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Research Paper



Water quality variation and screening of microalgal distribution in thachan pond Chidambaram taluk of Tamil nadu

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Abstract

A laboratory study was conducted to monitor the water quality and microalgal distribution of Thachan pond, Chidambaram taluk, Cuddalore district, Tamil Nadu, India. The important parameters tested were temperature, pH, turbidity, electric conductivity, total dissolved solids, turbidity, alkalinity, free CO2, dissolved oxygen, chloride, nitrate and phosphate. Microalgal distribution studies were observed. Monthly fluctuations of different seasonal diversity i.e., 35 algal species belongs to four groups viz., Cyanophyceae (41%), Chlorophyceae (27%), Euglenophyceae (14%) and Bacillariophyceae or Diatoms (17%). Among the microalgae Cyanophyceae was found to be dominant group throughout in the study period. Microalgae producing biotoxin such as *Microcystis aeruginosa, Chroococcus minor, Oscillatoria curviceps, Oscillatoria tenuis, Anabaena spiroides, Nostoc pruniforme* and *Aphanocapsa grevillei* were recorded in the pond. Pond was found to be moderately polluted and showed a trend of increasing eutrophication. The significant correlations were noted in the different parameters.

Keywords: *Eutrophication, Microalgal Distribution, Pond Water Quality, Seasonal Diversity*.

1. Introduction

The life is an aquatic ecosystem is directly or indirectly depends on the water quality. Ponds constitute an ecosystem that supports a wide array of organisms ranging from lower plants to higher plants. Water quality can be defined in terms of physical, chemical and biological characterization of water. In some developing countries they are a contributing source of water for domestic use such as washing of cloths, bathing and sometimes as a source of drinking water (Chia *et al*. 2009). Water supports life on earth and around which the entire fabric of life is woven. Ponds, as sources of water, are of fundamental importance to man. However pond may have been natural water sources exploited by man at different time to meet different needs or may have been created for a multitude of different purposes (Rajagopal *et al*. 2010). The increased demand for water as a consequence of population growth, agriculture and industrial development has usurped environmentalists to determine the chemical, physical and biological characteristics of natural water resources (Sawant and Telave, 2009).

The distribution and abundance of microalgae in this system are controlled by a wide range of physico-chemical parameters. While microalgae are important primary producers and the basis of the food chain in open water, some species on the other hand can be harmful to human and other vertebrates by releasing toxic substances (hepatotoxins or neurotoxins etc.) into the water. Proliferation of harmful organisms, particularly species should be monitored. Phytoplankton studies and monitoring are useful for control of the physico-chemical and biological conditions of the water in any irrigation project. Therefore certain groups of phytoplankton, especially blue green algae, can degrade recreational value of surface water, particularly thick surface scum, which reduces the use of amenities for contact sports, or large concentrations, which cause deoxygenating of the water leading to fish death (Whitton and Patts, 2000). Over the last few decades, there has been much interest in the processes influencing the development of phytoplankton communities, primarily in relation to physico-chemical factors (Elliott *et al*. 2002). The algae co-occur even though each species has a specific niche based on its physiological requirements and the constraints of the environment. There are many detailed descriptions of phytoplankton succession being correlated with changes in environmental parameters particularly temperature, light, nutrients availability and mortality factors such as grazing and parasitism.

Tamil Nadu is bestowed with a large number of perennial and temporary ponds. The biodiversity of algal flora in the water bodies shows a correlation with reference to their occurrence and the physico-chemical factors. The algae serve as the primary producers in the food chain and the productivity depends upon the quality of water. Water is a vital resource used for various activities such as drinking, irrigation, fish production, power generation etc. Increased human activities over the last 25 years are imposing a greater stress on these ecosystems resulting in changes in their features. There is a need for scientific management of exploitation and conservation of these natural resources. To achieve this goal there is an urgent need of basic and applied research on various aspects of aquatic ecosystems. In India algal diversity in fresh water wetlands along with their physico-chemical characteristics of the concerned water bodies studies were important. The purpose of this study was to collect sufficient baseline quality data to define current immunological conditions of the pond. This pond, in the urban area, is the main source of water supply for drinking, bathing and for other human activities. The present work is an attempt to explore the microalgal species, their composition along with their logistic correlation with different physico-chemical parameters of the pond water in different seasons during the study period.

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2. Materials and methods

2.1. Study area

Thachan pond is situated in Mandhakkarai 3 km near Chidambaram and 5 km away from Annamalai University. It spreads about approximately 200m in length and 150m in width. The depth of the water ranges from 2 meters to 4 meters in different seasons.

2.2. Water sample collection and analysis

In the present study sampling has been done for six months at Thachan pond in Mandhakkarai to study the change in physico-chemical characteristics and the microalgal diversity. A periodic collection of water sample has been made on monthly basis from January to June-2014. Samples have been collected in polythene bottles and analysed in the laboratory. An APHA (1992) method was used for water analyses. Physico-chemical parameters such as Temperature, pH, turbidity, electric conductivity, total dissolved solids, total alkalinity, FCO_2, dissolved oxygen, chloride, nitrate and phosphate were analysed. Microalgal were photographed using Niken Eclispe Microscope (Nikon Eclipse, 200). The algae were identified using the monographs by Desikachary (1959) for blue green algae and Krishnamurthy (1954) for diatoms.

2.3. Estimation of phytoplankton

Water samples were collected from Thachan pond for phytoplankton analysis in black coloured plastic carboys of one litre. Filamentous algae and other floating debris were avoided. For each sample collected, 25 ml of 4% formaldehyde was added (Welch, 1948) with few drops of Lugol's iodine. Sedimentation was done in glass columns. The sediment was finally reduced to 20 ml and was preserved in a glass vial. From each vial one drop was mounted on a slide and a cover slip was carefully put over it. Five high power fields (15X, 45X), one in each corner of the cover slip and at the centre were made and the algal populations were estimated. These observations were at random and were repeated four times for each sample. This procedure was repeated for each sample and the number of each organism was extra plated to exact number of organism/L (Rao, 1995). Phytoplankton count was done by Lackey's Drop Method (1938) as mentioned in APHA (1985) and modified by Saxena (1987).

3. Results and discussion

In the present investigation physico-chemical parameters viz., temperature, pH, turbidity, electric conductivity, total dissolved solids, turbidity, alkalinity, free CO_2, dissolved oxygen, chloride, nitrate and phosphate were depicted in the figures. The physico-chemical characteristics of water of an aquatic system reflect both the quality of the system and the type and density of its biota. By the analysis of such character, information regarding pollution and extent of pollutant loading of aquatic system may be generated.

3.1. Temperature (ºC)

Temperature is directly related with chemical and biochemical reactions in any aquatic system. The solubility of oxygen has been increased by low temperature. Temperature of surface water in the present study ranged between 29ºC-41.1ºC, highest being recorded in May (Figure 1). Shinde *et al*. (2011) and Sharma *et al*. (2007) observed maximum temperature in summer and minimum in post monsoon. A similar study was made by Mahesh *et al*. (2013) and Javaid and Ashok (2012).

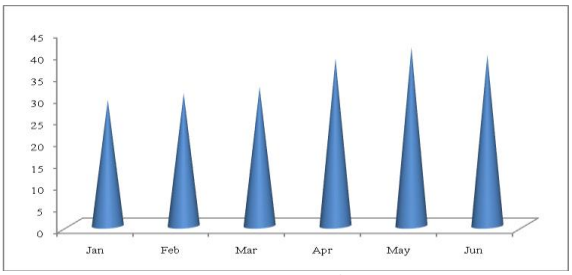


Fig. 1: Seasonal Variation of Temperature ºc

3.2. pH

Hydrogen ion concentration (pH) is closely related to free CO_2 complex which during present study ranged between 6.9-8.5. pH is controlled by the carbon dioxide bicarbonate- carbonate equilibrium system (Figure 2). High rate of photosynthetic activity increases the pH due to consumption of CO_2 in this process (Harney *et al*. 2013).

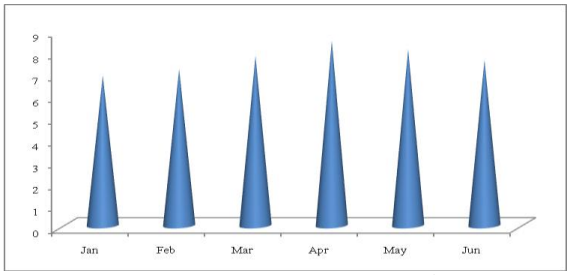


Fig. 2: Seasonal Variation of Ph

3.3. Turbidity (NTU)

Turbidity ranged between 49-61.9 NTU. It was minimum in summer and maximum in post monsoon months (Figure 3). The similar type of results were given by Khanna (1993) and Khanna and Bhutiani (2003). Turbidity is an important physical parameter which has a significant bearing on productivity of aquatic ecosystem (Rave *et al*. 2012). The particulate matter like clay, silt, colloidal particles, algal blooms, debris and the other microscopic organisms are responsible for turbidity in water. Turbidity directly affects the productivity of surface water because scatter and absorption of light in water depends upon turbidity.

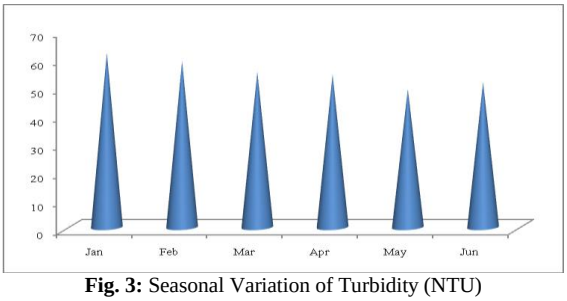


Fig. 3: Seasonal Variation of Turbidity (NTU)

3.4. Electrical conductivity (µS)

Electrical conductivity of water is a numerical expression of the ability of water sample to carry an electric current. It depends on the nature and concentration of ionized substances or electrolytes dissolved in water. Electrical conductivity values ranged between 462.1-582 µS (Figure 4). A sudden rise in conductivity in water during post monsoon and monsoon season indicates addition of some pollutants (Trivedy and Goel, 1984).

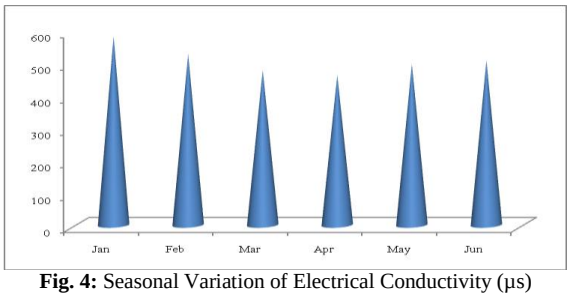


Fig. 4: Seasonal Variation of Electrical Conductivity (µs)

3.5. Total dissolved solids (mg/l)

Total dissolved solids of sample waters ranged between 212-380 mg/l (Figure 5). Total dissolved solids composed mainly of carbonates, bicarbonates, chlorides, sulphates, phosphates and nitrates. Higher content of total dissolved solids adversely affects the plants by increasing salinity of the soil. The wastes from inhabitations of the pond enhance total dissolved solids of water of pond. Total dissolved solids might be due to accumulation of the anthropogenic activity which hampered the quality of water (Senthilkumar and Sivakumar, 2008) and growth of diatoms.

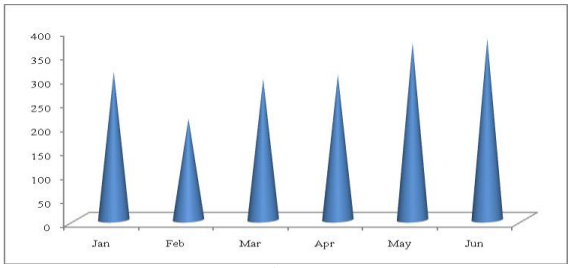


Fig. 5: Seasonal Variation of Total Dissolved Solids (Mg/L)

3.6. Total alkalinity (mg/l)

Total alkalinity varied from 64.9-99.6 mg/l. It is closely related to free carbon dioxide (Figure 6). It is formed due to dissolution of CO2 in water. The range of total alkalinity in Indian waters may be found between 40 mg l^{-1} to over 1000 mg l^{-1} (Rajyalakshmi *et al*. 1998). Dwivedi and Pandey (2002) reported that the total alkalinity of water was maximum during summer and gradually decreased during pre-monsoon season and reached its lowest values during monsoon season. Lashari *et al*. (2009) and Shinde *et al*. (2011) reported that the values of total alkalinity were more in summer when compared to other seasons.

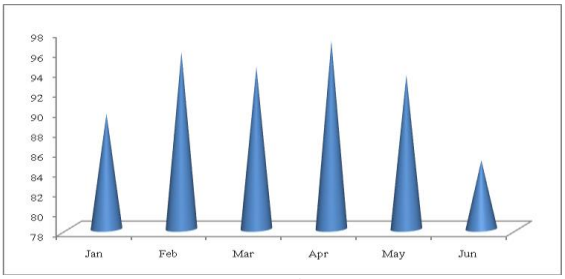


Fig. 6: Seasonal Variation of Total Alkalinity (Mg/L)

3.7. Free carbon dioxide (mg/l)

Free carbon dioxide enters into chemical combination of aquatic system to form carbonates and bicarbonates. It assimilates carbon and incorporates into the skeleton of aquatic autotrophs. The concentration of free CO_2 significantly varied from 34.0-72.1 mg/l (Figure 7). At high temperature during summer and post monsoon seasons the high rate of decomposition of organic matter, resulted in release of FCO_2 in surface water (Yadav *et al*. 1987). Dwivedi and Pandey (2002), the minimum range of carbon dioxide is in post monsoon season and this is due to the higher photosynthetic activities of phytoplankton.

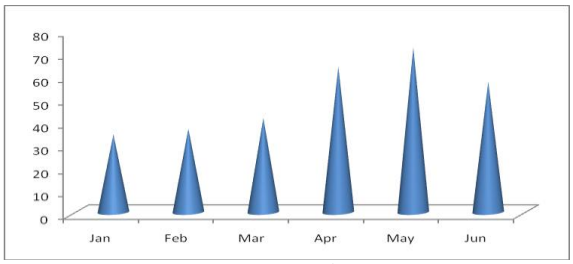


Fig. 7: Seasonal Variation of Free CO_2 (Mg/L)

3.8. Dissolved oxygen (mg/l)

Dissolved oxygen is required for many physical and biological processes prevailing in water. The oxygen supply in water comes by diffusion from the air and from photosynthesis by aquatic plants. Dissolved oxygen affects the solubility and availability of many nutrients and therefore productivity of aquatic ecosystem (Wetzel, 1983). During the present investigation, DO concentration varied from 9.0-14.8 mg/l. Highest value (14.8 mg/l) recorded during January may be due to low temperature of water during post monsoon season (Figure 8). During monsoon and post monsoon the level of dissolved oxygen was quite satisfactory, perhaps due to good aeration caused by rain water as reported earlier by Rekha Rani *et al*. (2004). Low content of dissolved oxygen is due to indiscriminate use of pond by local people and higher decomposition of organic matter with increase in temperature of water.

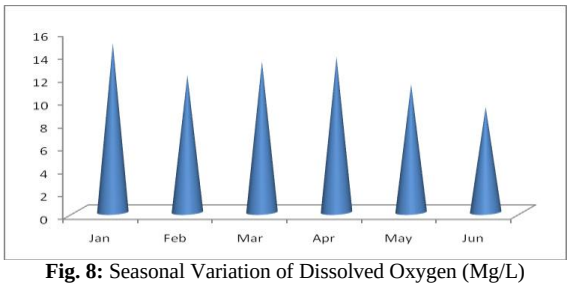


Fig. 8: Seasonal Variation of Dissolved Oxygen (Mg/L)

3.9. Chloride (mg/l)

Chloride values ranged between 169.96-224.97 mg/l. High chloride concentration during February may be due to direct mixing of cattle dung and human excreta to pond water (Figure 9). Increases in chloride value from earlier values of Nayak (1997) reflect magnitude of organic waste decomposition in pond water. The chloride contents normally increases as the mineral contents increases (Dubey, 2003).

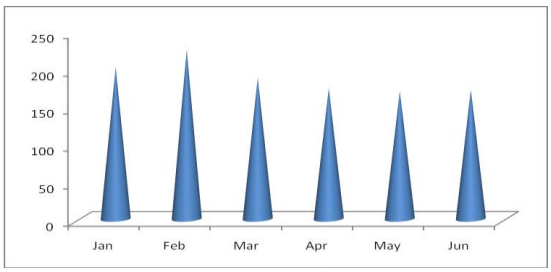


Fig. 9: Seasonal Variation of Chloride (Mg/L)

3.10. Nitrate and phosphate (mg/l)

Nitrate content is excellent parameters to judge organic pollution and it represents the highest oxidized form of nitrogen. The nitrates are an important source of nitrogen for phytoplankton. Nitrate-nitrogen in the present study varied from 0.245-0.377 mg/l. It is used by plants during their growth and utilized in the synthesis of organic nitrogenous compounds (Figure 10).

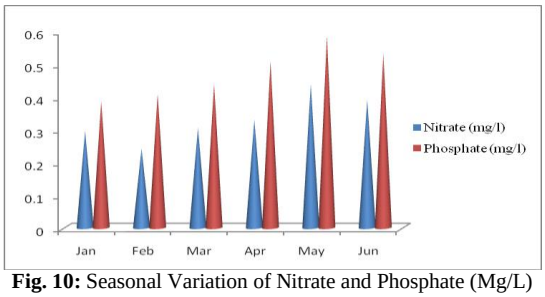


Fig. 10: Seasonal Variation of Nitrate and Phosphate (Mg/L)

Phosphorus occurs naturally in rocks and other mineral deposits. During the natural process of weathering, the rocks gradually release the phosphorus as phosphate ions which are soluble in water. Phosphate-phosphorous values varied from 0.284-0.685 mg/l. In the present investigation, high values of phosphate during summer seasons may be due to rapid evaporation and mineralization of decomposed materials in pond water. Harney *et al*. (2013) reported the maximum Nitrate and phosphate during summer and minimum during post monsoon in Pindavani Pond of Central India.

3.11. Phytoplankton community

Microalgal species belonging to Cyanophyceae, Chlorophyceae, Euglenophyceae and Bacillariophyceae or Diatoms groups were recorded in Thachan pond during the study period (Table 1). In the present investigation 35 species were identified, out of which 14 genera belongs to Cyanophyceae (41%), 9 of Chlorophyceae (27%), 5 of Euglenophyceae (14%) and 7 of Bacillariophyceae or diatoms (17%) in pond respectively (Figure 11). It was found that cyanophyceae was the dominant group in the pond.

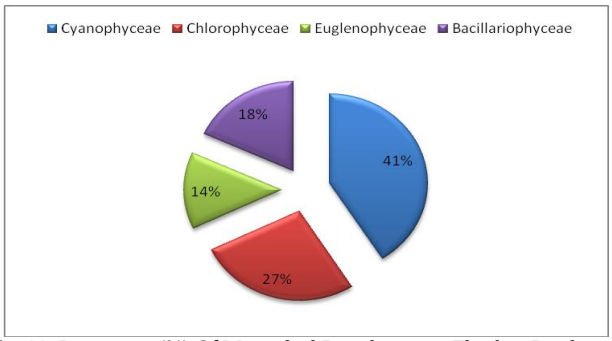


Fig. 11: Percentage (%) Of Microalgal Distribution in Thachan Pond

3.11.1. Cyanophyceae

Cynophyceae are well known to occur in diverse physico-chemical conditions with varying degree of abundance and can tolerate wide fluctuations in chemical factors. The maximum number of cyanophyceae was observed in the month of January, February and June the low density was noticed in the month of April and May. Among the cyanophytes *Microcystis aeruginosa*, *Chroococcus minor*, *Oscillatoria curviceps*, *Oscillatoria tenuis*, *Anabaena spiroides*, *Nostoc pruniforme* and *Aphanocapsa grevillei* was the dominant species in the study period.

Table 1: Microalgal Distribution in the Water Sample of Thachan Pond during the (January to June-2014)

Sl. No	Name of the Species	Months-2014					
		Jan	Feb	Mar	Apr	May	Jun
	Cyanophyceae						
01	*Microcystis aeruginosa* (Wittr.) Kirchner	+	+	+	+	+	+
02	*Chroococcus minor* (Kutz.) Nageli	+	+	+	+	+	+
03	*Lyngbya shackletoli* West	+	-	-	-	-	+
04	*Oscillatoria curviceps* Ag. ex Gomont	+	+	+	+	+	+
05	*Oscillatoria subbrevis* Schmidle F. Crassa	-	+	+	-	-	-
06	*Spirulina major* (Kütz.) Gomont	+	+	+	+	-	+
07	*Spirulina princeps* Voucher ex. Gomont	+	+	-	-	-	-
08	*Anabaena spiroides* Klebahn	+	+	+	+	-	+
09	*Nostoc pruniforme* Ag.	+	+	+	+	+	+
10	*Oscilltoria tenuis* Ag. Ex Gomont	+	+	+	+	+	+
11	*Merismopedia minima* Beck	+	+	+	+	-	-
12	*Chroococcus disperses* (V. Keissler) Lemm.	+	-	-	-	-	+
13	*Chroococcus minor* (Kutz.) Nageli	+	+	+	-	-	+
14	*Aphanocapsa grevillei* (Hass.) Rabenh	+	+	+	+	+	+
	Chlorophyceae						
15	*Chlamydomonas globosa* Snow.	+	+	+	+	+	+
16	*Palmella miniata* Lieb.	+	+	+	+	+	+
17	*Chlorella pyrenoidosa* Chick	-	-	+	+	-	+
18	*Chlorella vulgaris* Beyernick	+	+	+	-	-	-
19	*Scenedesmus accuminatus* Kutz.	-	-	+	-	-	+
20	*Scenedesmus quadricauda* (Turp.) Breb.	+	+	+	+	-	-
21	*Cladophora crispate* (Roth) Kutz.	-	-	-	-	-	+
22	*Spirogyra* sps.	+	+	+	+	+	+
23	*Closterium purvulum* Nageli	+	+	+	+	+	+
	Euglenophyceae						
24	*Euglena viridis* Ehr.	+	+	+	+	+	+
25	*Euglena convolute* Korsch	+	-	-	+	-	+
26	*Euglena oxyuris* fo. Maior	+	+	-	-	-	+
27	*Euglena elastica* Presc	+	-	-	+	+	-
28	*Euglena spirosura* var. fusca	+	+	+	+	+	+
	Bacillariophyceae or Diatoms						
29	*Cyclotella meneghiniana* Kutz.	+	+	+	+	+	+
30	*Actinella punctanta* Lewis	+	+	+	+	+	+
31	*Amphora ovalis* Kutz.	+	+	+	-	-	+
32	*Diatoma* sps.	+	+	+	+	+	+
33	*Navicula cincta* Kutz.	-	-	+	-	-	+
34	*Navicula peregrina* Kutz.	+	+	-	-	-	+
35	*Pinnularia borealis* Her.	-	-	-	+	-	-

(+) = Present, (-) = Absent.

3.11.2. Chlorophyceae

Chlorophyceae are free living and planktonic, mostly confined to shallow water and are attached to the submerged plants or found in moist soil (Huisman *et al*. 2005). This group was represented by nine species and the maximum density of Chlorophyceae was observed in the month of January, March and July and minimum number was noticed in the month of May respectively. Sommer *et al*. (1986) reported that maximum abundance of Chlorophyceae was in post monsoon months.

3.11.3. Euglenophyceae

In the present study the Euglenophyceae comprising of five species belonging to two genera were recorded in all seasons in Thachan pond. The maximum density of Euglenophyceae was observed in the month of January and minimum was noticed in the month of March.

3.11.4. Bacillariophyceae

Bacillariophyceae or Diatoms were represented by seven species out of these four species belonging to three genera were recorded in all seasons. Diatoms are considered to be the best indicators of quality and tropic status of the water body (Callieri, 2008). Temperature and pH will play key role in the distributions of diatoms and abundance of diatoms will be more in colder months. The maximum abundance of diatoms was encountered in the post monsoon season and low was noticed in summer season. Present findings are agreeable with earlier reports (Sommer *et al*. 1986). Goel *et al*. (1992) have stated that Bacillariophyceae occurs in all types of waters. *Navicula* and *Cyclotella* indicate pollution in the present water body that occurred commonly.

Maximum numbers of algal species were recorded for the site of sewage discharge and supported the earlier observations that the water bodies influenced by domestic sewage effluent are most conductive to luxuriant growth of plankton which form nuisance blooms of blue green algae (Tripathi and Pandey, 1990). Based on their distribution at the pond algae may be categorized in pollution tolerant and pollution sensitive species. *Microcystis aeruginosa, Chroococcus minor, Anabaena spiroides, Nostoc pruniforme, Oscillatoria* sp. (all cyanophyceae) *Chlamydomonos, Spirogyra* sp. *Palmella miniata* (all chlorophyceae) and *Cyclotella meneghiniana, Actinella punctanta, Diatoma* sp., (bacillariophyceae) were found to toxin producing algal species (Palmer, 1980; Duncan *et al*. 2000).

4. Conclusion

It was observed that *Microcystis aeruginosa, Chroococcus minor, Oscillatoria curviceps, Oscillatoria tenuis, Anabaena spiroides, Nostoc pruniforme* and *Aphanocapsa grevillei* are most abundant species throughout the study physico-chemical analyses of water sample from the Thachan pond indicate that all the pollution parameters, show values towards higher side for a typical freshwater pond. More research work is required for an assessment of human gastro-intestinal cancers with chronic consumption of cyanophytes in drinking water. The present work shows that parameters like pH, alkalinity and conductivity are within the permissible limits. However, parameters like dissolved oxygen, temperature and turbidity are above the permissible limits for drinking purposes as prescribed by the European Commission and all the physico-chemical parameters appeared within manageable levels and distribution of phytoplankton. If the pond is properly maintained in future, then it will be free from eutrophication.

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