Available online at www.elixirpublishers.com (Elixir International Journal)

Applied Botany

Elixir Appl. Botany 84 (2015) 33963-33969

ISSN: 2229-712X

# Limnological Studies of Thirupathisaram Temple Pond in Kanyakumari District of Tamil Nadu, India

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**ARTICLE INFO**

**Article history:**
Received: 8 June 2015;
Received in revised form:
15 July 2015;
Accepted: 25 July 2015;

**Keywords**
Thirupathisaram temple pond,
Bacillariophyceae,
Chlorophyceae,
Cyanophyceae,
Euglenophyceae.

**ABSTRACT**

Seasonal variations in the water qualities and algal diversity of Thirupathisaram temple pond in Kanyakumari district was studied for the period of one calendar year (2014). The physico-chemical parameters like water temperatures, transparency, pH, dissolved oxygen, total dissolved solids, free $CO_2$, carbonates, bicarbonates, chlorides, Calcium, phosphates, nitrates, magnesium and sulphate were analysed and correlated with seasonal variation in the algal count of the pond water. Out of 105 microalgae recorded in the pond, 24 species belonged to Bacillariophyceae (22.85%), 42 species belonged to Chlorophyceae (40%), 32 species belonged to Cyanophyceae (30.47%) and 7 species belonged to Euglenophyceae (6.7%). Members of Chlorophyceae, Cyanophyceae and Euglenophyceae were found maximum during the summer and declined during the winter and monsoon seasons whereas the members of Bacillariophyceae were maximum during the rainy season and they declined during the summer. An increasing trend in Photosynthetic productivity of algae was found from the rainy season to summer. Algal bloom was observed during the summer months and microalgae such as *Navicula cincta*, *Nitzschia amphibia*, *Pediastrum boryanum*, *Tetraedron trigonum*, *Microcystis aeruginosa f. flos-aqueae* and *Microcystis wesenbergii* were found as dominant among the species studied. Water in the temple pond was slightly eutrophic in nature.



## Introduction

Temple ponds are typical lentic water systems that are found in the vicinity of temples which are especially the centers of worship for Hindus and Sikhs elsewhere in India. Small temples at least have a well in their vicinity, from which local people most often fetch water for their domestic uses as the water is free of contaminants while large temples have a pond erected with stone wall and steps for bathing and washing the hands and feet before entering the temples for worshiping the deities. Thirupathisaram temple is one of the 108 Vaishnava shrines located at Thirupathisaram in Kanyakumari district and it has a temple pond to the east side. It is said that water in this pond can purify all the impurities and sins of people who take bath in the pond before worshipping the deities. In order to keep the pond clean, the temple management has imposed some restrictions to avoid the use of pond for washing clothes, use of detergents while bathing and throwing dirty things into the pond. Devotees most often wash their limbs or take bath or take some drops of water and placing it on their forehead before entering the temple for worship. This paper analyses the physico-chemical parameters and algal diversity of the pond water during 2014.

Swain and Adhikary (1991) have reported that most of the temple tanks, which are habitually used by pilgrims and devotees for various religious performances in India, are now polluted due to dumping of organic materials and dirt into the reservoirs. Characteristic algal bloom comes up in the polluted water and indicates the water quality of the reservoirs (Philipose, 1972; Treshow, 1970). Further, increased demand for water due to the rapid population growth, agriculture and industrial development has usurped environmentalists to determine the physical, chemical and biological characteristics of natural water resources (Sawant and Telave, 2009). Therefore, it is necessary to assay the algal components of the water bodies as well as physic-chemical characteristics of water bodies while testing the water quality in almost all circumstances (Krishnamoorthi and Chaudhury, 1990; Ingrid Chorus and Jamie Bartram, 1999).Swain *et al.*, (1994) and others were carried out Limnological investigations of the temple tanks of Purito determine the water quality. Physico-chemical characteristics of water in Padmahapapuram temple tank and Parvathipuram temple tank of Kalkulam taluk in Kanyakumari district were already investigated by Jemi and Balasingh, (2011). The present work was aimed to analyse the physico-chemical characteristics and algal components of Thirupathisaram temple pond in Agasteeswaram taluk of Kanyakumari district to assess the water quality for domestic use.

## Materials and Methods

Thirupathisaram is located at just 3 Km away from Nagercoil and it lies at 8º05´N and 77º30´ E. Thirupathisaram shrine was built by Travancore Kings in the 17$^{th}$ century in the middle of the Brahmin settlement at Thirupathisaram village which is located in the middle of a large stretch of paddy fields. Temple pond is located at the eastern side of the temple. This is a rectangular pond with the size of 600 feet length, 500 feet width and 18 feet depth, and it has stone lining on all sides and steps at western side. Water is supplied to the pond from Pazhayar river and excess water is drained out through an outlet in eastern side of the pond. This temple pond is about 400 years old perennial water body that has been used for bathing and various religious ceremonies by pilgrims.

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Water samples were collected at monthly interval from January 2014 to December of 2014, on 15th or 16th day of every month. Each four number of samples from the four corners, four sides and two samples from the center of the pond were taken in plastic jerkins before noon and carried to laboratory for the investigation. Surface water temperature, transparency, pH and dissolved oxygen concentration were measured at the spot itself using mercury thermometer, Secchi disc, Systronic digital pH meter and Winkler's method (APHA) respectively. BOD, free carbon-dioxide, total hardness, chloride, total phosphate, nitrogen, magnesium and sulphate content were tested in the laboratory according to the methods described by Adoni (1985) and APHA (1975). Light and dark bottle method of Gaardner and Gran (1972) was used for estimating gross primary production. For identification of algal species, samples were collected using plankton net (NXX13, 15μ), fixed with Lugol's iodine solution immediate after collection and the samples observed under Light Microscope for identifying algal species according to the standard monographs (Desikachary 1959; Philipose, 1967; Thompson, 1959; Anand, 1998; Krishnamoorthi, 2000). For counting the number of algal cells, one drop of sample was taken in a Neubauer haemocytometer counting chamber and the cell number was counted under a light microscope. Species abundance of algal components is calculated by the following formula:

$$Species\ abundance = \frac{\text{Total number of individuals in all samples}}{\text{Number of samples in which the species occurred}}$$

**Results and Discussion**

Table 1 illustrates the seasonal variation in the physico-chemical characteristics of the temple pond during 2014. The surface water temperature of the pond ranged from 25.3°C to 28.5°C from monsoon (Nov) to summer (April), which shows the impact of seasonal variation in the atmospheric temperatures of the study area. Transparency of water increased gradually from 70cm to 99cm from summer (March) to monsoon (Nov). The variation of transparence of water may be due to the dilution of algal biomass and suspended particles present in the water body as reported by Swain *et al.*, (1994) in temple tanks of Puri. The pH was within the range of 7.1 -8.8 entire period of study. This is mainly due to the variation in the dilution of water body by supply of river water and rainfall during monsoon. Dissolved oxygen (DO) content was lower in the monsoon (5.3mg/L) than in the summer months (8.6mg/L), which showed a negative correlation with temperature due to the oxidation of free oxygen during the summer (Patil and Dongare, 2006) and due to solubility of high amount of oxygen during the monsoon. The estimated DO level was almost identical to the DO values estimated in Parvathipuram temple tank (Jemi and Balasingh, 2011). Total dissolved solids (TDS) was maximum during summer (68.6 mg/L) and minimum during monsoon (45.3mg/L), which coincide with the findings of Narayan *et al.*, (2007), Kavitha and Balasingh (2007) and Jemi and Balasingh (2011).

The free $CO_2$ level increased from 2 mg/L (April) to 6.7mg/L (Oct-Nov),which might be due to high rate of $CO_2$ consumption during the warmer season by the dense population of algae and dilution of phytoplankton during the monsoon season. A similar result has reported by Philipose (1972). The estimated $CO_2$ level was more or less equal to the $CO_2$ levels observed in the temple tanks of Kalkulam taluk by Jemi and Balasingh(2011). Cole (1975) reported that free CO2 supply rarely limits the growth of phytoplankton in freshwaters. The BOD values which indicate the purity of water for domestic use were highest during the summer (5.85 mg / L) and lowest during the monsoon (2.99 mg / L), which agrees with the observations of Avinash and Prabhakar (2009), Thirugnanamoorthy and Selvaraju (2009) and Jemi and Balasingh (2011) in various temple tanks in India. The bicarbonates alkalinity that is a source of carbon for aquatic algae (Rawson, 1939), ranged from 82 to 123 mg/L during the summer to monsoon, which might be due to the fast consumption of .$CO_2$ for photosynthesis during the summer and its low availability in the water during the monsoon season as pointed out by Swain *et al.*, (1994). The estimated bicarbonate levels were almost identical to those values estimated in Parvathipuram temple tank in Kanyakumari district by Jemi and Balasingh(2011).Chloride content of this temple pond was ranging from 25.7 mg/L (January) to 92 mg/L (November), which indicates the slightly eutrophic status of the water throughout the year. The chloride content is slightly higher than that reported in both Padmanabapuram temple pond and Parvathipuram temple pond in Kanyakumari district (Jemi and Balasingh, 2011).

High value of Calcium (33.1mg/L) was observed during March and minimum during November (17mg/L). But in concerned with chlorides, the maximum value of 92mg/L was recorded in October and November and the minimum was observed during January (25.7mg/L). Although calcium is always found in high proportion in all freshwaters due to weathering of rocks, its concentration is relatively higher during the summer and northeast monsoon seasons than in the south west monsoon season. Swain *et al* (1994), Chandrasekar and Kodarkar (1995) and Sulabha and Prakasam (2006) have also noticed higher concentration of calcium in freshwater lakes during the summer and months in which rainfall is low. The rise in the chloride and calcium contents in freshwater bodies may be due to the high water temperature that facilitates the evaporation and transpiration of more water from the surface (Mishra and Yaddhav, 1978). The calcium combines with carbonates to form calcium carbonate which is responsible for the alkalinity of waters (Zafar, 1964). Magnesium content of water varied from 7.4 to 10.8 mg/L and is slightly low compared to the magnesium content in Padmanabapuram and Parvathipuram temple ponds (Jemi and Balasingh, 2011).Calcium and magnesium have antagonistic effects for neutralizing the excess acidic ions in the water (Munawar, 1970) and thereby support for the growth of aquatic algae and animals. The phosphate content was between the range of 0.57 - 0.84 mg/L and it was the highest during the summer. The phosphate concentration above 0.5 mg/L indicates pollution (Jain *et al.*, 1996). As the temple pond is located in the village surrounded by many rice fields, phosphate fertilizers might have leached into the ponds. Nitrate concentration ranged from 0.37 (monsoon) to 0.58 mg/L (summer), which may be due to the decay of aquatic macrophytes in large amounts because of the effect of summer (Kodarkar, 1995). Sulphate content was between the range of 4.9 – 10.6mg /L and it was low in the monsoon season and highest in the summer. High content of sodium, chloride, sulphate, phosphate and nitrate makes the water unfit for human consumption as per the Water Quality Standards of India.

Table 2 clearly depicts various species of microalgae and their seasonal abundance in the Thirupathisaram temple pond. There was a total of 105 species of microalgae, of which 24 species belonged to Bacillariophyceae, 42 species belonged to Chlorophyceae, 32 species belonged to Cyanophyceae and 7 species belonged to Euglenophyceae. Chlorophyceae (40%) was the dominant algal group, followed by Cyanophyceae (30.47%), Bacillariophyceae(22.85%) and Euglenophyceae (6.7%), which coincide with the findings of Gaunker and Kerkar (2004), Kavitha *et al.*, (2005), Murugan (2008) and JacklinJemi and ReginiBalasingh (2011) in various temple ponds in South India.

During the post-monsoon season (Jan-March), *Mastogloia oxigua, Pinnularia viridis, Ulothrix variables, Closteridium obesum*, *Crucigenia tetrapedia*, *Spirogyra varians, Closterium calosporum, Uronema*, *Stigeoclonium eubricum, Chroococcus disperses, Chroococcus micrococcus, Chroococcus minor, Gloeocapsa nigrescens, Gloeocapsa punctata, Merismopedia elegans, Merismopedia punctata, Oscillatoria magartifera, Phormidium pachydermaticum, Nostoc calcicola, Aphanosophon flos-aquae, Euglena, spirogyra, Lepocincilis playfairiana* and *Phacus curvicauda* were rare (1-4 /L), *Microcystis wesenbergii*, *Microcystis aeruginosa f. flos-aueae, Chlorella vulgaris, Pediastrum boryanum, Navicula cuspidata, Navicula radiosa* and *Nitzschia amphibian* were frequent (15-29/L), and all other species were occasional (5-14/L) in distribution. In the summer (April-June), *Navicula cincta, Nitzschia amphibia, Pediastrum boryanum, Tetraedron trigonum, Cladophora glomerata, Microcystis aeruginosa f. flos-aqueae* and *Microcysti swesenbergii* were abundant (30-99/L), which were the main components of algal bloom in the water, *Achnanthes inflata, Amphora ovalis, Anomoeneis serians, Cymbella tumida, Diatoma vulgaris, Eunotiamonodon, Mastogloia oxigua, Navicula cuspidata, Navicula radiosa, Nitzschia palaceae, Pinnularia interrupta, Pediastrum tetras, Scenedesmus armatus, Euastrum bidentatum, Euastrum insulare, Chlorella vulgaris, Chlorella conductrix, Hydrodictyon reticulatum, Ankistodesmus convolutes, Closterium purvulum, Microcystis aeruginosa, f. aeruginosa, Microcystis viridis, Gloeocapsa magma, Arthrospira jenneri, Lyngbya martensiana, Oscilltoria tenuis, Calothrix fusca, Merismopedia punctata, Anabaena flos-aquae, Euglena ehrenbergii, Euglena spirogyra, Lepocincilis playfairiana, Phacus accuminatus, Phacus. Caudatus,* and *Phacus indicus,* were frequent, and all other species were occasional in abundance class.

Most of the species of occasional distribution during the post monsoon had attained the status of frequent and abundant distribution during the summer because of high temperature, light intensity and nutrients level that favour the growth of algae in freshwaters.During the South -West Monsoon (July-Sep), the algal growth had declined gradually but surely because of the slight continuous rains and cloudy weather that negatively influence the photosynthesis and because of the dilution of nutrients in the water due to the input of more rain water and much overflow from the pond. Hence, *Achnanthes inflate, Amphora ovalis, Anomoeneis serians, Navicula cuspidata, Nitzschia amphibian, Pediastrum boryanum, Scenedesmus armatus, Selenastrum biraianum, Cladophora glomerata, Euastrum bidentatum, Chlorella conductrix, Dictyosphaerium pulchellum, Microcystis aeruginosa f. flos-aueae, Microcystis aeruginosa, f. aeruginosa, Microcystis wesenbergii, Microcystis viridis, Oscillatoria curviceps, Lepocincilis playfairiana,* and *Phacus accuminatus,* were frequent, *Navicula cincta* was abundant , *Crucigenia tetrapedia, Actinastrum hanzchi, Closterium calosporum, Uronema*sps., *Stigeoclonium eubricum, Chroococcus micrococcus, Chroococcus minor, Aphanosophon flos-aquae* and *Phacus Caudatus* ,were of rare occurrence and all the others were occasional in *Oscillatoria magartifera, Phormidium pachydermaticum, Nostoc calcicola,* distribution.

During the North-East Monsoon season (Oct-Dec), the rainfall was high and hence the rate of dilution of nutrients and carbon dioxide was high and at the same time there was minimum sunlight and temperature, because of which the algal abundance declined further to the least level and most species were forced towards the status of rare and occasional distribution. *Amphora ovalis, Anomoeneis serians, Eunotia monodon, Pinnularia viridis, Ulothrix variables, Closteridium obesum, Crucigenia tetrapedia, Actinastrum hanzchi, Spirogyra varians, Closterium calosporum, Cosmarium subcostatum, Uronema*sps., *Stigeoclonium eubricum, Aphanothece bullosa, Chroococcus disperses, Chroococcus micrococcus, Chroococcus minor, Gloeocapsa nigrescens, Gloeocapsa punctata, Merismopedia elegans, Merismopedia punctata, Oscillatoria magartifera, Phormidium pachydermaticum, Nostoc calcicola, Calothrix fusca, Anabaena flos-aquae, Gloeotrichiapisum, Aphanosophon flos-aquae, Euglena spirogyra, Phacus Caudatus* and *Phacus curvicauda* were rare in distribution while all others were occasional in distribution.

From these observations, it is clear that algal species which were frequent during the post-monsoon season becomes abundant in the subsequent summer that is endowed with more sunlight, high temperature and more level of dissolved carbon dioxide and minerals, and that the selective force for the bloom forming species would be the microclimate that decides which species has to be flourished to attain the maximum density. In this temple pond, *Navicula cincta, Nitzschia amphibia, Pediastrum boryanum, Tetraedron trigonum, Microcystis aeruginosa f. flos-aqueae* and *Microcystis wesenbergii* were found to have opportunities to produce algal blooms in the summer months. The present investigation is in the same line of the reports of Pendse *et al.,* (2000), Gaunker and Kerkar (2004).Kavitha *et al.,* (2005) and JacklinJemi and ReginiBalasingh (2011).

Table 3 illustrates that the number of Chlorophyceae, Eugleophyceae and Cyanophyceae is minimum during the monsoon season and it is the maximum during the summer while the number of Bacillariophyceae was minimum during the summer and maximum during the rainy season. The maximum density of Chlorophyceae in the summer months might be due to the influence of physic-chemical factors like high pH, alkalinity, dissolved oxygen, $CO_2$ and TDS as has been reported by Hosmani (1988), Gonzalves and Joshi (1964) and Gahotri *et al*., (1980).

The density of *Cyanophycean* members had attained the maximum level during the summer and then gradually decreased during winter and rainy seasons because of the reason that higher values of pH, temperature, phosphate, and nitrate and $CO_2$ in the water during the summer months had influenced their fast growth and the influences were so weak to induce growth during the rainy season (Philipose, 1959; Naik *et al*., 2005; Kavitha and Balasingh,2007; Murugan, 2008).

The members of Bacillariophyceae were more abundant in rainy season than in the summer since slight fall in pH, phosphate, nitrates, $CO_2$, TDS and DO favour the growth of most diatoms. This finding is in close conformity with the reports of Munawar (1970), Velecha and Bhatnagar (1988), Tripathy and Pandey (1990), Jose and Patel (1991), Chitra and Meena (2004). The density of Euglenophyceae was found to be the maximum in the summer months and low in the rainy season because their growth is influenced by high pH, $CO_2$ alkalinity, DO, Nitrate, phosphate and TDS during the summer (Kavitha and Balasingh, 2007; Murugan, 2008; Thirugnanamoorthi and Selvaraju, 2009).

The total cell count ranged from 10167 /L (October) to 14687 /L (May), which shows that the density of algae in the temple pond increases from October to May and then it declines gradually, which shows close conformity with the findings of JacklinJemi and ReginiBalasingh (2011) in temple ponds of Kanyakumari district.

**Table 1. Average conditions of physico-chemical parameters of water in Thirupathisaram temple pond during 2014**

| Parameter | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Water temperature | 25.9±0.7 | 27.3±0.5 | 28.4±0.4 | 28.5±0.5 | 26.41±0.7 | 25.5±0.8 | 25.7±12 | 25.9±0.6 | 25.8±0.4 | 25.5±0.3 | 25.3±0.2 | 25.8±0.7 |
| Transparency | 71±3.0 | 73±2.0 | 70±3.0 | 68±2.0 | 70±3.0 | 76±4.0 | 79±2.0 | 82±4.0 | 96±3.0 | 98±2.0 | 99±3.0 | 92±3.0 |
| pH | 7.6±3.0 | 7.8±0.2 | 8.4±0.3 | 8.6±0.3 | 8.8±0.4 | 8.2±0.3 | 8.0±0.2 | 7.9±0.3 | 7.6±0.3 | 7.2±0.3 | 7.1±0.2 | 7.2±0.3 |
| DO ($mg/l^{-1}$) | 7.1±0.2 | 6.4±0.1 | 5.4±0.3 | 5.3±0.2 | 8. 2±0.2 | 8.2±0.2 | 8.4±0.3 | 8.5±0.3 | 8.5±0.4 | 8.4±0.3 | 8.6±0.3 | 8.3±0.3 |
| TDS (mg/L) | 62±5.0 | 65±7.0 | 68±5.0 | 68±6.0 | 65.4±2.0 | 65±3.0 | 63±4.0 | 60±2.0 | 54±3.0 | 51±2.0 | 48±2.0 | 45±3.0 |
| Free $CO_2$ ($mg.\ l^{-1}$) | 2.3±0.2 | 2.1±0.3 | 2.1±1 | 2.0±0.2 | 4.2±0.3 | 5.3±0.3 | 5.8±0.2 | 5.9±0.3 | 6.3±0.3 | 6.7±0.2 | 6.7±0.3 | 6.2±0.2 |
| BOD (mg/L) | 3.61±1.0 | 4.52±0.5 | 4.81±0.8 | 4.98±2.0 | 5.46±0.4 | 5.85±0.3 | 4.9±2.0 | 4.62±0.5 | 4.51±0.6 | 4.11±2.0 | 3.6±1.0 | 2.99±0.2 |
| Carbonate (mg/L) | 5.5±2.0 | 6.3±2.0 | 6±1.2 | 6.3±3.0 | 6.9±2.0 | 7.3±3.0 | 8.2±3.0 | 8.5±1.0 | 8.6±2.0 | 8.6±1.0 | 8.6±3.0 | 7.8±2.0 |
| Bicarbonate (mg/L) | 82±4.0 | 82±3.0 | 83±3.0 | 84±4.0 | 96±6.0 | 102±3.0 | 108±7.0 | 112±8.0 | 120±6.0 | 123±3.0 | 122±6.0 | 96±7.0 |
| Chloride (mg/L) | 25.7±4.0 | 26.6±.03 | 26.8±4.0 | 28±3.0 | 69±4.0 | 72±6.0 | 89±6.0 | 90±6.0 | 91±6.0 | 92±3.0 | 92±4.0 | 63±3.0 |
| Calcium (mg/L) | 32.5±1.0 | 32.9±1.0 | 33±2.0 | 32.8±1.0 | 29±1.0 | 27±1.0 | 23±1.0 | 20±2.0 | 20±1.0 | 18±2.0 | 17±1.0 | 23±1.0 |
| Phosphates (mg/L) | 0.83±0.2 | 0.84±0.2 | 0.84±0.3 | 0.83±0.2 | 0.76±0.3 | 0.71±0.2 | 0.64±0.2 | 0.60±0.2 | 0.59±0.2 | 0.58±0.2 | 0.57±0.2 | 0.63±0.2 |
| Nitrates (mg/L) | 0.57±0.3 | 0.58±0.2 | 0.58±0.4 | 0.57±0.4 | 0.50±0.3 | 0.48±0.3 | 0.46±0.2 | 0.41±0.3 | 0.40±0.2 | 0.37±0.2 | 0.34±0.2 | 0.41±0.3 |
| Magnesium (mg/L) | 10.2±0.2 | 10.6±0.2 | 10.8±0.3 | 10.4±0.3 | 9.4±0.3 | 9.2±0.2 | 8.9±0.3 | 8.1±0.2 | 7.8±0.2 | 7.6±0.2 | 7.4±0.3 | 8.2±0.2 |
| Sulphate (mg/L) | 4.9±0.2 | 5.1±0.3 | 5.2±0.2 | 5.2±0.4 | 6.3±0.3 | 7.1±0.3 | 7.9±0.1 | 8.3±0.3 | 9.1±0.4 | 9.8±0.3 | 10.6±0.6 | 6.8±0.3 |

**Table 2. Seasonal variation in the abundance of microalgae in Thirupathisaram temple pond during 2014**

| No. | Name of algal species | JAN-MAR | APR-JUN | JUL-SEP | OCT-DEC |
|---|---|---|---|---|---|
| Class: Bacillariophyceae | | | | | |
| 1. | *Achnanthes inflate* Kutz. | + | ++ | ++ | + |
| 2. | *Amphora ovalis* Kutz. | + | ++ | ++ | - |
| 3. | *Anomoeneis serians* (Breb.) Celve | + | ++ | ++ | - |
| 4. | *Cymbella tumida* (Breb.) | + | ++ | + | + |
| 5. | *Diatoma vulgaris* Bory | + | ++ | + | + |
| 6. | *Eunotiamonodon* Her. | + | ++ | + | - |
| 7. | *Fragillaria intermedia* Grun | + | + | + | + |
| 8. | *Frustulia rhomboids* (Ehr.) De Toni | + | + | + | + |
| 9. | *Gomphonema herculeana* (Ehr.) Cleve | + | + | + | + |
| 10. | *Mastogloia oxigua* Lewis | - | ++ | + | + |
| 11. | *Navicula cincta* Kutz. | + | +++ | +++ | ++ |
| 12. | *Navicula cuspidate* Kutz. | ++ | ++ | ++ | + |
| 13. | *Navicula radiosa* Kutz. | ++ | ++ | + | + |
| 14. | *Nitzschia amphibian* Grun. | ++ | +++ | ++ | + |
| 15. | *Nitzschia brebissonii* W. Smith | + | + | + | + |
| 16. | *Nitzschia palaceae* (Kutz.) | + | ++ | + | + |
| 17. | *Nitzschia vitrea* Norman | + | + | + | + |
| 18. | *Pinnularia braunii*Grun. | + | + | + | + |
| 19. | *Pinnularia interrupta* W. Smith | + | ++ | + | + |
| 20. | *Pinnularia viridis* (Nitzsch) Ehr. | - | + | + | - |
| 21. | *Surirella elegans*Ehr. | + | + | + | + |
| 22. | *Synedra ulna* (Nitz.) | + | + | + | + |
| 23. | *Tabellaria fenestrate* | + | + | + | + |
| 24. | *Tabellaria quadrisepta* | + | + | + | + |
| Class: Chlorophyceae | | | | | |
| 1. | *Pediastrum boryanum* (Turp.) Menegh. | ++ | +++ | ++ | + |
| 2. | *Pediastrum duplex* Meyen | + | + | + | + |
| 3. | *Pediastrum simplex* var. BiwanseFukush | + | + | + | + |
| 4. | *Pediastrum tetras* (Ehr.) Ralfs. | + | ++ | + | + |
| 5. | *Scenedesmus armatus* (Chodat) Smith | + | ++ | ++ | + |
| 6. | *Selenastrum biraianum* Reinsch | + | + | ++ | + |
| 7. | *Tetraedron trigonum*(Nag.) Hansg. | + | +++ | + | + |
| 8. | *Ulothrix variables* | - | + | + | - |
| 9. | *Cladophora glomerata* (L.) Kutz. | + | +++ | ++ | + |
| 10. | *Euastrum bidentatum* Nag. | + | ++ | ++ | + |
| 11. | *Euastrum insulare* (Wittr.) Roy | + | ++ | + | + |

| | | | | | |
|---|---|---|---|---|---|
| 12. | *Euastrum spinlosum* | + | + | + | + |
| *13.* | *Chlorella vulgaris* Beijerinck | ++ | ++ | + | + |
| 14. | *Chlorella conductrix* Brandt. | + | ++ | ++ | + |
| 15. | *Hydrodictyon reticulatum* Legerheim | + | ++ | + | + |
| 16. | *Dictyosphaerium pulchellum* Wood | + | + | ++ | + |
| 17. | *Closteridium benghalicum* Turner | + | + | + | + |
| 18. | *Closteridium obesum* Smith | - | + | + | - |
| 19. | *Oocystis*sp. Nag. | + | + | + | + |
| 20. | *Ankistodesmus convolutes* Cords. | + | ++ | + | + |
| 21. | *Crucigeniaapiculata* (Lem.) Schmidle. | + | + | + | + |
| 33. | *Crucigenia tetrapedia* West & West | - | + | - | - |
| 34. | *Actinastrum hanzchii* Legerheim | + | + | - | - |
| 35. | *Spirogyra varians* | - | + | + | - |
| *36.* | *Closterium purvulum* Nageli | + | ++ | + | + |
| 37. | *Closterium calosporum* Wittrock | - | + | - | - |
| 38. | *Cosmarium botrytis* Menegh | + | + | + | + |
| 39. | *Cosmarium depressum* (Naeg.) Lund | + | + | + | + |
| 40. | *Cosmarium subcostatum*Nordst | + | + | + | - |
| 41. | *Uronema*sps. Lagerheim | - | + | - | - |
| 42. | *Stigeoclonium eubricum*Dillw. | - | + | - | - |
| Class: Cyanophyceae | | | | | |
| 1. | *Aphanothece bullosa* (Menegh) Rabenh | + | + | + | - |
| 2. | *Chroococcus disperses* (V. Keissler) Lemm. | - | + | + | - |
| 3. | *Chroococcus macrococcus* (Kutz.) Rabenh | - | + | - | - |
| 4. | *Chroococcus minor* (Kutz.) Nageli | - | + | - | - |
| 5. | *Microcystis aeruginosaf. flos-aueae*Kutz. | ++ | +++ | ++ | ++ |
| 6. | *Microcystis aeruginosa f. aeruginosa*Wittr. | + | ++ | ++ | + |
| 7. | *Microcystis wesenbergii*Kutz. | ++ | +++ | ++ | + |
| 8. | *Microcystis viridis* (A.Br.) Lemm, | + | ++ | ++ | + |
| 9. | *Gloeocapsa magma* (Breb.) Kutz | + | ++. | + | ++ |
| 10. | *Gloeocapsa nigrescens* Nag. | - | + | + | - |
| 11. | *Gloeocapsa punctata* Nag. | - | + | + | - |
| 12. | *Merismopedia elegans* G.M. Smith | - | + | + | - |
| 13. | *Merismopedia punctate* Meyen | - | + | + | - |
| 14. | *Arthrospira jenneri* Stizenb. Et Gomont | + | ++ | + | + |
| 15. | *Lyngbya martensiana* Mengh. Ex. Gomont. | + | ++ | + | + |
| 16. | *Lyngbya versicolor* (Vartm) Gom. | + | + | + | + |
| 17. | *Oscillatoria chlorine* Kutz. exGomont | + | + | + | + |
| 18. | *Oscillatoria curviceps* Ag. exGomont | + | ++ | ++ | + |
| 19. | *Oscillatoria laeteviresis* (Grouan) Gomont. | + | + | + | + |
| 20. | *Oscillatoria magartifera*Kutz Ex Gomont. | - | + | - | - |
| 21. | *Oscilltoria tenuis* Ag. Ex Gomont | + | ++ | + | + |
| 22. | *Phormidium pachydermaticum*Fremy | - | + | - | - |
| *23.* | *Nostoc calcicola*Breb ex. Born etFlah. | - | + | - | - |
| *28.* | *Calothrix fusca* (Kutz.) Born et. Flah. | + | ++ | + | - |
| 29. | *Merismopedia punctate* Meyen | + | ++ | + | + |
| *30.* | *Anabaena flos-aquae*(Lynb.) Breb. | + | ++ | + | - |
| *31.* | *Gloeotrichiapisum*(Agarth) Thuret. | + | + | + | - |
| *32.* | *Aphanosophon flos-aquae (L.)Ralfs.* | - | - | - | - |
| Class:Euglenophyceae | | | | | |
| 1. | *Euglena ehrenbergii* Klebsi | + | ++ | + | + |
| 2. | *Euglena spirogyra* Ehr. | - | ++ | + | - |
| 3. | *Lepocincilis playfairiana* Deflandre | - | ++ | ++ | + |
| 4. | *Phacus accuminatus* Stokes | + | ++ | ++ | + |
| 5. | *Phacus. caudatus* Huebner | + | ++ | - | - |
| 6. | *Phacus curvicauda* Swirenkow | - | + | + | - |
| 7. | *Phacus indicus* Skwortzow | + | + + | + | + |

[Note: -= rare (1 – 4), +=occasional (5-14), ++ = frequent (15-29), +++ = Abundant (30-99), ++++ = Very abundant (100 +) as used in the study of terrestrial plant communities]

**Table 3. Algal density and photosynthetic production in Thirupathisaram temple pond during 2014**

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of Cyanophyceae/ L | 3072 | 3125 | 3656 | 4369 | 5198 | 4982 | 4473 | 4369 | 3987 | 3684 | 3411 | 2993 |
| No. of Chlorophyceae/ L | 3011 | 3158 | 3458 | 3983 | 4586 | 4526 | 4214 | 4156 | 3564 | 3358 | 3258 | 2689 |
| No. of Bacillariophyceae/L | 2689 | 2365 | 2218 | 2198 | 1645 | 1764 | 1961 | 2058 | 2154 | 2283 | 2320 | 2740 |
| No. of Euglenophyceae | 1921 | 2014 | 2146 | 2658 | 3258 | 2825 | 2654 | 2486 | 2257 | 2142 | 2011 | 1896 |
| Total number of algae /L | 11693 | 10762 | 11378 | 13208 | 14687 | 14079 | 13302 | 13069 | 11962 | 10167 | 11000 | 11318 |
| GPP (mg/L) | 0.72 | 0.86 | 0.98 | 1.13 | 1.19 | 1.11 | 0.97 | 0.91 | 0.87 | 0.78 | 0.76 | 0.74 |

As the cell density increased from October to May and declined gradually thereafter, the GPP increased from 0.72mg/L (January) to 1.11mg /L (May) and then it declined to 0.74 mg/L (December). Swain *et al.,* (1994) have proved that primary productivity is directly correlated with the algal density in the ponds, which is also confirmed in Thirupathisaram temple pond during this study.

Although physico-chemical characters showed distinct peaks in different seasons, there were many sudden variations in the water qualities of the temple pond as observed by Treshow (1971) and Swain *et al.,* (1994) in their study. It was mainly because of the reason that hundreds of villagers and pilgrims have been using this water for bathing, religious rituals and even for washing clothes, but Municipal Corporation took attempts for clearing the temple pond once in 4 or 5 years. The slight changes in water qualities favour one species to overcome others and alter the algal diversity in the pond suddenly as has pointed out by Treshow (1970). However, the plankton density showed definite pattern of distribution in different seasons.

**Acknowledgement**

The author is grateful to the Professor and Head of the Department of Botany, Annamalai University, Chidambaram, for providing laboratory facilities and to Professor K. Adhish Kumar, Department of Applied Zoology, Sivanthi Adhithanar College, Pillaiyarpuram, Kanyakumari District, for timely helps in water sampling and guidance.

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