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RESEARCH ARTICLE

Biodiversity on Aquatic Microphytes in Veeranam Tank, Cuddalore District, Tamil Nadu

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ABSTRACT

In the present investigation, 140 species of phytoplankton belonging to 4 classes, viz., Cyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae were recorded. They belonged to 46 genera and 11 orders. Among the phytoplankton population, Bacillariophyceae constituted 40%, followed by Chlorophyceae (30%), Cyanophyceae (20%) and Euglenophyceae (10%). The Bacillariophyceae was the dominant group of the phytoplankton population in all the stations followed by Chlorophyceae, Cyanophyceae and Euglenophyceae. The main reason for the high Bacillariophyceae population (40%) was rich nutrient and high temperature found in the tank. A total of 19 species belonging to 14 genera (Oscillatoria, Anabaena, Ankistrodesmus, Chlorella, Pediastrum, Scenedesmus, Tetraedron, Gomphonema, Navicula, Nitzschia, Synedra, Euglena, Phacus and Coelastrum) were recorded in all the stations. The maximum species was recorded in S-3 and S-4 due to the pollution status in this station.

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INTRODUCTION

Biodiversity means the variability among living organisms from all sources and the ecological complexes of which they are part and include diversity within species or between species and of eco-systems [1]. India is one of the twelve mega biodiversity countries in the world and the United Nations has declared the year 2010 as the International year of Biodiversity. In aquatic biodiversity, the density and diversity of organisms depend on availability and quality of water. As water is an essence and elixir of life on the earth and that water totally dominates the chemical composition of all organisms, it is obvious that the quality of water affects the species composition, abundance, productivity and physiological conditions especially, the indigenous population of aquatic organisms. Therefore, the nature and health of any aquatic community is an expression of quality of the water [2]. The aquatic microphytes play a significant ecological role and are being extensively used as an indicator of water pollution as they are natural inhabitants of aquatic ecosystem that harbours a variety of communities, which constitutes the characteristics and functioning of the ecosystem in terms of maintaining the production of food chain. The density and diversity of phytoplankton and their association as biological indicators is very crucial for the assessment of water quality.

Algae constitute a major part of primary producers in a aquatic ecosystems and are ubiquitous components of the biosphere [3]. They are cosmopolitan in distribution. Algae along with the other higher plants are the primary source of energy in the biosphere and form the basic of all life on land, fresh and marine water environment. These organisms along with the other aquatic as well as terrestrial plants make up the biodiversity and also sustain life by providing food, shelter, oxygen and play a fundamental role in regulating global climate [4]. Algal diversity and species

composition respond to change of water quality in all perennial water bodies. The composition of algal diversity serves as an important tool to analyse the water quality [5]. Phytoplankton plays an important role in the biosynthesis of organic matter (primary production) in aquatic systems, which directly or indirectly serve all the living organisms of a water body as food [6], [7]. Generally, the different planktonic species can tolerate different ranges of temperature as well as light and nutrient limitations. These tolerance levels determine the dominance of species at different localities and seasons. In a multi species algal community, the growth of different species is likely to be limited by the resources, including different nutrients [8]. The structure of aquatic communities is important in monitoring the water quality. Planktons also strongly influence certain non-biological aspects of water quality such as pH, colour, taste and odour [9].

Aquatic plants attached to the bottom play an important role in maintaining the potable, recreational and aesthetic characteristics, as well as the ecological functioning of most waters [10]. These plants compete with algae in the water column for nutrients, there by maintaining water clarity. They protect shorelines from erosion and stabilize deeper substrates by trapping silts and clays, limiting turbidity by physical disturbance and preventing the re-suspension of sediments which have nutrients adsorbed to them [11]. Very little studies are conducted to assess and map biodiversity of Indian water bodies. Such studies are essential, especially for comparison of the data on concurred basis to estimate the impact of anthropogenic activity on these naturally occurring natural bodies. The present study is one such humble initiative. The intended study is to be conducted in Veeranam tank which dates back to 9th century. Veeranam tank (Lat. 11°-15'N, Long. 79°-35'E) is one of the biggest freshwater tanks. It is situated in the western side of Chidambaram in Kattumannarkudi taluk, Cuddalore district in the state of Tamil Nadu, India. The tank is

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located 235 km from Chennai. The length of tank in North to South is 16 km, and in East to West it is 5 km. The full tank level is 45.50 feet and water catchment area is 165 sq. miles. It irrigates about 70,000 acres of agriculture land in around 128 villages, and since the year 2004 the tank water has also been used by the Chennai Metropolitan City Water Supply and Sewage Board (CMWSSB), to fulfill the drinking water needs of Chennai city. As on date, Chennai receives about 90 million liters of water per day (mld) from the tank and bore wells sunk in the Neyveli aquifer, through which pipelines are laid under the 'New Veeranam Project', a water supply scheme of Government of Tamil Nadu. Apart from being a source of irrigation and drinking water, the Veeranam tank also exhibits the following functions: i) check dam to control flood situation, ii) an agent of stabilizing local climate (such as temperature, rainfall) and iii) helps to maintain the ecological balance of vicinity. It also attracts a good number of migratory birds from different parts of the world. The present study focuses its attention on the aquatic plant biodiversity in Veeranam tank, Cuddalore district, Tamil Nadu, for a period of two years from January 2010 to December 2011. This is done on a real time basis. The objective of the study is to find out the phytoplankton distribution, density and diversity of the Veeranam tank.

MATERIALS AND METHODS

Topography of the study area

District profile

Cuddalore district lies in the eastern part of Tamil Nadu on the East Coast Region (Maps 1 and 2). It is spread over the geographical area of 3,564 km² and lies between latitude of 15°5'11" and 12°35' north and longitude of 70°38' and 80° east. It is bounded on the north by Villupuram district, on the east by the Bay of Bengal, on the south by Nagapattinam district, and on the west by Perambalur district. The district has 3 revenue divisions, 7 taluks, 13 blocks, 5 corporation and municipalities, 16 town panchayats, 901 revenue villages and 682 panchayat villages. The population of the district is 22,85,395 as per the census of 2001 with the average density of population being 702 per sq. km. 11,50,908 male and 11,34,487 female population. Veeranam tank surface water samples were collected at four sampling stations [Station 1 (S-1), Station 2 (S-2), Station 3 (S-3) and Station 4 (S-4)].

Station 1 –	Kanthakumaran	–	Eastern side
Station 2 –	Vanamadevi	–	Western side
Station 3 –	Poothankudi	–	Northern side
Station 4 –	Vadavaru	–	Southern side

Location

The tank lies in between Velar in north and Kollidam in the south.

Climate

The Veeranam tank enjoys tropical climate. The maximum and minimum temperature of the study area (36.8–29.0°C).

Wind

The wind prevailing in the region generally modeally in strength with mean velocity variation from 6-14 km/hr, wind speed is higher in May and lowers in October. South westerly wind prevails over 33% of days in a year and north easterly wind over 32% of the day.

Land use

The land use pattern of the district depends mainly on topography, land form, soil cover etc., but of the total geographical area of the district, only 0.39% is covered by forest and 12.53% of the area is pot on non-agricultural uses.

Rainfall

The district is beneficial by the influence of south-west monsoon stretching from June to September and north-east monsoon from October to December. The summer and not season from January to June from the transition period during which the rainfall is scanty. The long term average annual rainfall of the district is 1162.35 mm. Water source of the tank.

Rainy season

The continuous rainfall from 3 to 4 days in the Udayarpalayam taluk gives 10,000 to 15,000 sq. ft. of water to the tank, the water catchment area Jayamkondam, Chenturai, Aandimadam in this area rain water comes to way of Sengal odai, Karuvaatu odai and Paapakudi odai and 42 small inlet supply water to inflow the Veeranam tank. The maximum inflow of water for the Veeranam tank is during the monsoon period of north-east monsoon (October to December) tank water holding capacity (47.5 feet).

Non-Rainey season

Usually June to August month the Cauvery water released from Mettur dam and then directed to the Coleroon river and main source of water supply for Vadavaru channel to Veeranam tank.

Water out let

In flood time over flow the Veeranak tank water discharged in north side – Sethiyathope anicut (via.), Vellar river, Pazhi vaikkal, Urithria solai zero point, south side – Velliangal odai (Plate 1) and a total of 17,845 sq. ft. of extra water during rainy season has been drained out through 14 canals from the Lalpet regulators and 5,265 sq. ft. of water are drained by natural outlets.

Plankton Estimation

For qualitative and quantitative analysis of phytoplankton 1 L of composite waste sample at surface level were collected at interval of 30 days. 1 L of sample was fixed with 20 mL of 1% Lugol's Iodine solution and kept 24 hrs for sedimentation. 100 mL of sample is subjected to centrifugation at 1500 rpm for 20 min. and used for further investigation. Identification of plankton up to species level was done by referring standard key of [12]; [13]; [14]; [15]; [16]; [17] and [18] quantitative estimation of phytoplankton was done using by a sedge wick rafter counting cell and the values are expressed in organisms per litre (org/L) species diversity index (H) was calculated using formula of [19]; species richness (SR) calculated by [20]; species evenness (J) was calculated by the formula of [21].

Statistical analysis method

Diversity indices

1. Species richness (S): Total number of species in the study area
2. Simpson's diversity index (D): This index represents the abundance ratio of individual species to that of total abundance values. It was calculated using the following formula.

$$D = 1/\sum pi^2$$

Where, 'pi' is the preparation of the species to total abundance value.

3. Simpson's equitability index (E): The change of occurrence of individual species in one sample can be understood using this index, calculated using the formula.

$$E = D/S$$

Where, 'D' is the Simpson's diversity index and 'S' is the species richness.

4. Shannon – Weiner diversity index (H): This index value was calculated by using the formula.

$$H = \sum p_i \ln p_i$$

Where, 'p_i' is the preparation of the ith species to total abundance value.

5. Shannon-Wiener's equitability (J): It was calculated using the formula.

$$J = H/\ln s$$

Jaccard's similarity index (J_i)

This index represents the extend of similarity the amphibian sampling (composition) in different study sites.

$$J_i = a/a+b+c$$

Where 'a' is the number of species common to habitats, 'x' and 'y' and 'b' is the number of species unique to habitat, 'x' and 'c' is the number of species unique to habitat 'y'.

ANOVA

The data collected were statistically analysed using SPSS package, employing ANOVA.

Correlation coefficient

Correlation co-efficient (r) was calculated to detect the relationship between the various parameters of the Veeranam tank.

RESULTS

aquatic plant biodiversity at veeranam tank

Phytoplankton (Microphytes)

In this present investigation the phytoplankton were identified and are classified under four classes namely Cyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae. The phytoplankton diversity, density monthly variations, seasonal average and yearly average of four stations on Veeranam tank have been analyzed. The total number of 140 species belonging to 46 genera, 11 orders and 4 classes were identified. 28 species of 11 genera and 3 orders belongs to the class Cyanophyceae (Plate 1). 42 species of 17 genera and 5 orders belongs to the class Chlorophyceae (Plate 2). 56 species of 16 genera and 2 orders belongs to the class Bacillariophyceae (Plate 3) and 14 species of 1 genera and 1 order to the class Euglenophyceae (Plate 4). The percentage distribution of Bacillariophyceae (40%) followed by Chlorophyceae (30%), Cyanophyceae (20%) and Euglenophyceae (10%) respectively in total phytoplankton (Bacillariophyceae > Chlorophyceae > Cyanophyceae > Euglenophyceae) (Tables 1 to 9).

Station 1 – Kanthakumaran (eastern side)

Periodicity

A totally 80 species, 41 genera, 11 orders under 4 classes are recorded in this station. Bacillariophyceae species diversity in highest (28) and lowest (7) in Euglenophyceae respectively.

Class : Cyanophyceae

A total of 19 species, 9 genera and 3 orders have been recorded from this station and constitutes about 23.75% of total phytoplankton population of this station. Species belonging to the genera Aphanocapsa, Chroococcus, Gloeocapsa, Merismopedia, Microcystis, Polycystis, Oscillatoria, Spirulina

and Nostoc occurred throughout the study period. Monthly variations of Cyanophyceae maximum density (1190 org/L) in the month of November 2011 and minimum (650 org/L) in the month of May 2010. Seasonal average of Cyanophyceae maximum (1118 org/L) recorded during the summer season April to June 2010 and minimum (742 org/L) recorded during the monsoon season October to December 2011. Yearly average of Cyanophyceae maximum (1034 org/L) was recorded 2010 and minimum (981 org/L) was recorded 2011.

Class: Chlorophyceae

A total of 26 species, 15 genera and 5 orders have been recorded from this station and constitutes about 32.50% of total phytoplankton population of this station. Species belonging to the genera Ankistrodesmus, Chlorococcum, Chlorella, Coelastrum, Coleochaete, Pediastrum, Scenedesmus, Tetraedron, Cladophora, Closterium, Cosmarium, Chlamydomonas, Palmella, Tetraspora and Spirogyra occurred throughout the study period. Monthly variations of Chlorophyceae maximum density (2139 org/L) in the month of May 2010 and minimum (905 mg/L) in the month of January 2011. Seasonal average of Chlorophyceae maximum (2009 org/L) recorded during the summer season April to June 2010 (Table 45 and Fig. 5) and minimum (948 org/L) recorded during the post-monsoon season January to March 2011. Yearly average of Chlorophyceae maximum (1593 org/L) was recorded 2010 and minimum (1250 org/L) was recorded 2011.

Class : Bacillariophyceae

A total of 28 species, 15 genera and 2 orders have been recorded from this station and constitutes about 35.00% of total phytoplankton of this station. Species belonging to the genera Cyclotella, Cymbella, Fragilaria, Frustulia, Gomphonema, Gyrosigma, Mastogloia, Melosira, Navicula, Nitzschia, Pinnularia, Surirella, Synedra, Tabellaria and Stauroneis occurred throughout the study period. Monthly variations of Bacillariophyceae maximum density (3506 org/L) in the month of May 2011 and minimum (1216 org/L) in the month of November 2011. Seasonal average of Bacillariophyceae maximum (3254 org/L) recorded during the summer season April to June 2011 and minimum (1463 org/L) recorded during the monsoon season October to December 2010. Yearly average of Bacillariophyceae maximum (2179 org/L) was recorded in 2011 and minimum (2088 org/L) was recorded 2010.

Class: Euglenophyceae

A total of 7 species, 2 genera and 1 order have been recorded from this station and constitutes about 8.75% of total phytoplankton of this station. Species belonging to the genera Euglena and Phacus occurred throughout the study period. Monthly variations of Euglenophyceae maximum density (133 org/L) in the month of April 2010 and minimum (51 org/L) in the month of October 2010. Seasonal variation of Euglenophyceae maximum (105 org/L) recorded during the post monsoon season January to March 2010 and minimum (62 org/L) was recorded during the monsoon season October to December 2010. Yearly average of Euglenophyceae maximum (85 org/L) was recorded in 2011 and minimum (80 org/L) was recorded in 2010.

Station 2 – Vanamadevi (Western side)

Periodicity

A totally 64 species, 34 genera and 10 orders under 4 classes are recorded in this station. Bacillariophyceae species diversity in highest (22) and lowest (6) in Euglenophyceae respectively.

Table 1. Diversity of Cyanophyceae in Veeranam tank at different stations (January 2010 to December 2011)

Sl.No.	Name of the organisms	S-1	S-2	S-3	S-4
Order-Chroococcales					
1.	<i>Aphanocapsa litroralis</i>	+	+	+	+
2.	<i>Aphanocapsa pulchra</i>	+	+	+	+
3.	<i>Aphanocapsa grevillei</i> (Hass) Rabenh	-	+	-	+
4.	<i>Chroococcus tenax</i> (Kirch.) Hiron	+	+	+	-
5.	<i>Chroococcus turgidus</i> Var. Max	+	+	+	+
6.	<i>Chroococcus disperses</i>	-	-	+	-
7.	<i>Chroococcus prescottii</i>	+	-	-	+
8.	<i>Gloeocapsa magma</i>	+	-	+	+
9.	<i>Gloeocapsa nigrescens</i>	-	-	+	-
10.	<i>Merismopedia glauca</i> (Ehrenb.) Nag	+	-	+	+
11.	<i>Merismopedia elegans</i>	+	+	-	-
12.	<i>Microcystis aeruginosa</i> Kutez	-	+	+	-
13.	<i>Microcystis flos – aquae</i>	-	-	-	+
14.	<i>Microcystis viridis</i>	+	+	-	-
15.	<i>Polycystis aeruginosa</i>	+	-	-	+
16.	<i>Polycystis incerta</i>	+	+	-	-
17.	<i>Tetrapedia reinschiana</i>	-	+	-	+
Order-Oscillatoriales					
18.	<i>Oscillatoria enlorine</i>	-	-	-	+
19.	<i>Oscillatoria subbrevis</i> Schmiele	-	+	-	-
20.	<i>Oscillatoria tenuis</i>	+	+	-	+
21.	<i>Oscillatoria curviceps</i> Ag. Ex. Gom	+	+	-	+
22.	<i>Oscillatoria chlorine</i>	+	+	+	+
23.	<i>Spirulina major</i>	+	-	+	-
24.	<i>Spirulina subsalsa</i> Oerstd	+	-	+	+
Order-Nostocales					
25.	<i>Anabaena spiroides</i>	-	+	+	+
26.	<i>Anabaena constricta</i>	-	-	+	-
27.	<i>Anabaena circinalis</i> Rab. Bor	-	-	-	+
28.	<i>Nostoc carneum</i>	+	+	+	+

(+) Present; (-) Absent

Table 2. Diversity of Chlorophyceae in Veeranam tank at different stations (January 2010 to December 2011)

Sl. No.	Name of the organisms	S-1	S-2	S-3	S-4
Order-Chlorococcales					
1.	<i>Ankistrodesmus falcatus</i> (Corda) Ralfs	+	-	+	+
2.	<i>Ankistrodesmus convalutus</i> Corda	+	+	+	+
3.	<i>Ankistrodesmus spiralis</i> (Turner) Lemm	+	+	+	-
4.	<i>Chlorococcum humicola</i>	+	-	+	-
5.	<i>Chlorella vulgaris</i>	+	-	+	-
6.	<i>Chlorella pyrenoidosa</i>	-	-	-	+
7.	<i>Chlorella ellipsoidea</i>	+	-	+	+
8.	<i>Chlorella protothecoids</i>	+	-	-	+
9.	<i>Coelastrum microporum</i>	+	+	-	+
10.	<i>Coleochaete suluta</i>	+	+	+	+
11.	<i>Pediastrum ovatum</i> (Her) A.Braun	+	+	-	-
12.	<i>Pediastrum simplex</i>	+	-	+	-
13.	<i>Pediastrum tetras</i> Var. tetradon	-	-	+	-
14.	<i>Pediastrum duplex</i> Var. Subg	+	-	+	+
15.	<i>Pediastrum constrictum</i>	+	-	-	+

16.	<i>Scenedesmus dimorphus</i> (Turpin)	-	-	-	+
17.	<i>Scenedesmus bijiugatus</i> (Turpin)	+	-	+	-
18.	<i>Scenedesmus armatus</i>	-	+	+	+
19.	<i>Scenedesmus carinatus</i>	+	+	+	+
20.	<i>Scenedesmus bicaudatus</i>	-	+	+	+
21.	<i>Scenedesmus abundance</i>	+	-	+	+
22.	<i>Scenedesmus caudatus</i>	+	-	-	+
23.	<i>Scenedesmus platydiscus</i> Smith Chodat	+	-	+	+
24.	<i>Scenedesmus quadricauda</i> (Turpin) Breb	+	-	-	+
25.	<i>Scenedesmus inermis</i>	-	+	-	-
26.	<i>Scenedesmus liniaris</i>				
27.	<i>Tetraedron minimum</i>	-	+	+	+
28.	<i>Tetraedron muticum</i>	-	+	-	-
29.	<i>Tetraedron regular</i> – Kretz	+	-	+	+
Order-Cladophorales					
30.	<i>Cladophora crispate</i>	+	+	+	-
Order-Coniuciales					
31.	<i>Closterium purvulum</i> Naegelii	+	+	+	+
32.	<i>Closterium luna</i>	+	+	+	+
33.	<i>Cosmarium retusiforimi</i>	+	-	-	+
34.	<i>Cosmarium depressum</i>	+	+	-	+
35.	<i>Comarium lundelli</i> Delb	+	+	-	+
Order-Volvocales					
36.	<i>Chlamydomonas globasa</i>	-	-	+	-
37.	<i>Chlamydomonas fasciata</i>	-	+	-	+
38.	<i>Eudorina elegans</i>	-	-	-	-
39.	<i>Palmella miniata</i>	+	+	+	-
40.	<i>Pendorina morum</i>	-	+	-	+
41.	<i>Tetraspora lubrica</i>	+	+	+	-
Order-Zygnematales					
42.	<i>Spirogyra varians</i>	+	-	+	+

(+) Present; (-) Absent

Table 3. Diversity of Bacillariophyceae in Veeranam tank at different stations (January 2010 to December 2011)

Sl. No.	Name of the organisms	S-1	S-2	S-3	S-4
Order-Centrales					
1.	<i>Cyclotella stelligera</i>	+	-	-	-
Order-Pennales					
2.	<i>Amphora ovalis</i>	-	-	+	+
3.	<i>Cymbella cistula</i>	+	-	-	-
4.	<i>Cymbella turgid</i>	+	+	-	-
5.	<i>Cymbella stelligera</i>	+	-	+	+
6.	<i>Cymbella alpine</i>	-	+	-	-
7.	<i>Cymbella tumida</i>	-	-	+	+
8.	<i>Fragilaria ratonensis</i>	+	+	-	-
9.	<i>Fragilaria brevistriata</i>	-	+	+	+
10.	<i>Fragilaria intermedia</i>	-	+	-	+
11.	<i>Frustulia rhomboids</i>	+	-	-	+
12.	<i>Gomphonema vibrio</i>	-	+	+	-
13.	<i>Gomphonema parvulum</i>	+	-	+	+
14.	<i>Gomphonema herculeana</i>	-	-	-	-
15.	<i>Gomphonema acuminatum</i>	+	+	-	+
16.	<i>Gyrosigma acuminatum</i>	+	-	+	-
17.	<i>Gyrosigma attenuvate</i>	-	-	-	-
18.	<i>Gyrosigma elongate</i>	+	+	-	+
19.	<i>Gyrosigma gracilis</i>	-	+	+	+
20.	<i>Mastogolia dolosa</i>	-	+	-	+

21.	<i>Mastogolia brauni</i>	-	-	-	+
22.	<i>Mastogolia smithii</i>	+	+	+	-
23.	<i>Mastogolia apiculata</i>	-	-	-	+
24.	<i>Melosira granulate</i>	+	-	+	-
25.	<i>Navicula pupula</i>	+	-	+	-
26.	<i>Navicula cincta</i>	+	-	-	-
27.	<i>Navicula rostellata</i>	+	-	+	+
28.	<i>Navicula pycmae</i>	-	+	+	-
29.	<i>Navicula mutica</i>	+	+	+	+
30.	<i>Navicula cuspidate</i> Kutz.	-	-	-	+
31.	<i>Navicula cryptocephala</i>	+	+	+	+
32.	<i>Navicula radiosa</i>	+	-	-	+
33.	<i>Navicula dicephala</i>	-	-	+	+
34.	<i>Navicula hasta</i>	-	-	+	-
35.	<i>Navicula penegrina</i>	+	+	-	-
36.	<i>Navicula lacostriis</i>	-	-	+	+
37.	<i>Navicula acicularis</i>	+	-	-	+
38.	<i>Nitzschia palea</i> Kutz.	-	+	+	+
39.	<i>Nitzschia vitrea</i>	+	-	-	-
40.	<i>Nitzschia plana</i>	+	-	-	+
41.	<i>Nitzschia amphibian</i>	+	-	+	
42.	<i>Pinnularia braunii</i>	+	+	+	-
43.	<i>Pinnularia interrupta</i>	-	-	+	+
44.	<i>Pinnularia microstauron</i>	+	+	-	-
45.	<i>Pinnularia gibba</i>	+	-	+	+
46.	<i>Pinnularia viridis</i>	-	+	-	-
47.	<i>Surirella elegans</i>	-	+	+	+
48.	<i>Surirella capronii</i>	-	+	+	-
49.	<i>Surirella robusta</i> Ehr. V.	-	+	+	+
50.	<i>Synedra tabulate</i>	-	-	-	+
51.	<i>Synedra ulna</i> (Nitzsch) Her	-	+	+	+
52.	<i>Synedracus</i> Kutz	+	-	-	+
53.	<i>Tabellaria flocculosa</i>	+	-	+	-
54.	<i>Tabellaria fenestrata</i>	+	-	-	+
55.	<i>Stauroneis anceps</i>	-	-	+	+
56.	<i>Stauroneis phoenicenteron</i>	-	-	-	-

(+) Present; (-) Absent

Table 4. Diversity of Euglenophyceae in Veeranam tank at different stations (January 2010 to December 2011)

Sl. No.	Name of the organisms	S-1	S-2	S-3	S-4
Order-Euglenales					
1.	<i>Euglena spirogyra</i>	+	-	+	+
2.	<i>Euglena obtuse</i>	+	-	+	+
3.	<i>Euglena viridis</i>	-	-	+	-
4.	<i>Euglena acus</i>	+	-	-	+
5.	<i>Euglena oxyalis</i>	-	+	+	+
6.	<i>Euglena gracile</i> Kelbs	-	+	+	+
7.	<i>Euglena acutissima</i>	+	+	+	+
8.	<i>Euglena elastic</i>	-	-	+	+
9.	<i>Phacus meson</i>	+	-	+	+
10.	<i>Phacus longicauda</i> Ehr	-	+	-	-
11.	<i>Phacus orbicauda</i>	+	-	+	+
12.	<i>Phacus pleuronectes</i>	-	+	-	+
13.	<i>Phacus acuminatus</i>	+	-	+	+
14.	<i>Phacus circumflexes</i>	-	+	-	-

(+) Present; (-) Absent

Table 5. Monthly variations and yearly average, different groups of phytoplankton density (org/L) at Veeranam tank in S-1 (January 2010 to December 2011)

Months and Year	Cyanophyceae	Chlorophyceae	Bacillariophyceae	Euglenophyceae	Total
Jan 2010	911	1508	2036	90	4545
Feb 2010	986	1312	2766	105	5169
Mar 2010	1453	1865	2050	121	5489
Apr 2010	1055	2084	2180	133	5452
May 2010	1190	2139	2150	85	5564
June 2010	1110	1805	3200	76	6191
July 2010	1499	1745	2856	67	6167
Aug 2010	988	1433	1655	55	4131
Sep 2010	887	1625	1780	53	4345
Oct 2010	771	1356	1540	51	3718
Nov 2010	671	1265	1448	63	3447
Dec 2010	895	980	1402	71	3348
Yearly Avg. 2010	1034	1593	2088	80	4797
Jan 2011	884	905	1910	76	3775
Feb 2011	955	959	2156	91	4161
Mar 2011	1023	981	2233	109	4346
Apr 2011	1055	1250	3156	115	5576
May 2011	1815	1556	3506	90	6967
June 2011	1011	1850	3100	98	6059
July 2011	985	1644	2142	101	4872
Aug 2011	966	1865	2089	66	4986
Sep 2011	850	985	1404	77	3316
Oct 2011	720	947	1966	72	3705
Nov 2011	650	959	1216	75	2900
Dec 2011	858	1105	1281	52	3296
Yearly Avg. 2011	981	1250	2179	85	4496

Table 6. Monthly variations and yearly average, different groups of phytoplankton density (org/L) at Veeranam tank in S-2 (January 2010 to December 2011)

Months and Year	Cyanophyceae	Chlorophyceae	Bacillariophyceae	Euglenophyceae	Total
Jan 2010	840	1644	1868	70	4422
Feb 2010	911	2138	2132	68	5250
Mar 2010	991	1865	2509	71	5436
Apr 2010	960	1750	2377	75	5162
May 2010	1055	1658	1055	85	3853
June 2010	956	1541	1369	65	3931
July 2010	890	1375	1377	52	3694
Aug 2010	837	1170	1488	56	3551
Sep 2010	790	905	1201	50	2947
Oct 2010	855	1112	1439	57	3463
Nov 2010	945	1120	1642	56	3763
Dec 2010	911	959	1678	61	3609
Yearly Avg. 2010	911	1436	1678	63	4090
Jan 2011	980	1110	1886	71	4047
Feb 2011	1070	1210	2218	80	4578
Mar 2011	1098	1311	2422	85	4916
Apr 2011	1110	1459	2444	101	5114
May 2011	1010	1865	1758	133	4766
June 2011	985	1610	1250	75	3920
July 2011	890	1415	1105	80	3490
Aug 2011	755	1211	1201	68	3235
Sep 2011	780	980	1414	74	3248
Oct 2011	652	1015	1215	71	2953
Nov 2011	680	1098	1310	69	3157
Dec 2011	852	1315	1112	80	3359
Yearly Avg. 2011	905	1299	1611	82	3898

Table 7. Monthly variations and yearly average, different groups of phytoplankton density (org/L) at Veeranam tank in S-3 (January 2010 to December 2011)

Months and Year	Cyanophyceae	Chlorophyceae	Bacillariophyceae	Euglenophyceae	Total
Jan 2010	1641	2022	2750	52	6465
Feb 2010	1112	1811	3210	64	6197
Mar 2010	1246	2212	3100	60	6618
Apr 2010	1750	2062	3058	58	6928
May 2010	1865	2788	4102	57	8812
June 2010	2131	2196	2850	58	7235
July 2010	1758	1045	2088	82	4973
Aug 2010	966	845	2065	92	3968
Sep 2010	975	933	1055	70	3033
Oct 2010	986	866	1266	72	3190
Nov 2010	1262	912	2177	86	4437
Dec 2010	905	1155	2688	92	4840
Yearly Avg. 2010	1383	1570	2534	70	5558
Jan 2011	981	1799	2858	60	5698
Feb 2011	1265	2133	3058	68	6524
Mar 2011	1627	2244	3160	41	7072
Apr 2011	1804	3015	2958	25	7802
May 2011	1714	2956	2670	32	7372
June 2011	1373	2010	2441	58	5882

July 2011	1213	1799	1881	81	4974
Aug 2011	950	1102	1980	90	4122
Sep 2011	990	911	1850	83	3834
Oct 2011	975	950	1716	99	3740
Nov 2011	1105	1105	1515	64	3789
Dec 2011	1263	982	915	56	3216
Yearly Avg. 2011	1271	1750	2250	63	5335

Table 8. Monthly variations and yearly average, different groups of phytoplankton density (org/L) at Veeranam tank in S-4 (January 2010 to December 2011)

Months and Year	Cyanophyceae	Chlorophyceae	Bacillariophyceae	Euglenophyceae	Total
Jan 2010	711	3766	4402	70	8949
Feb 2010	818	2115	5105	85	8123
Mar 2010	1190	3845	6128	101	11264
Apr 2010	1088	2215	8402	99	11804
May 2010	1101	1110	9150	105	11466
June 2010	1048	1058	7805	85	9996
July 2010	896	981	5401	75	7353
Aug 2010	798	1088	3500	60	5446
Sep 2010	541	1984	2010	51	4586
Oct 2010	654	1811	1958	45	4468
Nov 2010	955	2817	2345	52	6169
Dec 2010	708	2500	2133	52	5403
Yearly Avg. 2010	875	2107	4861	73	7918
Jan 2011	798	1950	3510	66	6324
Feb 2011	1011	3558	4802	80	9451
Mar 2011	1090	2510	2215	96	5911
Apr 2011	2200	4222	4601	111	11134
May 2011	2600	1105	8505	122	12332
June 2011	1045	1210	6510	101	8866
July 2011	990	1448	5432	98	7968
Aug 2011	885	2110	4305	80	7380
Sep 2011	705	1850	4110	72	6737
Oct 2011	700	1658	3115	84	5557
Nov 2011	890	810	3511	69	5280
Dec 2011	758	1112	2025	78	3973
Yearly Avg. 2011	1139	1961	4386	88	7576

Table 9. Seasonal average of phytoplankton density (org/L) at Veeranam tank in S-1

Sl. No.	Phytoplankton	January 2010 to December 2010				January 2011 to December 2011			
		Post-monsoon (Jan-Mar)	Summer (Apr-Jun)	Pre-monsoon (Jul-Sep)	Monsoon (Oct-Dec)	Post-monsoon (Jan-Mar)	Summer (Apr-Jun)	Pre-monsoon (Jul-Sep)	Monsoon (Oct-Dec)
1.	Cyanophyceae	1116	1118	1124	779	954	1293	933	742
2.	Chlorophyceae	1561	2009	1601	1200	948	1552	1498	1003
3.	Bacillariophyceae	2284	2510	2097	1463	2099	3254	1878	1487
4.	Euglenophyceae	105	98	58	62	92	101	81	66
	Total	5066	5735	4880	3503	4093	6200	4390	3298

Class: Cyanophyceae

A total of 16 species 9 genera and 3 orders have been recorded from this station and constitutes about 25.00% of total phytoplankton population of this station. Species belonging to the genera *Aphanocapsa*, *Chroococcus*, *Gloeocapsa*, *Merismopedia*, *Microcystis*, *Polycystis*, *Oscillatoria*, *Spirulina* and *Nostoc* occurred throughout the study period. Monthly variations of Cyanophyceae maximum density (1098 org/L) in the month of March 2011 and minimum (652 org/L) in the month of October 2011. Seasonal variation of Cyanophyceae maximum (1049 org/L) recorded during the post monsoon season January to March 2011 and minimum (728 org/L) recorded during the monsoon season October to December 2011. Yearly average of Cyanophyceae maximum (911 org/L) was recorded in 2010 and minimum (905 org/L) was recorded in 2011.

Class : Chlorophyceae

A total of 20 species, 13 genera and 4 orders have been recorded from this station and constitutes about 31.25% of total phytoplankton population of this station, species belonging to the genera *Ankistrodemus*, *Chlorella*, *Coleochacete*, *Pediastrum*,

Scenedesmus, *Tetraedron*, *Cladophora*, *Closterium*, *Cosmarim*, *Chlamydomonas*, *Palmella*, *Pendorina*, *Tetraspora* occurred throughout the study period. Monthly variations of Chlorophyceae, maximum density (2138 org/L) in the month of February 2010 and minimum (905 org/L) in the month of September 2010. Seasonal average of Chlorophyceae maximum (1882 org/L) recorded during the post-monsoon season January to March 2010 and minimum (1063 org/L) was recorded during the monsoon season October to December 2010. Yearly average of Chlorophyceae maximum (1436 org/L) was recorded in 2010 and minimum (1299 org/L) was recorded in 2011.

Class: Bacillariophyceae

A total of 22 species 10 genera and 1 order have been recorded from this station and constitutes about 34.37% of total phytoplankton population of this station species belonging to the genera *Cymbella*, *Fragilaria*, *Gomphonema*, *Gyrosigma*, *Mastogolia*, *Navicula*, *Nitzschia*, *Pinnularia*, *Suriella* and *Synedra* occurred throughout the study period. Monthly variations of Bacillariophyceae maximum density (2509 org/L) in the month of March 2010 and minimum (1055 org/L) in the month of May 2010. Seasonal average of Bacillariophyceae maximum (2175 org/L) was recorded during the post-monsoon

season January to March 2011 and minimum (1212 org/L) was recorded during the monsoon season October to December 2011. Yearly average of Bacillariophyceae maximum (1678 org/L) was recorded in 2010 and minimum (1611 org/L) was recorded in 2011.

Class: Euglenophyceae

A total of 6 species, 2 genera and 1 order have been recorded from this station and constitutes about 9.38% of total phytoplankton population of this station, species belonging to the genera *Euglena* and *Phacus* occurred throughout the study period. Monthly variations of Euglenophyceae maximum density (133 org/L) in the month of May 2011 and minimum (50 org/L) in the month of September 2010 (Table 42 and Fig. 4). Seasonal average of Euglenophyceae maximum (103 org/L) was recorded during the summer season April to June 2011 (Table 46 and Fig. 7) and minimum (53 org/L) was recorded during the pre-monsoon season July to September 2010. Yearly average of Euglenophyceae maximum (82 org/L) was recorded in 2011 and minimum (63 org/L) recorded in 2010.

Station 3 – Poothankudi (Northern side)

Periodicity

A totally 78 species, 35 genera and 10 orders under 4 classes are recorded in this station. Bacillariophyceae species diversity in highest (28) and lowest (10) in Euglenophyceae respectively.

Class: Cyanophyceae

A total of 15 species, 8 genera and 3 orders have been recorded from this station and constitutes about 19.23% of total phytoplankton population of this station species belonging to the genera *Aphanocapsa*, *Chroococcus*, *Gloeocapsa*, *Merismopedia*, *Oscillatoria*, *Spirulina*, *Anabaena* and *Nostoc* occurred throughout the study period. Monthly variations of Cyanophyceae maximum density (2131 org/L) in the month of June 2010 and minimum (905 org/L) in the month of December 2010. Seasonal average of Cyanophyceae maximum (1915 org/L) was recorded during the summer season April to June 2010 and minimum (1050 org/L) was recorded during the monsoon season October to December 2010. Yearly average of Cyanophyceae maximum (1383 org/L) was recorded in 2010 and minimum (1271 org/L) was recorded in 2011.

Class: Chlorophyceae

A total of 25 species, 14 genera and 5 orders have been recorded from this station and constitutes about 32.05% of total phytoplankton population of this station, species belonging to the genera *Ankistrodesmus*, *Chlorococcum*, *Chlorella*, *Coleochaete*, *Pediastrum*, *Scenedesmus*, *Tetraedron*, *Cladophora*, *Closterium*, *Cosmarium*, *Chlamydomonas*, *Palmella*, *Tetraspora* and *Spirogyra* occurred throughout the study period. Monthly variations of Chlorophyceae maximum density (2788 org/L) in the month of May 2010 and minimum (845 org/L) in the month of August 2010. Seasonal average of Chlorophyceae maximum (2660 org/L) was recorded during the summer season April to June 2011 (Table 47 and Fig. 10) and minimum (941 org/L) was recorded during the pre-monsoon season July to September 2010. Yearly average of Chlorophyceae maximum (1750 org/L) was recorded in 2011 and minimum (1570 org/L) was recorded in 2010.

Class : Bacillariophyceae

A total of 28 species, 14 genera and 1 order have been recorded from this station and constitutes about 35.90% of total phytoplankton population of this station species belonging to

the genera, *Amphora cymbella*, *Fragilaria*, *Gomphonema*, *Gyrosigma*, *Mastogloia*, *Melosira*, *Navicula*, *Pinnularia*, *Nitzschia*, *Synedra*, *Tabellaria*, *Surirella* and *Stauroneis* occurred throughout the study period. Monthly variations of Bacillariophyceae maximum density (4102 org/L) in the month of May 2010 and minimum (915 org/L) in the month of December 2011. Seasonal average of Bacillariophyceae maximum (3336 org/L) was recorded during the summer season April and June 2010 (Table 47 and Fig. 9) and minimum (1382 org/L) was recorded during the monsoon season October to December 2011. Yearly average of Bacillariophyceae maximum (2534 org/L) was recorded in 2010 and minimum (2250 org/L) was recorded in 2011.

Class: Euglenophyceae

A total of 10 species, 2 genera and 1 order have been recorded from this station and constitutes about 12.82% of total phytoplankton population of this station species belonging to the genera *Euglena* and *Phacus* occurred throughout the study period. Monthly variations of Euglenophyceae maximum density (99 org/L) in the month of October 2011 and minimum (22 org/L) in the month of May 2010. Seasonal average of Euglenophyceae maximum (84 org/L) was recorded during the pre-monsoon season July to September 2011 (Table 47 and Fig. 10) and minimum (25 org/L) was recorded during the summer season April to June 2010. Yearly average of Euglenophyceae maximum (70 org/L) was recorded in 2010 and minimum (63 org/L) was recorded in 2011.

Station 4 – Vadavaru (Southern side)

Periodicity

A totally 86 species, 42 genera and 10 orders under 4 classes are recorded in this station Bacillariophyceae species diversity in highest (30) and lowest (11) in Euglenophyceae, respectively.

Class: Cyanophyceae

A total 22 species, 11 genera and 3 orders have been recorded from this station and constitutes about 25.58% of total phytoplankton population of this station species belonging to the genera *Aphanocapsa*, *Chroococcus*, *Gloeocapsa*, *Merismopedia*, *Microcystis*, *Polycystis*, *Tetrapedia*, *Oscillatoria*, *Spirulina*, *Anabaena* and *Nostoc* occurred throughout the study period. Monthly variations of Cyanophyceae maximum (2600 org/L) in the month of May 2011 and minimum (541 org/L) in the month of September 2010. Seasonal average of Cyanophyceae maximum (1948 org/L) was recorded during the summer season April to June 2011 (Table 48 and Fig. 12) and minimum (745 org/L) was recorded during the pre-monsoon season July to September 2010. Yearly average of Cyanophyceae maximum (911 org/L) was recorded in 2011 and minimum (875 org/L) was recorded in 2010.

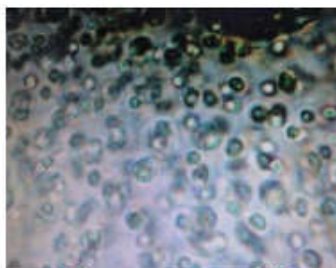
Class: Chlorophyceae

A total of 26 species, 12 genera and 5 orders have been recorded from this station and constitutes about 30.23% of total phytoplankton population of this station species belonging to the genera *Ankistrodesmus*, *Chlorella*, *Coelastrum*, *Coleochaete*, *Pediastrum*, *Scenedesmus*, *Tetraedron*, *Closterium*, *Cosmarium*, *Chlamydomonas*, *Pendroina* and *Spirogyra* occurred throughout the study period. Monthly variations of Chlorophyceae maximum density (4222 org/L) in the month of April 2011 and minimum (810 org/L) in the month of November 2011. Seasonal average of Chlorophyceae maximum (3944 org/L) was recorded during the post-monsoon season January to March 2010 and minimum (1306 org/L) was recorded during the monsoon season

PLATE 1
CYANOPHYCEAE



Aphanocapsa pulchra



Aphanocapsa grevillei



Chroococcus turgidus



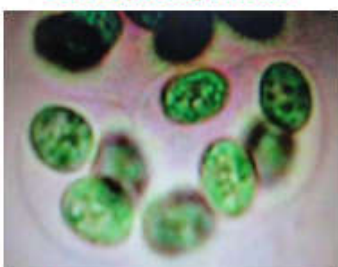
Gloeocapsa nigrescens



Merismopedia glauca



Gloeocapsa magma



Gloeocapsa nigrescens



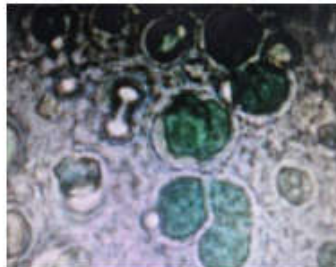
Merismopedia glauca



Merismopedia elegans



Microcystis aeruginosa



Microcystis flos



Oscillatoria subbrevis



Oscillatoria tenuis



Spirulina major



Spirulina subsalsa



Anabaena spiroides



Anabaena constricta



Nostoc carneum

PLATE 2

CHLOROPHYCEAE

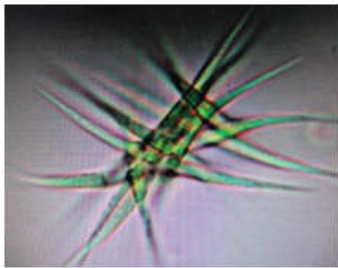
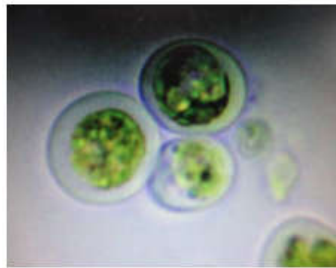
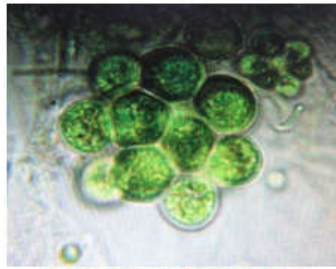
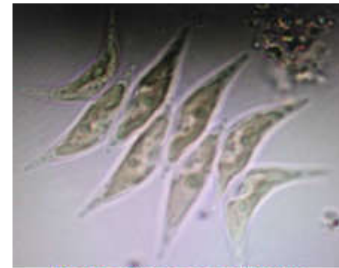
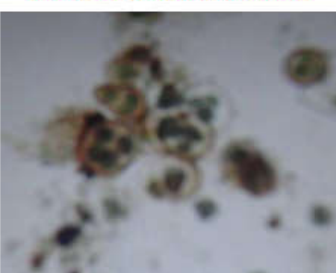
*Ankistrodesmus spiralis**Chlorococcum humicola**Chlorella vulgaris**Chlorella pyrenoidosa**Coelastrum microporum**Pediastrum simplex**Pediastrum tetras**Pediastrum duplex**Pediastrum constrictum**Scenedesmus dimorphus**Scenedesmus bijugatus**Scenedesmus armatus**Scenedesmus abundance**Scenedesmus platydiscus**Scenedesmus quadricauda**Chlamydomonas globosa**Palmella miniata**Spirogyra varians*

PLATE 3
BACILLARIOPHYCEAE



Cyclotella stelligera



Cymbella cistula



Cymbella alpina



Cymbella tumida



Fragilaria ratonensis



Frustulia rhomboids



Gomphonema vibrio



Gomphonema parvulum



Gomphonema acuminatum



Gyrosigma acuminatum



Mastogolia smithii



Navicula pupula



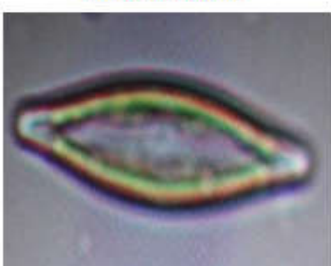
Navicula cincta



Navicula rostellata



Navicula mutica



Navicula cuspidate



Navicula cryptocephala



Navicula hasta

BACILLARIOPHYCEAE

*Navicula penegrina**Navicula lacostris**Nitzschia palea**Nitzschia plana**Nitzschia amphibia**Pinnularia interrupta**Pinnularia microstauron**Pinnularia gibba**Pinnularia viridis**Surirella elegans**Surirella capronii**Surirella robusta**Synedra ulna**Synedracus**Tabellaria flocculosa**Tabellaria fenestrata**Stauroneis anceps**Stauroneis phoenicenteron*

PLATE 4
EUGLENOPHYCEAE



Euglena spirogyra



Euglena viridis



Euglena acus



Euglena oxyalis



Euglena gracile



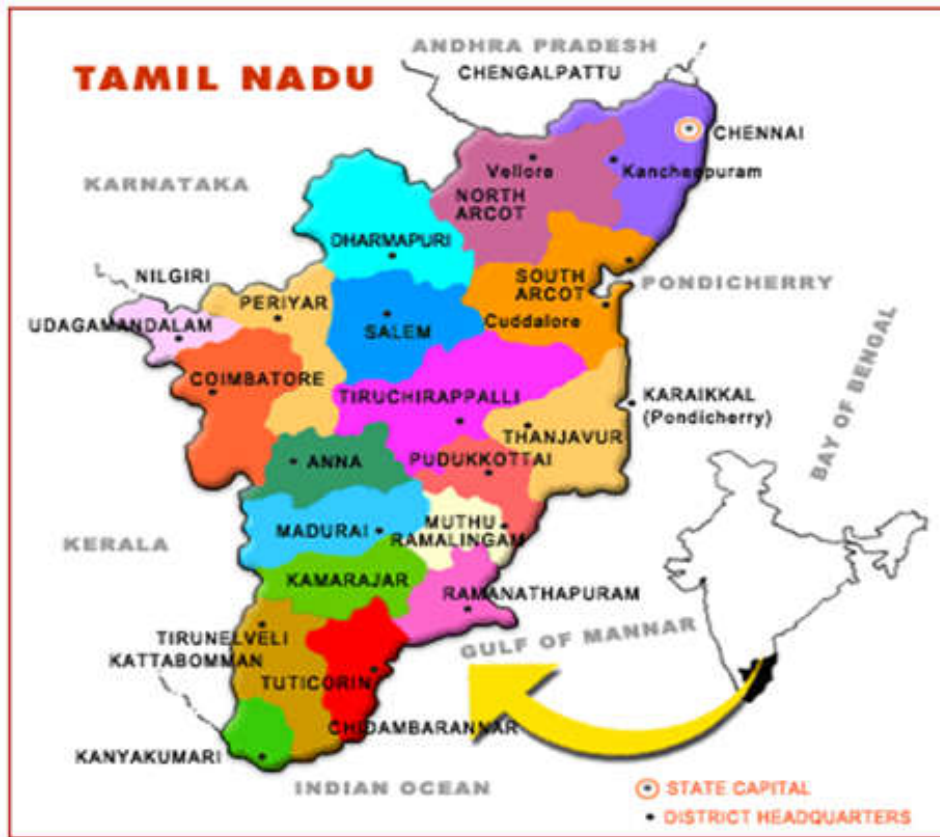
Phacus longicauda



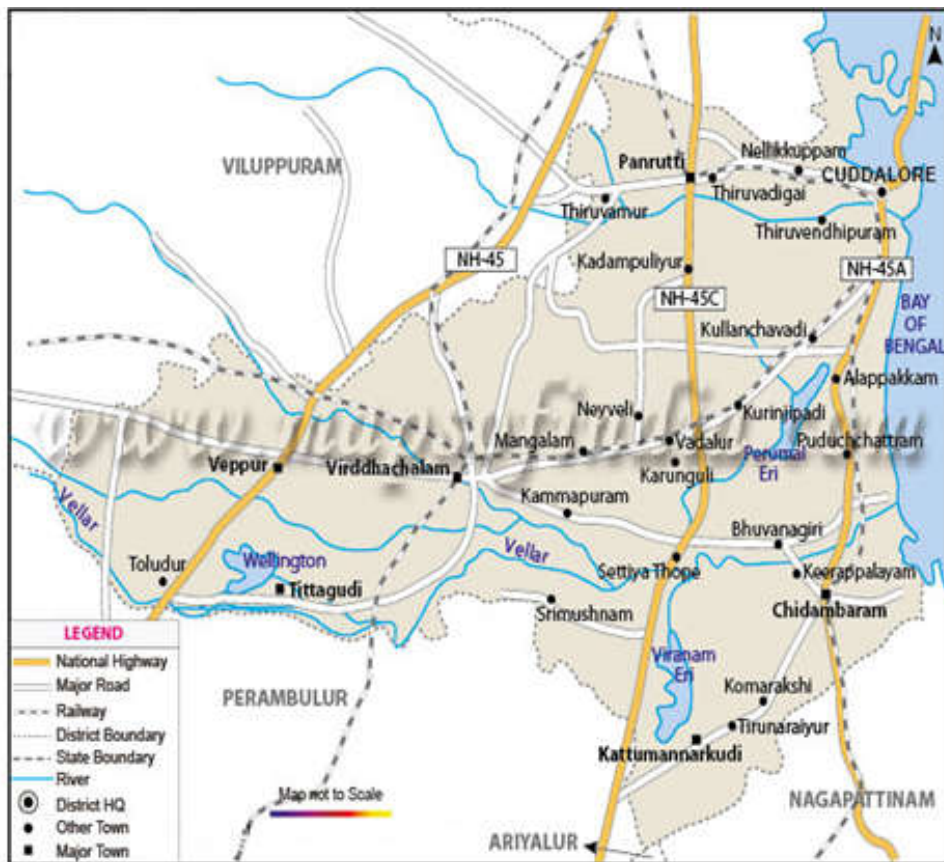
Phacus pleuronectes



Phacus acuminatus



Map 1. Location of Tamil Nadu map



Map 2. Location of Cuddalore district

October to December 2011. Yearly average of Chlorophyceae maximum (2283 org/L) was recorded in 2010 and minimum (1814 org/L) was recorded in 2011.

Class: Bacillariophyceae

A total of 31 species, 14 genera and 1 order have been recorded from this station and constitutes about 36.04% of total phytoplankton population of this station species belonging to the genera, Amphora, Cymbella, Fragilaria, Frustulia, Gomphonema, Gyresigma, Mastogloia, Navicula, Nitzschia, Pinnularia, Surirella, Synedra, Tabellaria and Stauroneis occurred throughout the study period. Monthly variations of Bacillariophyceae maximum density (9150 org/L) in the month of May 2010 and minimum (1958 org/L) in the month of October 2010. Seasonal average of Bacillariophyceae maximum (8452 org/L) was recorded during the summer season April to June 2010 and minimum (2145 org/L) was recorded during the monsoon season October to December 2010.

Yearly average of Bacillariophyceae maximum (4861 org/L) was recorded in 2010 and minimum (4386 org/L) was recorded in 2011.

Class: Euglenophyceae

A total of 11 species, 2 genera and 1 order have been recorded from this station and constitutes about 12.80% of total phytoplankton population of this station species belonging to the genera Euglena and Phacus occurred throughout the study period. Monthly variations of Euglenophyceae maximum density (122 org/L) in the month of May 2011 and minimum (45 org/L) in the month of October 2010. Seasonal average of Euglenophyceae maximum (111 org/L) was recorded during the summer season April to June 2011 and minimum (53 org/L) was recorded during the monsoon season October to December 2010. Yearly average of Euglenophyceae maximum (88 org/L) was recorded in 2011 and minimum (73 org/L) was recorded in 2010.

DISCUSSION

Phytoplankton (Microphytes)

In this present investigation, the diversity, density, monthly variations, seasonal average and yearly average of phytoplankton in the four stations of Veeranam tank have been analyzed. A total 140 species of phytoplankton belonging to 46 genera, and 11 orders from four classes viz., Cyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae have been recorded. The Bacillariophyceae was found to be the dominant group among the total phytoplankton population in all the stations followed by Chlorophyceae, Cyanophyceae and Euglenophyceae (Bacillariophyceae > Chlorophyceae > Cyanophyceae > Euglenophyceae).

Cyanophyceae

The blue greens are found in almost all the aquatic ecosystems. They frequently form dense plankton population called water blooms. In tropical lakes, their growth may be continuous throughout the year but in the temperate lakes, there is a characteristic seasonal succession of bloom forming species. The Cyanophyceae formed the third most dominant group of in all the stations. Some of the factors such as temperature, pH, free CO₂, dissolved oxygen, phosphate and nitrate a major role in the distribution of blue greens in freshwater bodies [22]; [23]. High temperature has been found to play an important role in the periodicity of blue green as emphasized by Hutchinson [24]. [25] Recorded that Cyanophyceae were most dominant during summer. Further [26]; [27], concluded that the high temperature

factors affect the growth of blue greens. During the present investigation, the high temperature 36.8°C was recorded in the summer season 2011 and maximum density (2600 org/L) in S-4. The greater species composition (25.58%) was recorded in S-4 followed by S-2 (25.00%), S-1 (23.7%) and S-3 (19.23%), respectively. The present observations are similar to the findings of the above workers. Further the same result was observed by [28]. Seasonal average of minimum Cyanophyceae (728 org/L) was recorded in monsoon season 2011 in S-2 and maximum (1948 org/L) was recorded in summer season 2011 in S-4. The same trend was observed by [29]. Some of the pollution tolerant blue greens, [30] recorded from the study were *Oscillatoria* sp. (S-1, S-2 and S-3), *Anabaena* sp. (S-3) and *Microcystis* sp. (S-1 and S-2).

Chlorophyceae

Chlorophyceae (or) green algae comprise unicellular and colonial forms having a remarkable ability to grow luxuriantly in a wide variety of quantity and periodicity of phytoplankton flora [31]. The Chlorophyceae formed the second most dominant group of in all the stations. Several workers have concluded that the species composition and abundance of phytoplankton population in a biotype is altered by any change in the prevailing environmental conditions [32]. The Chlorophyceae members have been studied by many researchers like [33] and [34] who are of the opinion that high temperature favoured the abundance of chlorococcales. Agbeti and Smot [35] confirmed that the low range of temperature do not support the chlorococcales. In this present investigation, high temperature 36.8°C was recorded in the summer season 2011 in S-4 and low temperature 29.5°C in monsoon season 2011 in S-4. Calcium and magnesium in higher concentration favour the abundance of chlorococcales as reported in this tank [36]. The Chlorophyceae constitutes about 32.50% as recorded in S-1 followed by 32.05% in S-3, 31.25% in S-2 and 26.74% in S-4. Some of the pollution tolerant species [30] identified during the present study are *Ankistrodesmus falcatus* (S-1, S-3 and S-4), *Scenedesmus quadricauda* (S-1 and S-3), *Scenedesmus dimorphus* (S-4) and *Tetraedron muticum* (S-2). The maximum species were recorded in S-4 because of rich in organic matter and agriculture runoff in this station.

Bacillariophyceae

The Bacillariophyceae (diatoms and desmids) in this group form an important part of freshwater or marine plankton. Diatoms are unicellular algae characterized by siliceous cell wall. The ecology of diatoms has been studied by several researchers like [37] and [35]. Diatoms are ubiquitous, unicellular microscopic organisms that form the basic bulk of planktonic population in freshwater characterized by siliceous cell wall. Parameters such as silicates, pH, dissolved oxygen, calcium play a significant role in regulating the distribution and periodicity of diatoms. Desmids are the most sensitive organisms and they perish when a slight change in water quality occurs due to the input of pollutants and have been regarded as the indicator organisms of water quality. About 40 genera and more than 1000 species of desmids are recorded which occur both in freshwater and marine water habitats. The ecology of desmids has been studied by several researchers like [38]. During the present investigation, the Bacillariophyceae members were the most dominant of all other groups. Its species composition was 40% in the total phytoplankton population. The Bacillariophyceae members dominated in S-3 (35.90%) followed by S-1 (35.00%), S-4 (34.88%) and S-2 (34.37%), respectively. [39] Observed an inverse relationship between temperature and diatomic population and discussed the importance of water temperature in the periodicity of diatoms. In this present investigation, high temperature (36.7°C) was recorded in summer season in S-3

supported the high growth of Bacillariophyceae members (4102 org/L) and low in monsoon season (915 org/L). [40] Have discussed the importance of temperature and bright sunshine on desmids that are evident from the results. pH is also one of the factors that influence the occurrence of diatoms. [41] Have concluded that alkaline pH favoured the abundance of diatom population. During the present investigation, higher density of diatoms was recorded when the pH was nearly alkaline. Dissolved oxygen is an important factor that influences the growth and development of diatoms. In the present study, dissolved oxygen content was low (100 mg/L) in the month of December 2011 in S-1 which resulted in the lowest density (1402 org/L) of diatoms during the same month. Similar results were reported by [36]. Seasonal variations of diatoms population showed maximum density during summer season (3254 org/L) and minimum (1487 org/L) in monsoon season in S-3. The same trend was observed by [29] and [42]. Some of the pollution tolerant species identified during the present study are Gomphonema parvulum (S-1, S-3 and S-4), Navicula cryptocephala (S-1 to S-4), Navicula cuspidate (S-4), Nitzschia palea (S-2, S-3 and S-4) and Synedra ulna (S-2, S-3 and S-4).

Euglenophyceae

Euglenoids are very sensitive group of flagellates, which respond to slight changes in the quality of water. During the present investigation the Euglenophyceae members were the least count of other groups in all the station. Euglenophyceae species composition of 10% was recorded in the total phytoplankton population. Euglenophyceae comprising species 11 was recorded in S-4 followed by 10 in S-3, 7 in S-1 and 6 in S-2. Many workers have studied the ecological aspects of euglenoids. [38] have considered that dissolved oxygen, free CO₂ as the chief factors that regulate the distribution of euglenoids in freshwaters. During the present investigation, higher concentration of CO₂ and low concentration of DO were found to be associated with increased density of euglenoids. High temperature regulates the multiplication of euglenoids. [43] were of the opinion that temperature in the range of 30 to 35°C may be suitable for the luxuriant growth of euglenoids. In the present investigation, S-4 was supported with the temperature of 35.6°C in summer season had high density (88 org/L) of euglenoids. [44] reported that higher phosphate and nitrate concentration supported the growth of euglenoids. In S-4, high nitrate (2.8 mg/L) supported luxuriant growth of euglenoids compared to other stations. The results of the study are in agreement with those of above researchers. Seasonal average showed a maximum density of 111 org/L during the summer season 2011 in S-4 and minimum (49 org/L) during the monsoon season 2010 in S-4. The same result was observed on [29]. [25] who recorded that Euglenophyceae were the most dominant during summer in their studies, which supported for the present results. Some of the pollution tolerant euglenoids [30] recorded from the study area are *Euglena viridis* (S-3), *Euglena gracillia* (S-2, S-3 and S-4) and *Phacus pleuronectes* (S-2 and S-4). The maximum and high density was recorded in S-4 which had organic matter and agriculture runoff and was highly polluted.

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