SEASONAL DIVERSITY OF SCENEDESMUS SP. IN A TEMPLE TANK: A CASE STUDY FROM CHENNAI, TAMIL NADU, INDIA

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ABSTRACT

A temple tank located in Chennai, Tamil Nadu was monitored for a period of one year to assess the seasonal diversity of Scenedesmus sp. contained in it. A total of 23 species of Scenedesmus were recorded throughout the study period. Highest diversity (23 species) was recorded during monsoon season. The results of water quality revealed organic pollution during monsoon season. Pollution tolerant species of Scenedesmus were also workedout.

Keywords: Sacred pond, Scenedesmus species, Water quality, Bio-indicators of pollution.

INTRODUCTION

The present investigation deals with the diversity of Scenedesmus species in Arulmigu Karaneeswarar Temple pond in Saidapet, Chennai, India. The previous study on Scenedesmus by Philipose (1967) reported thirty-one species in and around the Indian region. Apart from the sanctity attached to temple tanks, these water bodies help to recharge the wells in and around the area. In the Indian context, the word “tank” normally refers to a dug-out reservoir which has stepped on all sides reaching down to the water level. Usually, the rainfall is relatively low in chennai. Therefore, every effort was made to retain all the water that fell on the ground, through appropriate water retention and conservation strategies such as erys (lakes) (Madhavi Ganesan, 2008).

Phytoplanktons belonging to species of Microcystis, Oscillatoria, Scenedesmus, Euglena and Phacus are indicators of organic pollution in Dams (Ibrahim, 2017). Environmental parameters and other anthropogenic factors influence seasonal variations in the phytoplankton composition and water quality of dams and other reservoirs. Most of the phytoplanktons can tolerate various degrees of organic pollution and continuous bio monitoring programmes is necessary to control the organic pollution in these water bodies.

Algae are the dominant primary producers in lakes and ponds and are found in virtually every water body where there is sufficient light for photosynthesis. Algae are important bioindicators of environmental conditions for a variety of reasons (Stevenson and Smol, 2003). Knowledge of freshwater algae that respond rapidly and predictably to environmental change has been particularly useful, with the identification of particular indicator species or combinations of species being widely used in assessing water quality (Bellinger and Sigee 2015). Since decades, detailed information has
accumulated about the preferences and restrictions of different organisms (e.g. benthic macroinvertebrates, planktonic algae, fishes, macrophytes) to particular types of aquatic environment, and their potential to act as environmental monitors or bioindicators.

Naumann, (1927) states that the green alga *Scenedesmus quadricauda* is not a significant constituent of the pelagic plankton population of oligotrophic waters, although it is common or even abundant in eutrophic waters. It may also be present in the littoral regions of oligotrophic lakes, and lack of adequate nutrients prevents them from establishing in deeper regions.

A majority of algae are affected adversely by the gross pollution of streams with organic wastes mostly in the form of domestic sewage. After partial self-purification of the stream, diversity and population of the algae become much more numerous than are present in the clean portion of the water body, adjoining the area of pollution. This increase is due to the nutrients that are made available from the decomposing organic wastes. The un-decomposed organic wastes affect the growth of algae by causing chemical and physical changes in the waterbody. Increased turbidity reduces the light available for photosynthesis. Increased organic content in the water stimulates saprophytic and saprozoic organisms which compete for space with the algae. Certain constituents of the waste are toxic to many algae. Thus, many factors of the environment that are altered by the organic wastes have an effect on the diversity and population of algae (Palmer, 2006).


The main objective of the present study was to assess the diversity of Scenedesmus species in relation to the physicochemical characteristics of a sacred pond (tank) of Arulmigu Karaneeswarar temple, Chennai, Tamil Nadu and to find out species which is susceptible to environmental pollution.

**MATERIALS AND METHODS**

**Study Area**

Arulmigu Karaneeswarar temple tank is located in Saidapet in Chennai, Tamilnadu. The temple tank is located at 13° 1’ 29.15” N and 80° 13’ 23.595” E. Water samples were collected from the tank monthly during December 2016 – November 2017. The collected samples were brought to the laboratory and divided into two parts; one part was preserved in 4% formalin and the other part was subjected to physicochemical analysis. The water samples were analysed according to standard methods (APHA, 2000).

Microalgae observations were made using a light microscope. Taxonomical descriptions of taxa were determined on the basis of morphological features such as the outline of cells, number of lobes and depth of incisions in marginal cells, sculpture of cell wall, etc. Cell dimensions are given in description: width x length. In the case of marginal cells, the length of a cell includes the length of lobes. All observations were made using an oil immersion objective lens (10X x 100X magnification). Identification of the microalgae was done using monograph on Chlorococcales by Philipose (1967). The population of *Scenedesmus* species per unit volume of water sample was also determined by a Haemocytometer. The *Scenedesmus* species were expressed as organism per ml for the purpose of expressing population density.

**RESULTS**

The results concerning physico-chemical characteristics of water body is given in table 1 and that of the diversity of *Scenedesmus* species noticed in table 2. Also the distribution of the population of *Scenedesmus* species is depicted in table 3. The photographs of *Scenedesmus* species identified are depicted in Plate 2 (a and b).

**Results of physico-chemical characteristics of water**

Physico-chemical characteristics of water confining to the temple tank are shown in table 1. The appearance, colour and odour of water samples remained consistent throughout the study period.

Higher extent of chloride (100mg/l) and Total Dissolved Solids (420 mg/l) are noticed with the water samples during monsoon season. The areas surrounding the water body are occupied by regions rich in organic matter and an inflow of water to the tank has been noticed during rainy season. The higher extent of chloride and thereby organic load associated with the tank during monsoon season can be attributed to this reason. The higher extent of alkalinity, hardness, calcium, nitrite, nitrate, phosphate and residual chlorine were also noted to be higher during monsoon season. This can be reason for higher species
Table 1. Physico-chemical parameters of water samples

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Parameters studied</th>
<th>Winter</th>
<th>Summer</th>
<th>Monsoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Appearance</td>
<td>Turbid</td>
<td>Turbid</td>
<td>Turbid</td>
</tr>
<tr>
<td>2</td>
<td>Colour</td>
<td>Slightly greenish</td>
<td>Slightly greenish</td>
<td>Slightly greenish</td>
</tr>
<tr>
<td>3</td>
<td>Odour</td>
<td>Agreeable</td>
<td>Agreeable</td>
<td>Agreeable</td>
</tr>
<tr>
<td>4</td>
<td>Turbidity (NTU)</td>
<td>105</td>
<td>115</td>
<td>101</td>
</tr>
<tr>
<td>5</td>
<td>Electrical Conductivity (micromhos/cm)</td>
<td>306</td>
<td>455</td>
<td>378</td>
</tr>
<tr>
<td>6</td>
<td>pH at 25°C</td>
<td>8.72</td>
<td>7.7</td>
<td>8.2</td>
</tr>
<tr>
<td>7</td>
<td>Total Alkalinity (as CaCO₃) mg/l</td>
<td>100</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>8</td>
<td>Total Hardness (as CaCO₃) mg/l</td>
<td>50</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>9</td>
<td>Calcium (as Ca) mg/l</td>
<td>18</td>
<td>25</td>
<td>27</td>
</tr>
<tr>
<td>10</td>
<td>Magnesium (as Mg) mg/l</td>
<td>4</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>11</td>
<td>Sodium (as Na) ppm</td>
<td>43</td>
<td>48</td>
<td>39</td>
</tr>
<tr>
<td>12</td>
<td>Potassium (as K) ppm</td>
<td>4</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>13</td>
<td>Iron (as Fe) mg/l</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>14</td>
<td>Manganese (as Mn) mg/l</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>Free ammonia (as NH₃) mg/l</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>16</td>
<td>Nitrite (as NO₂) mg/l</td>
<td>0.1</td>
<td>0.2</td>
<td>0.2</td>
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<tr>
<td>17</td>
<td>Nitrate (as NO₃) mg/l</td>
<td>0</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>18</td>
<td>Chloride (as Cl) mg/l</td>
<td>50</td>
<td>50</td>
<td>100</td>
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<tr>
<td>19</td>
<td>Fluoride (as F) mg/l</td>
<td>0.2</td>
<td>1</td>
<td>1.5</td>
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<td>20</td>
<td>Sulphate (as SO₄) mg/l</td>
<td>24</td>
<td>23</td>
<td>22</td>
</tr>
<tr>
<td>21</td>
<td>Phosphate (as PO₄) mg/l</td>
<td>0.2</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>22</td>
<td>Residual chlorine (mg/l)</td>
<td>0</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>23</td>
<td>Total Dissolved Solids (mg/l)</td>
<td>240</td>
<td>360</td>
<td>420</td>
</tr>
</tbody>
</table>

The composition of *Scenedesmus* associated with the tank during monsoon season. The influence of nitrate content of water in sustaining micro algal population is well documented. Sampath Kumar (1977) observed that the nitrate content is higher in most of the water bodies during monsoon.

Also the water samples from the tank were noted to have high turbidity, electrical conductivity, magnesium, sodium and potassium content during summer season. The evaporation and subsequent concentration of salts in water attributed by higher solar incidence might have resulted in the higher concentration of these components in water during summer season. The extent of pH and sulphate content were higher in winter season. All other water quality parameters were noted to be lower in the tank during winter season.

Thus the results of water quality parameters indicated that there are differences in the quality of water with respect to seasons and the extent of various chemical components associated with the tank was higher during monsoon season.

**Results of micro algal diversity**

Also an assessment on the micro algal diversity of the temple tank indicated a higher extent of 23 species of *Scenedesmus* during monsoon, followed by 11 and 8 species during winter and summer seasons, respectively. Highest population of the species (cells/ml) was also recorded during monsoon season. Systematic description of the species identified, based on the monograph on *Chlorococcales* by M.T. Philipose, (1967) is given below:

**Class: Chlorophyceae**

**Order: Chlorococcales**

**Subfamily Scenedesmoideae**

**Genus Scenedesmus Meyen,**

The colony consists of a flat (rarely curved) plate of usually 2-4-8 (rarely 16-32), cells which are always in multiples of two. Cells acicular, ellipsoidal, ovoid or cylindrical, arranged in one or two rows are in lateral contact with each other. The cell wall is
smooth or granulate, with or without lateral ridges, lateral teeth or spines. Chloroplast single and parietal and often fills the cell, and possess a single pyrenoid. Thirty-one species were recorded from the India region.

1. Scenedesmus dimorphus (Turpin) Kuetzing (Pl.2 Fig.1) M.T. Philipose 1967. p.249, fig.160a, b, c. Colonies 4-8 celled, having cells arranged in a linear or sub alternating series (eight-celled colonies always in sub-alternating series). The colony of *S. dimorphus* differs from *S. Obliquus* in the outer cells of the colony being more or less lunate and the apices of the cells attenuated. Cells are 2-8 μm broad, and 14-35 μm long. Occurrence: Royal Lakes, Rangoon (Handa, l.c.); Museum Pond, Madras (Philipose, 1940); River Cooum, Madras (Iyengar and Venkataraman, 1951); ponds and tanks, Barrackpore.

2. *Scenedesmus dimorphus forma tortus* G.M Smith (Pl.2 Fig.2) M.T. Philipose 1967 p.251, fig.160d. The species differs from other species in having the central cells of the colony at an angle to the axes of the terminal cells instead of being parallel. Cells are 2.5-6.5 μm broad, and 20-34.3 μm long. Occurrence: Pond, Cuttack

3. *Scenedesmus bernardii* G.M.Smith (Pl.2 Fig.3) M.T. Philipose 1967 p.251,fig.162b. Colonies are four to eight cells. Internal cells are fusiform, lunate or sigmoid with acute apices and arranged alternately in contact with their apices or the apices of median portions of adjacent cells. Terminal cells are fusiform or lunate, usually attached to the apices of the inner cell and frequently at an angle to the plane of the

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Table 2. List of *Scenedesmus* species recorded from Arulmigu Karaneeswarar temple tank with respect to seasons.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the species</th>
<th>W</th>
<th>S</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Scenedesmus dimorphus</em> (Turpin) Kuetzing</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>2</td>
<td><em>Scenedesmus dimorphus</em> (Turpin) Kuetzing forma tortus G.M Smith</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>3</td>
<td><em>Scenedesmus bernardii</em> G. M. Smith</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>4</td>
<td><em>Scenedesmus bijugatus</em> var. graevenitzii (C. Bernard)</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>5</td>
<td><em>Scenedesmus bijugatus</em> forma parvus (G.M. Smith)</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>6</td>
<td><em>Scenedesmus bijugatus</em> forma irregularis Wille</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>7</td>
<td><em>Scenedesmus acutiformis</em> Schroder</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>8</td>
<td><em>Scenedesmus armatus</em> (Chodat) G.M. Smith</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>9</td>
<td><em>Scenedesmus armatus</em> var. bicaudatus (Guglielmetti) Chodat</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>10</td>
<td><em>Scenedesmus hystrix</em> Lagerheim</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>11</td>
<td><em>Scenedesmus denticulatus</em> var. australis Playfair</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>12</td>
<td><em>Scenedesmus smithii</em> Teiling</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>13</td>
<td><em>Scenedesmus smithii</em> var. linearis</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>14</td>
<td><em>Scenedesmus longus</em> var. naegelii (Brébisson) G. M. Smith</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>15</td>
<td><em>Scenedesmus opoliensis</em> var. mononensis Chodat</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>16</td>
<td><em>Scenedesmus protuberans</em> Fritsch et Rich</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>17</td>
<td><em>Scenedesmus rostrato-spinosus</em> Chodat</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>18</td>
<td><em>Scenedesmus abundans</em> (Kirchner) Chodat</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>19</td>
<td><em>Scenedesmus perforatus</em> Lemmermann</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>20</td>
<td><em>Scenedesmus quadricauda</em> (Turpin) Brébisson</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>21</td>
<td><em>Scenedesmus quadricauda</em> var. quadrispina (Chodat) G.M.Smith</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>22</td>
<td><em>Scenedesmus quadricauda</em> var. maximus West &amp; G.S.West</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>23</td>
<td><em>Scenedesmus quadricauda</em> var. westii G.M.Smith</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>24</td>
<td><em>Scenedesmus quadricauda</em> var. bicaudatus Hansgirg</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

W-Winter  S-Summer  M-Monsoon
colony. The cell wall is smooth and without spines or teeth. Cells measure 3-6.3 μm broad, and 8-23 μm long. Occurrence: N. America, Europe, India.

4. *Scenedesmus bijugatus var. graevenitzii* (C. Bernard) (Pl.2 Fig.4)  
M.T. Philipose 1967. p.252. fig.164a, 164b.  
Colonies are four to eight-celled. Cells fusiform, ellipsoid, or oblong-ellipsoid to ovoid with obtuse poles and are arranged in an alternating series with adjacent cells in contact only along a short portion of their length. Colonies are frequently aggregated in syncocenobia by the broken remains of parent cell walls as in *Dimorphococcus*. Cells measure 4.5-7.9 μm broad and 10-16.7 μm long. Occurrence: Planktonic in research station Tank, Barrackpore (W. Bengal); River Cauvery, Tanjore (Madras).

5. *Scenedesmus bijugatus forma parvus* (G.M. Smith) (Pl.2 Fig. 5)  
M.T. Philipose 1967. p.256. fig.164h.  
Colonies are four-celled with the cells in a regular subalternating series. Cells are much smaller than in var. *alternans* and usually oblong-ovoid. The cell wall is smooth (or rarely, finely punctate). Cells measuring 2.8-4 μm broad and 4.8-9 μm long. Occurrence: Museum Pond, Madras.

6. *Scenedesmus bijugatus forma irregularis* Wille (Pl.2 Fig.6)  
M.T. Philipose 1967 p. 253. fig.164m.  
This species differs from *S. bijugatus* form in the cells being arranged in an irregular sub-alternating or at times in an almost double series. Inner cells are often arranged laterally with basal contact. Colonies are 4- or 8 celled.

Table 3. Population distribution of *Scenedesmus* species (org/ml) recorded from Arulmigu Karaneeswarar temple tank with respect to seasons.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the <em>Scenedesmus</em> species</th>
<th>W</th>
<th>S</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Scenedesmus dimorphus</em> (Turpin) Kuetzing</td>
<td>36</td>
<td>30</td>
<td>56</td>
</tr>
<tr>
<td>2</td>
<td><em>Scenedesmus dimorphus</em> (Turpin) Kuetzing forma tortus G.M Smith</td>
<td>25</td>
<td>-</td>
<td>34</td>
</tr>
<tr>
<td>3</td>
<td><em>Scenedesmus bernardii</em> G.M. Smith</td>
<td>-</td>
<td>-</td>
<td>26</td>
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<tr>
<td>4</td>
<td><em>Scenedesmus bijugatus var. graevenitzii</em> (C. Bernard)</td>
<td>45</td>
<td>32</td>
<td>68</td>
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<tr>
<td>5</td>
<td><em>Scenedesmus bijugatus forma parvus</em> (G.M. Smith)</td>
<td>-</td>
<td>-</td>
<td>24</td>
</tr>
<tr>
<td>6</td>
<td><em>Scenedesmus bijugatus forma irregularis</em> Wille</td>
<td>-</td>
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<tr>
<td>7</td>
<td><em>Scenedesmus acutiformis</em> Schroder</td>
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<td>8</td>
<td><em>Scenedesmus armatus</em> (Chodat) G.M. Smith</td>
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<td><em>Scenedesmus armatus</em> var. bicaudatus (Guglielmetti) Chodat</td>
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<td><em>Scenedesmus denticulatus</em> var. australis* Playfair</td>
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<tr>
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<td><em>Scenedesmus longus</em> var. naegeli (Brébisson) G.M. Smith</td>
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<td>37</td>
<td>45</td>
<td>18</td>
</tr>
<tr>
<td>23</td>
<td><em>Scenedesmus quadricauda</em> var. westii* G. M. Smith</td>
<td>34</td>
<td>26</td>
<td>67</td>
</tr>
<tr>
<td>24</td>
<td><em>Scenedesmus quadricauda</em> var. bicaudatus* Hansgirg</td>
<td>23</td>
<td>-</td>
<td>45</td>
</tr>
</tbody>
</table>

W-Winter  S-Summer  M-Monsoon
the latter being more common. Cells measure 2.5-6 μm broad and 6.5-15 μm long.

Occurrence: Museum Pond, Madras; swamp, Kausalya Ganga, Puri, Orissa.

7. Scenedesmus acutiformis Schroder (Pl.2 Fig.7)
Colonies, 2-4-8 celled (usually 4-celled). Cells are cylindrical-fusiform and are in a single linear series. The cell wall is smooth. Median cells are with a lateral longitudinal ridge extending from pole to pole on each side. Terminal cells with two to four ridges. Poles of cells are acute and lack teeth or spines, but sometimes possess a minute papilla. Cells measure 3.8-8 μm broad, and 12-22.4 μm long.

Occurrence: Tank near Trincomalile, September (Crow, 1923); cess pool, Hyderabad; tank, Raipur (Madhya Pradesh).

8. Scenedesmus armatus (Chodat) G. M. Smith (Pl.2 Fig.8)
Colonies are usually four-celled, rarely two-or eight-celled. Cells are oblong-ellipsoid with acute spines and arranged in a linear series. Terminal cells are with a single long spine from each pole. All cells with a median lateral longitudinal rib which is sometimes indistinct or distinct only at either end of the cell. Cells measure 3-8 μm broad and 7-16 μm long. Four -celled colony measures 7-16 μm broad and 12-25 μm long.

Occurrence: Rockpool, Ceylon, September (Crow, 1923); pool at Companygunj, Khasia, Assam (Biswas, l.c.).

9. Scenedesmus armatus var. bicaudatus (Guglielmetti) Chodat (Pl.2 Fig.9)
M.T. Philipose 1967. p.262. fig.171e,f.
Colonies consist of two to four cells. They differ from the other types in having a long spine only from one of the poles of the terminal cell, the spines of the two terminal cells alternate with each other. Longitudinal ribs are usually seen only in the internal cells. Cells measure 2.5-4.6 μm broad and 8.3-12 μm long. Occurrence: Pond, Cuttack; Visakhapatnam (Andhra Pradesh) and Azhicode (Kerala).

10. Scenedesmus hystrix Lagerheim (Pl.2 Fig.10)
M.T. Philipose 1967.p.266.fig.173c.
Colonies are two-four-eight celled. Cells are oblong – cylindrical with obtuse ends and are arranged in a single linear series. The cell membrane is covered with minute spines, and measures 3-6 μm broad, and 12-20 μm long.

Occurrence: At Kamayut, lower Burma-April (Skuja, l.c.); pond, Dibrugarh (Assam).

11. Scenedesmus denticulatus var. australis Playfair (Pl.2 Fig.11)
M.T. Philipose 1967.p.271.fig.176g.
Colonies are two to four-celled. Cells are arranged in a single linear series, oblong or cylindrical with more or less rounded ends with one (very rarely with two) short teeth from the poles of all cells. Cells measure 4-7 broad and 13.5-21 μm long. Teeth are 1-1.8 μm long.

Occurrence: Loktak Lake, Manipur (Bruhl and Biswas, l.c.); Museum pond, Madras.

12. Scenedesmus smithii Teiling (Pl.2 Fig.12)
The colony is four-celled with the cells arranged in a subalternating series. The cells are less naviculoid with the sides of cells, in contact with one another and poles of cells possess 2-3 sharp spines which are often obliquely placed. Cells measure 5-10 μm broad and 15-23.5 μm long.

13. Scenedesmus smithii var. linearis (Pl.3 Fig.13)
It differs from the other types in that the cells are arranged in a linear series, and is in contact with adjacent cells except at the poles. Cells measure 6.6-7.5 μm broad, 19.4-21.2 μm long.

14. Scenedesmus longus var. naegelii (Brébiisson) G M. Smith (Pl.3 Fig.14)
M.T. Philipose 1967.p.274.fig.180c.
Colonies are two- four –eight-celled. Cells are more or less oblong to cylindrical to subpyriform with rounded ends, arranged in a linear or sublinear series. Terminal cells have a long recurved spine from one pole and a long or short, straight or slightly curved spine from one pole and a long or short or long, erect or recurved, spine usually only from one pole; but sometimes rudiments of spines from the other pole are also seen. Cells measure 5.3-11 μm broad, and 10.6-33 μm long.

Occurrence: Filter beds, Bengal (Bruhl and Biswas, l.c.); Srikakulam (Andhra Pradesh) and Visakhapatnam.

15. Scenedesmus opoliensis var. mononensis Chodat (Pl.3 Fig.15).
M. T. Philipose 1967.p.276.fig.181c.
The colony consists of two-four-eight cells (usually 4-celled). Internal cells are broadly fusiform with rounded ends and with or without a short or long spine from their poles. Terminal cells have attenuated, semi truncate to rostrate ends with a long, straight or recurved spine from each pole. Cells measure 3.5-10 μm broad, and 11-31.5 μm long. Spines of terminal cells measure 11-28 μm long.

Occurrence: Swamp Kausalya Ganga.
16. *Scenedesmus protuberans* Fritsch et Rich (Pl.3 Fig.16)  
M. T. Philipose 1967.p.276.fig.182.  
Colonies are usually four-celled, rarely 2- or 8-celled. Cells are arranged in a linear series and in close lateral contact with adjoining cells except at the ends. Terminal cells are longer than the inner cells with their apices drawn out and protruding, with a long spine usually arising from the outer side of each end. Inner cells are pointed or slightly truncated ends. The inner edge of the terminal cells and ends of inner cells sometimes have minute spines or granular thickenings. Cells measure 6-7 m broad and 25-34 m long with spines measuring 25-35 m long.

17. *Scenedesmus rostrato-spinosus* Chodat (Pl.3 Fig.17)  
M. T. Philipose 1967. p.278.fig.183.  
Colonies are mostly four-celled with the cells arranged in a linear series. Adjacent cells adnate to each other for a short length in the median region. Internal cells are oblong – fusiform. Terminal cells are slightly curved with the inner face concave and the outer face convex and with abruptly and obliquely retuse ends having a conspicuous angle at the inner edge with a long spine from the outer edge. The outer face of terminal cells is also with a shorter spine from the median region. Cells measure 10-13 m long.

18. *Scenedesmus abundans* (Kirchner) Chodat (Pl.3 Fig.18)  
M. T. Philipose 1967. p.278.fig.184 c,d.  
Colonies are usually 2-4 celled or rarely eight-celled, and arranged in a linear series. Cells are generally ovoid to oblong-ovoid. External cells have one or more median lateral spines from the outer face in addition to spines from the four corners of the colony. Internal cells are with 1-2 spines from their poles, or rarely lack such spines. Cells are 2-7 m broad, 6-15 m long and spines 3.5-8 m long.  
Occurrence: pond, Mandalay, Burma-November (Skuja l.c.); Dyke’s Tank, Visakhapatnam (Andhra Pradesh), common- December; Ponnampet tank, Coorg (Mysore).

19. *Scenedesmus perforatus* Lemmermann (Pl.3 Fig.19)  
Colonies are usually eight-celled, sometimes four-celled with capitae ends. The outer face of external cells is slightly convex with the inner face concave, the poles curved outwards with a long recurved spine. Internal cells have concave sides and linear to lenticular perforations between adjacent cells. The cell membrane is smooth or punctuate. Cells measure 3-10 m broad, 10-28 m long and Spines 10.6-25 m long and perforations 1.5-3.6 m broad.

20. *Scenedesmus quadricauda* (Turpin) Brébisson (Pl.3 Fig.20)  
Colonies are usually four-celled, sometimes 2 or 8-celled. Cells oblong-cylindrical with round ends and arranged in a linear series. Poles of terminal cells with a long, more or less straight or curved spine. Cell wall smooth and without ridges. Cells measure 3-7 m broad, 9-18.5 m long and spines 6.5-15 m long.

21. *Scenedesmus quadricauda* var. *quadrispina* (Chodat) G.M.Smith (Pl.3 Fig.21)  
Colonies are usually 2-4 celled. Cells are broadly ovoid and about twice as long as broad. Poles of terminal cells have a single short recurved spine. Cells are 3.5-8.5 m broad, 8.5-15-19 m long and spines 2.5-5.5 m long.  
Occurrence: Ponds and tanks, Cuttack, Visakhapatnam (Andhra Pradesh).

22. *Scenedesmus quadricauda* var. *maximus* West & G.S. West (Pl.3 Fig.22)  
M. T. Philipose 1967.p.286.fig.187g.  
Colonies are usually four-celled, rarely eight-celled. Colonies and cells are much larger in this type. Cells are 9-11.5 m broad, 27-36 m long and spines measure 18-30 m long.  
Occurrence: Artificial tank, Peradeniya, Ceylon (W. and G.S. West, 1902; Royal Lakes and pond, Cantonment Gardens, Rangoon (Skuja,l.c.).

23. *Scenedesmus quadricauda* var. *westii* G. M. Smith (Pl.3 Fig.23). M. T. Philipose 1967,p.286.fig187i.  
Colonies are usually four to eight-celled. Cells are 4.5-9-13 m broad, 10-22-29 m long and spines measure 10.6-16.7 m long.  
Occurrence: Ponds and lakes, Rangoon, Ponds, Cuttack, abundant, July and September and Azhicode (Kerala).

24. *Scenedesmus quadricauda* var. *bicaudatus* Hansgirg (Pl.3 Fig.24)  
Colonies are 2-4-8 celled. Terminal cells have a long spine from only one pole. The spine of one terminal cell is at an angle opposite to the other terminal cell. Internal cells any without spines from their poles. Cells measure 4-5 m broad, 8-12 m long and spines measure 7-8.8 m long.  
Occurrence: Ponds and tanks, Cuttack, rare-August, Visakhapatnam (Andhra Pradesh), and Madras.
DISCUSSION

In the present study, an influx of organic load was noticed with the water body with respect to seasons and the extent is higher during monsoon season. Blum (1956) observed that the addition of nitrates in the form of runoff water and organic pollution due to the entry of sewage in river Ganges was considered to be a function of enrichment, a characteristic feature of rivers. Further, high nitrogen content was recorded when the rainfall was maximum, since nitrogenous substances were mostly carried into the stream by run-off water and appeared to be abundant at the time of heavy rains. The depletion of nitrate in winter and summer season can happen due to the photosynthetic activity of the algal population or may be due to the oxidation of organic compounds.

The growth of algae is affected by environmental factors in a number of ways. They may be discouraged from growing as a result of being deprived of sunlight; the substances may be toxic or may ecologically modify the physical or chemical environment sufficiently to retard or prevent growth; they may suddenly have competition with additional organisms; certain algae may be stimulated to increased growth and multiplication; a change also occurs in the individual types or the groups of organisms that predominate (Palmer, 1969). In the present study, a higher extent of diversity with respect to *Scenedesmus* species is noticed in the water body, with respect to seasons.

The density and diversity of phytoplanktons and their association as biological indicators in the assessment

Plate 2 (a). Species diversity *Scenedesmus* in water samples of Arulmigu Karaneeswarar temple tank

1. *Scenedesmus dimorphus* (Turpin) Kuetzing
2. *Scenedesmus dimorphus* (Turpin) Kuetzing *forma tortus* G.M Smith
3. *Scenedesmus bernardii* G.M Smith
4. *Scenedesmus bijugatus* var. *graevenitzii* (C.Bernard
5. *Scenedesmus bijugatus* *forma parvus* (G.M. Smith)
6. *Scenedesmus bijugatus* *forma irregularis* Wille
7. *Scenedesmus acutiformis* Schroder
8. *Scenedesmus armatus* (Chodat) G.M. Smith
9. *Scenedesmus armatus* var. *bicaudatus* (Guglielmetti) Chodat
10. *Scenedesmus hystrix* Lagerheim
11. *Scenedesmus denticulatus* var. *australis* Playfair
of water quality have been worked out by Round, (1965) and Clesseri et al., (1998). The higher concentration of effluents and low water level in water bodies indirectly increases the phosphate and nitrates concentrations, thereby increasing the growth of phytoplanktons. Nandan and Aher (2005) have shown that the algal genera, Euglena, Oscillatoria, Scenedesmus, Navicula, Nitzschia and Microcystis are found in organically polluted waters. Species of algae like Ankistrodesmus, Scenedesmus, Closterium, Crucigenia, Kirchneriella, Pediastrum, Chroococcus, Merismopedia, Oscillatoria, Navicula, Fragillaria, Synedra, Phacas and Trachelomonas are reported as pollution indicators (Prathap Singh and Regini Balasingh, 2011). Kshirsagar et al. (2012), showed the dominance of Chlorella, Scenedesmus, Pediastrum, Oscillatoria, Melosira, Navicula, Nitzschia, Gomphonema, Euglena etc., throughout their study. Similar observations were made by Hosmani and Bharti (1980); Trivedi (1988); More and Nandan (2000). Palmer (1980) stated that the presence of Scenedesmus indicates the eutrophication of the water body. Dadadahalli Lake, Dalvoi Lake and Karanji Lake which were organically polluted recorded the presence of species of Euglena, Scenedesmus, Lepocinclis and Synedra. These algae species are the top indicators of water quality (Hosmani, 2013). Kshirsagar (2013) in his study of algae sensitive to water pollution in the case of river Mula showed the dominance of Scenedesmus quadricauda, Chlorella vulgaris, Oscillatoria limosa and Melosira granulate throughout the year. These genera are considered to be indicators of organic pollution in fresh water.

Plate 2 (b). Species diversity of Scenedesmus in water samples of Arulmigu Karaneeswarar temple tank

13. Scenedesmus smithii var. linearis
14. Scenedesmus longus var. naegellii (Brébisson) G.M.Smith
15. Scenedesmus opoliensis var. mononensis Chodat
16. Scenedesmus protuberans Fritsch et Rich
17. Scenedesmus rostrato-spinosus Chodat
18. Scenedesmus abundans (Kirchner) Chodat
19. Scenedesmus perforatus Lemmermann
20. Scenedesmus quadricauda (Turpin) Brébisson
21. Scenedesmus quadricauda var. quadrispina (Chodat) G.M.Smith
22. Scenedesmus quadricauda var. maximus West & G.S.West
23. Scenedesmus quadricauda var. westii G.M.Smith
24. Scenedesmus quadricauda var. bicaudatus Hansgirg.

From the above-mentioned list of most pollution tolerant species of Scenedesmus, 7 species in monsoon, 4 species in winter and 5 species in summer were found in the present study, indicating the presence of high levels of organic nutrients in temple tank during monsoon season (table 4).

**CONCLUSION**

A seasonal survey of water quality and resultant algal population of the sacred pond Indra Tirtham located in Arulmigu Karaneeswarar Temple, Saidapet, was carried out for a period of one year. Highest diversity of Scenedesmus sp. (23 sps.) and highest population (cells/ml) were recorded in the monsoon season. Six species of Scenedesmus were present throughout the three seasons. Of these, the occurrence of five species; Scenedesmus dimorphus (Turpin) Kuetzing, Scenedesmus bijugatus var. graevenitzii (C. Bernard), Scenedesmus bijugatus forma parvus (G.M. Smith), Scenedesmus bijugatus forma irregularis Wille, Scenedesmus denticulatus var. australis Playfair, had already been reported by Philipose in 1967 from Madras region of Tamil Nadu.

The physicochemical analysis of water samples from the temple tank showed elevated levels of organic materials during monsoon periods. The diversity of seven species of Scenedesmus in the water body, which is organically polluted, is indicative of their capacity as a pollution indicator in aquatic environments.

**ACKNOWLEDGEMENT**

The authors gratefully acknowledge the help and facilities extended by the Secretary, RKM. Vivekananda College, Mylapore, Chennai, Tamil Nadu, for the study.

**REFERENCES**


