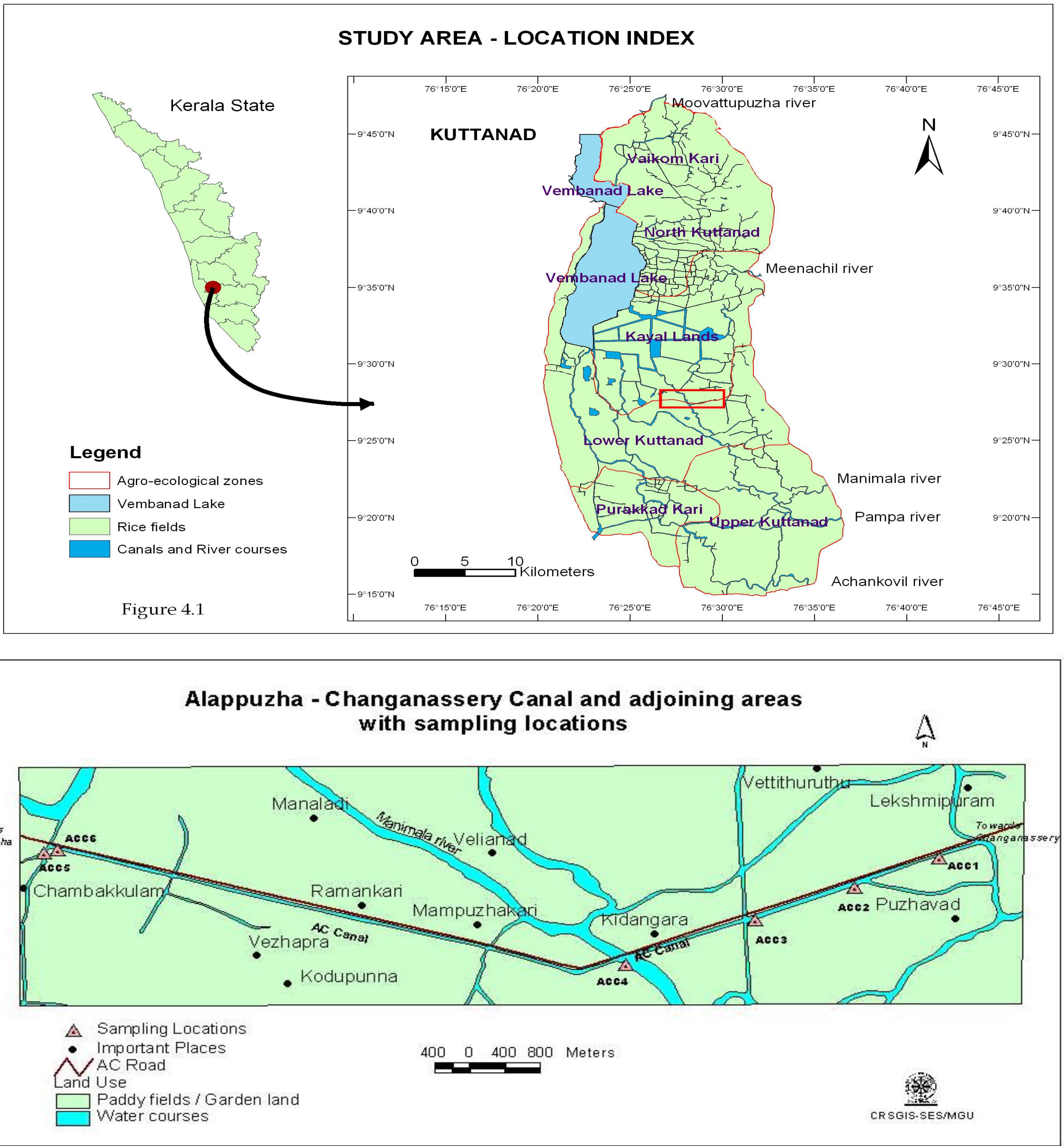

Fig. 1. Study area with sampling locations

RESULTS AND DISCUSSION

Physico – chemical parameters

From the study it was observed that the area experiences fairly uniform water temperature. Turbidity varied from 3.8 to 4.7 NTU in February, while in March it varied from 2.8 to 3.7 NTU. In April the turbidity increased to 9.3 NTU. During the present investigation all the stations remained acidic throughout the period of investigation. The lowest pH (5.6) was recorded in the month of March at Site-1. Neutral value recorded at sites 2 and 3 in the month of June. The lowest TDS (20 ppm) was noticed in the month of May at sites 3 and 4. The highest TDS value of 2046 ppm was observed in March at site - 6. Sites - 5 and - 6 registered higher values in comparison to that of the other sites except in June. June showed a narrow variation in TDS between the sites. The monsoon rainfall made a drastic reduction in TDS at all the stations except sites 3 and 4.

animal faeces, domestic sewage and discharge from agricultural fields.

Monthly variations in sulphate concentration showed different trends in different months. The minimum concentration of 1.6 mg/l was recorded from site – 4 in May, peak value of 36 mg/l was observed in the month of April at site - 6. The months of February and June showed narrow fluctuations in sulphate content between the stations where as, March, April and May recorded highly irregular pattern in the entire stretch of the canal. Enhanced values at site - 5 and - 6 may be due to fertilizers added in the nearby agricultural fields. Nitrate fluctuated during the different months and also between the sampling stations. The values increased from 0.09 mg/l to 6.94 mg/l in the study period. The minimum value recorded from the site 6 during the month of June and the maximum value recorded from the site 3 during the month of April. Nitrate nitrogen is one of the most important indicators of pollution of water.

Table 1. Sampling Stations, their, code, name and nature

S.No.	Code	Name	N Latitude	E Longitude	Nature
1.	Site-1	Manackachira	$9^0$26’3.9’’	$76^0$32’4.3’’	Stagnant water, luxuriant growth and overtopping of *Eichhornia crassipes* and *Ischaemum travancorense*, sewage from Changanassery municipality.
2.	Site-2	Poovam	$9^0$25’40.2’’	$76^0$30’58’’	Slow flowing due to the presence of thick submerged vegetation of *Cabombo caroliniana* and *Utricularia flexuosa*.
3.	Site-3	Deivamthara	$9^0$25’27.6’’	$76^0$30’22.1’’	Human habitation and continuous flow of water is observed.
4.	Site-4	Kidangara	$9^0$25’20.7’’	$76^0$28’14.1’’	Good flow and mixing of water observed through out the period due to the joining of Manimala river course.
5.	Site-5	Onnamkara	$9^0$25’47.2’’	$76^0$26’1.9’’	A major side canal carrying discharge from the nearby rice fields and joins the AC-Canal.
6.	Site-6	Thekkekara	$9^0$25’25.7’’	$76^0$26’5.7’’	The tail end of the AC-Canal and joining place of site-5 canal.

The DO showed different trends in its fluctuation during the different months and also between the sampling stations. The least DO (0.4 mg/l) was recorded at site - 1 in the month of Feb, while the maximum was observed at site - 2 in May. Greater levels of DO were noted in the months of March, April & May. This may be the result of enhanced production of algae in these months and subsequent increase in DO. Between the stations no regular pattern of fluctuation in DO level was observed. Total hardness showed drastic fluctuation in different months. It ranged from 442 mg $CaCO_3$/l in March at site - 6 to 12 mg $CaCO_3$/l at site - 1 in the month of February and site - 4 in the month of March. March recorded a wide range of fluctuation between the different stations. The same month recorded the maximum (442) and the minimum total hardness in the study period. June showed similar values in total hardness varying between 20 mg $CaCO_3$/l and 28 mg CaCO3/l. The dilution of water by the monsoon rainfall reduced the range in variation. Sites -5 and 6 recorded very high hardness (404 and 442 $CaCO_3$/l respectively) in the month of March. This might be due to the entry of discharge from nearby rice field containing addition of lime having calcium and magnesium ions. Chloride content in the canal ranged between 3.08 mg/l (site 2 in March) to 644.68 mg/l (site 6 in February). February registered peak values at all the stations. June did not show wide fluctuation in chloride concentration. Except in the month of June site - 5 and - 6 showed enhanced chloride content compared to the other stations. The increases of chloride at these sites clearly indicate the pollution through

The most important source of the nitrate is biological oxidation of organic nitrogenous substances, which came with sewage, industrial waste and discharge from agricultural fields or produced indigenously in water. The phosphate recorded its highest concentration (1.042 mg/l) at site - 5 in the month of June. The minimum concentration of phosphate noted in the study period was 0.022 mg/l in the month of April at site - 3. Wide range of variation in phosphate concentration was observed during the month of June. The values increased from 0.03 mg/l to 1.042 mg/l in the entire stretch of the canal in June. High phosphate content of silty flood water was observed by Vollenweider (1968). In the present study also most of the sites recorded higher values of phosphate in the month of June during the heavy rains.

Phytoplankton

The phytoplankton identified belong to the groups *Chlorophyceae, Chrysophyceae, Bacillariophyceae, Eugleninae* and *Myxophyceae (Cyanophyceae)*. In total, 78 species were recorded in the whole stretch of the canal. Out of these, 39 species belonged to *Chlorophyceae,* 1 species to *Chrysophyceae,* 15 species to *Bacillariophyceae,* 10 species to *Eugleninae* and 15 species to *Myxophyceae*.

Anabaena utermohli (47992 organisms/l) *Anabaenopsis arnoldii var. indica* (46680 organisms/l) of *Myxophyceae* was abundant followed by *Melosira granulata* (13032 organisms/l) of *Bacilariophyceae.* Based on their density *Myxophyceae* is placed first followed by *Bacillariophyceae, Chlorophyceae* and *Eugleninae. Dinobryon sociale* of *Chrysophyceae* is represented only in sites 2, 3 and 4.

Table 2. Distribution of physico-chemical parameters in AC Canal

Parameter	Months	Sites					
		I	II	III	IV	V	VI
Water Temperature ^{0}C	February	30.0	32.0	32.0	32.0	32.0	32.0
	March	31.9	33.5	33.1	33.2	34.0	33.8
	April	34.0	36.0	34.0	34.0	34.0	33.0
	May	32.8	34.5	34.3	33.2	33.5	34.5
	June	28.7	30.3	29.5	28.2	28.3	29.2
	Mean	31.4	33.2	32.5	32.1	32.3	32.5
	± SD	± 2.1	± 2.2	±1.9	±2.3	± 2.4	± 2.0
Turbidity (NTU)	February	4.7	4.2	3.9	4.1	3.8	3.8
	March	3.4	3.1	2.8	3.7	2.9	2.0
	April	2.1	9.3	3.7	2.9	2.3	2.5
	May	6.2	5.2	2.7	4.1	0.2	0.5
	June	4.6	3.0	0.7	1.1	1.6	1.2
	Mean	4.2	4.9	2.7	3.1	2.1	2.0
	± SD	± 1.5	± 2.5	±1.2	±1.2	±1.3	±1.2
pH	February	5.9	6.2	6.8	6.2	6.2	6.5
	March	5.6	6.4	6.8	6.4	6.4	6.4
	April	6.2	6.3	6.9	6.6	6.6	6.6
	May	6.4	6.7	6.6	6.7	6.6	6.6
	June	6.2	7.0	7.0	6.7	6.4	6.7
	Mean	6.0	6.5	6.8	6.5	6.4	6.5
	± SD	±0.3	±0.3	±0.1	±0.2	±0.1	±0.1
TDS (ppm)	February	81.8	76.5	26.0	30.8	532	555
	March	54.3	98	26.1	67.3	2020	2046
	April	140	160	30.0	30.0	230	270
	May	110	60	20.0	20.0	250	230
	June	42.4	31.3	20.9	24.2	33.4	28.1
	Mean	85.7	85.1	24.6	34.4	613.0	625.8
	± SD	±40.0	±48.4	±4.1	±18.8	±806.3	±815.8
DO (mg/l)	February	0.4	5.6	6.8	4.8	4.0	5.6
	March	4.4	5.6	6.8	6.8	7.2	8.4
	April	6.4	6.8	8.0	8.8	6.0	6.4
	May	0.8	9.2	7.2	6.8	4.6	6.6
	June	4.4	7.2	5.2	4.8	0.6	3.6
	Mean	3.2	6.8	6.8	6.4	4.4	6.1
	± SD	± 2.5	±1.4	±1.0	±1.6	±2.5	±1.7
Hardness (mg/l)	February	12	32	16	16	72	52
	March	28	40	24	12	404	442
	April	16	68	16	24	48	96
	May	44	32	24	18	54	48
	June	28	24	20	22	28	24
	Mean	34.4	39.2	20	18.4	121	132
	± SD	±18.2	±17.0	±4.0	±4.7	±158.8	±175.0
Chloride (mg/l)	February	59.64	71.00	24.56	34.08	619.12	644.68
	March	22.73	03.08	11.36	14.20	34.08	42.60
	April	42.60	35.50	19.88	14.20	97.98	120.70
	May	17.01	11.34	06.38	05.67	55.30	46.79
	June	19.88	17.04	19.88	14.20	19.88	17.04
	Mean	32.37	27.59	16.41	16.47	165.27	17.36
	± SD	±18.2	±27.0	±7.3	±10.5	±255.4	±256.7
Sulphate (mg/l)	February	23.5	24.0	14.0	22.0	18.0	17.0
	March	4.5	7.5	7.0	5.0	30.0	26.5
	April	5.5	12.0	3.5	2.0	23.0	36.0
	May	4.5	8.6	4.6	1.6	20.0	30.0
	June	20.0	19.0	16.0	11.0	14.0	15.0
	Mean	11.6	14.22	9.02	8.32	21.0	24.9
	± SD	±9.3	±7.0	±5.6	±8.5	±6.0	±8.8
Nitrate (mg/l)	February	1.15	1.10	0.53	0.62	0.88	0.93
	March	0.53	0.80	0.35	2.03	0.48	0.79
	April	0.80	0.75	6.94	1.33	0.53	2.30
	May	0.88	0.22	0.93	1.41	0.44	0.75
	June	0.35	0.35	0.09	2.30	2.13	1.24
	Mean	0.74	0.64	1.76	1.53	0.89	1.20
	± SD	±0.31	±0.35	±2.90	±0.65	±0.71	±0.64
Phosphate (mg/l)	February	0.03	0.03	0.09	0. 11	0.16	0.06
	March	0.08	0.05	0.09	0.10	0.19	0.07
	April	0.90	0.06	0.02	0.02	0.07	0.07
	May	0.10	0.06	0.03	0.05	0.06	0.07
	June	0.04	0.18	0.12	0.03	1.04	0.12
	Mean	0.23	0.07	0.07	0.06	0.30	0.08
	± SD	±0.37	±0.06	±0.04	±0.04	±0.41	±0.03

Phytoplankton distribution against physico-chemical parameters

TDS declined from summer to monsoon. This is due to the dilution of dissolved salts especially sulphate during monsoon. Dissolved oxygen (DO) is the most important factor to assess water quality and reflects in the the physical and biological status of water. Higher values of DO noted in the summer months (March, April, May). DO increased due to photosynthesis. Hutchinson (1967) and Reid (1961) pointed out that an abundant growth of phytoplankton increase the oxygen content of water during summer. The present study is in agreement with this. A higher density of phytoplankton was noticed during summer. Similar results were obtained by Unni and Pawar (2000) and Ray and David (1966). *Chlorophyceae* and *Bacillariophyceae* members showed positive correlation with DO.

In the present study high chloride concentration was noticed during the month of February at sites 5 and 6. This drastic increase might be due to the intrusion of saline water from the Vembanad estuary and during monsoon it gets diluted. Chloride showed a direct positive correlation with the density of *Chlorophyceae*.

During the study, the maximum concentration of sulphate was observed during summer and minimum during rainy season. The sulphate concentration in sites 5 & 6 were comparatively higher than the other sites. It may be due to the discharge of sulphate based fertilizers from agricultural fields. Sulphate concentration showed positive correlation with the density of *Chlorophyceae* and negative correlation with that of *Bacillariophyceae*.

Nitrate is an important nitrogen source for phytoplankton. Rainfall was supposed to be responsible for increase in the nitrates in water (Nandan and Patel, 1992). This is in agreement with the observation at sites - 4, 5 and 6. The direct relationship emerged between phytoplankton standing crop and nitrate indicated that the increase in the concentration of nitrates promoted the growth of phytoplankton. All the 5 groups of phytoplankton encountered in the present study exhibited a high positive correlation with nitrate especially the group *Bacillariophyceae*. (Table 4)

High phosphate content of silty flood water was observed by Vollenweider (1968). In the present study also most of the sites recorded higher values of phosphate in the month of June after heavy rains. Members of *Cyanophyceae* and *Euglenophyceae* showed positive correlation with the concentration of phosphate.

TDS, hardness, chloride, nitrate, phosphate and sulphate which are mineral nutrients were found to be in higher levels at sites 5 and 6 especially during the summer months, due to the discharge from the nearby paddy fields flowing in to these sites. Similar results were found in river Cauvery (Dhanapakiam *et al*., 1998; Suvarna and Somashekar, 1997). Sites 3 and 4 recorded lower values for inorganic salts. Both the sites show continuous flow of water so the nutrients get diluted.

Table 3. Density of phytoplankton (organisms/l) under different classes during different months

Classes	Months	Sites					
		I	II	III	IV	V	VI
Chlorophyceae	February	320	1020	980	2160	840	1440
	March	1160	1240	1740	2280	1560	2960
	April	880	1480	2900	2560	1520	3120
	May	240	560	800	1320	1260	1000
	June	160	240	360	600	320	960
	Mean	552	908	1356	1784	1100	1896
	± SD	± 442	± 504	± 996	±807	±521	±1062
Bacillariophyceae	February	200	640	1408	1808	40	640
	March	560	880	3288	3008	920	880
	April	880	1800	5480	840	240	480
	May	520	560	1200	760	200	520
	June	320	560	1040	560	200	400
	Mean	496	888	2483	1395	320	584
	± SD	±260	±526	±1904	±1022	±344	±186
Cyanophyceae	February	13480	280	3680	1480	160	5520
	March	1112	1344	840	4680	680	1120
	April	3616	664	2000	1600	3120	360
	May	848	960	1040	2088	720	760
	June	7360	5000	7520	10520	9840	8800
	Mean	5283	1649	3016	40736	2904	3312
	± SD	±5276	±1913	±2756	±3831	±4043	±3708
Euglenophyceae	February	1432	0	240	1200	0	200
	March	440	400	80	80	80	120
	April	480	184	400	0	160	80
	May	0	0	40	80	80	80
	June	120	200	80	120	360	560
	Mean	494.4	156	168	296	136	208
	± SD	±562	±166	±150	± 507	±137	±202

Table 4. Correlation coefficients of Physico-chemical parameters of water with different phytoplankton groups

Plankton Groups	Water Temp.	Turbidity	pH	TDS	DO	Hardness	Chloride	Sulphate	Nitrate	Phosphate
Cyanophyceae	-0.78177	-0.25257	0.1144	-0.24790	-0.38745	-0.25349	-0.18981	-0.0439	0.09674	0.407607
Euglenophyceae	-0.24979	-0.13951	-0.2961	-0.15716	-0.28279	-0.14167	-0.07101	-0.1732	0.27962	0.441039
Bacillariophyceae	0.29957	0.20999	0.2337	-0.01502	0.37910	-0.02759	-0.24315	-0.3511	0.66356	-0.180432
Chlorophyceae	0.50569	-0.00102	0.2330	0.36336	0.53447	0.37202	0.34367	0.1416	0.47169	-0.285746

This is in accordance with the studies by Rajkumar and Dharmaraj (2003) at river Umshyrpi, Meghalaya. Site 2 was having salt concentrations higher than sites 3 and 4. Submerged water plants at the site reduce the flow of water.

The canal is dominated by *Myxophyceae* at all the sites. Site-1 has density of 1706 organisms/litre. The dominance of *Cyanophyceae,* the reduced diversity of phytoplanktons and the presence of diatoms *Cyclotella meneghiniana, Melosira granulate, Nitzschia palea* and *Synedra ulna* which are identified as tolerant to organic pollution (Palmer, 1980) indicate the presence of sewage at the site. Site-2 recorded about 23 members of *Chlorophyceae,* 12 species of *Bacillariophyceae,* 7 species of *Eugleninae* and 10 of *Cyanophyceae* were present. Site 3 was dominated by *Cyanophyceae* followed by *Bacillariophyceae* with 15 species. A density of 1756 organisms/litre were observed.

High density (1887 organisms/l) of phytoplankton and presence of desmids like *Euastrum sp., Strurastrum sp.* and *Ulothrix sp.,* which are clean water algae indicate that the Site-4 is less polluted than all the other sites. The site is the confluence of the Manimala River with the canal.

Site-5 showed dominance of *Cyanophyceae* and had the lowest density (737 organisms/l). Site-6 also dominated with *Cyanophyceae*. It is poor in phytoplankton density (715 organisms/l). Both sites receive high volume discharge from the nearby rice fields and sewage from dwellings.

Conclusion

The present study revealed that AC canal is less polluted in terms of physico-chemical parameters except Site-1 which show high organic pollution. Site-1 is organically polluted due to the municipal sewage from Changanassery town. Sites 5 and 6 are inorganically polluted which receives the agricultural drainage from the nearby rice fields and domestic sewage causing the changes in water quality. Sites 2, 3 and 4 were found to be much cleaner than the other sites and the rate of flow of water were greater compared to other sites. Water quality is in agreement with standards of surface water except at site - 1. So the water in the rest of the canal can be used as a surface water source and not for drinking purpose. Distribution of phytoplankton showed that the canal supports 78 species of phytoplankton. Among them, *Chlorophyceae* is the dominant group followed by *Bacillariophyceae* in the canal. It can be concluded that nitrate nitrogen is promoting the growth all phytoplankton groups as revealed from the direct relationship emerged between phytoplankton standing crop and nitrate. The diatoms (*Bacillariophyceae*) showed the highest positive correlation with the concentration of nitrates. Phosphate is the most important controlling factor responsible for the growth of *Euglenophyceae* and *Cyanophyceae* members resulting in Euglenoid blooms. The density of *Chlorophyceae* members showed high positive correlation with water temperature and DO. *Chrysophyceae,* which is a group present in clean water, was represented by only a single member, *Dinobryon sociale.* The species was recorded from the less polluted sites 2, 3 and 4 indicating the clean water status of these sites. Further studies are needed to ascertain specifically the indicator status of many species of algae which are identified and quantified in the present study.

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