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A COMPARATIVE STUDY OF THE GROWTH OF PHYTOPLANKTONS IN SURFACE WATER SAMPLES AND IN THE FORMATION OF ALGAL BOOMS

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Abstract: Phytoplankton diversity in four surface water samples from Coorg district i.e., Kaveri Nisargadhama, Abbey falls, Bhagamandala and Talakaveri of Karnataka state and two samples from Wynad district i.e., Irrity river and Pazhassi dam of Kerala state belonging to western ghats were studied for the year 2011 and 2012 and discussed in the paper. Six classes of 53 species of phytoplanktons were identified *viz*., Bacillariophyceae, Chlorophyceae, Cyanophyceae, Desmidaceae, Euglenophyceae and Ulvophyceae. Bacillallariophyceae group dominated followed by Desmidaceae, Chlorophyceae, Euglenophyceae, Cyanophyceae and Ulvophyceae. Members of Bacillariophyceae formed blooms in Abbey falls, Bhagamandala and Pazhassi dam which often lead to eutrophication. The evenness and dominance of species in the lake was not well marked. An experiment was also set up to see the formation of algal blooms from the same surface water samples and to identify whether same group of species are identified which is responsible in the formation of algal blooms. Hence it has become essential to develop conservation strategies for control of lakes based on the diversity and abundance of phytoplankton blooms.

Keywords: Surface water, phytoplanktons, algal blooms, diversity, western ghats

I. INTRODUCTION

Freshwater ecosystem is remarkable as large number of phytoplankton species that are present at any given time. Such species diversity appears as a paradox (Hutchinson, 1967). High diversity of fresh water plankton are based on the fact that interactions in the plank tonic environment are highly complex. The early studies on freshwater phytoplankton were on distribution of Bacillariophyceaen members by Patrick (1948) and on benthic communities by Round (1981). Plankton composition of freshwater lakes were studied by Seenayya (1972), while Bharathi and Hosmani (1974) made an extensive study of the plankton in lakes of Dharwar. Seasonal diversity was studied by Nygaard (1976) in lakes of Denmark. Aiyaz *et al*. (2010) studied diversity index of algal flora. Hosmani (2010) reported the importance of algal diversity in lake ecosystems. Basavarajappa *et al*. (2010) have given a detailed account of the diversity of phytoplankton in lakes of Mysore.

Phytoplanktons which include green algae, blue green algae, diatoms, desmids, euglenoids etc., are important among the aquatic flora. They are also ecologically significant as they form the basic link in the food chain of all aquatic animals and when in large number they make water appear greenish (Misra *et al*., 2001; Harsha and Malammanavar, 2004). Being an index of trophic status, phytoplankton reflects the overall environmental condition of the system and its potentiality (Agrawal, 1999; Agarwal and Rozgar, 2010), as their densities have been reported to be affected by the quality of water. Phytoplanktons encountered in the water body reflect the average ecological conditions and they may be used as indicators of water quality (Dalal *et al*., 2013).

The importance of microorganisms in human health and disease, and the massive impact of the pure culture approach devised by Robert Koch and others, has understandably led to a philosophy in microbiological research that emphasizes the study of microorganisms in pure liquid culture. This approach has so prominently pervaded microbiology that biofilm research was long neglected until microbiologists 're-discovered' these fascinating communities (Costerton *et al*., 1995; Stoodley *et al*., 2004; Kolter, 2005). Battin *et al*. (2007) gave a concept for biofilm research that is spatially explicit and solidly rooted in ecological theory, which might serve as a universal approach to the study of the numerous

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facets of biofilms. Underwood (2005) showed that there are significant differences in the behaviour and physiology of different taxa of diatoms within the same biofilm and the species respond differently to the external nutrient environment.

Although it appears that a great deal of work has been done on plankton ecology, there are still many potential areas with indigenous algae being not reported. An attempt has been made to assess the phytoplankton diversity of six sampling sites; from Coorg district i.e., Kaveri Nisargadhama, Abbey falls, Bhagamandala and Talakaveri and two samples from Wynad district i.e., Irrity river and Pazhassi dam were studied for the year 2011 and 2012 Mysore district. The present study is based on the data collected over a period of one year on the distribution of algal biodiversity in ten lakes of my sore district.

II. MATERIALS AND METHODS

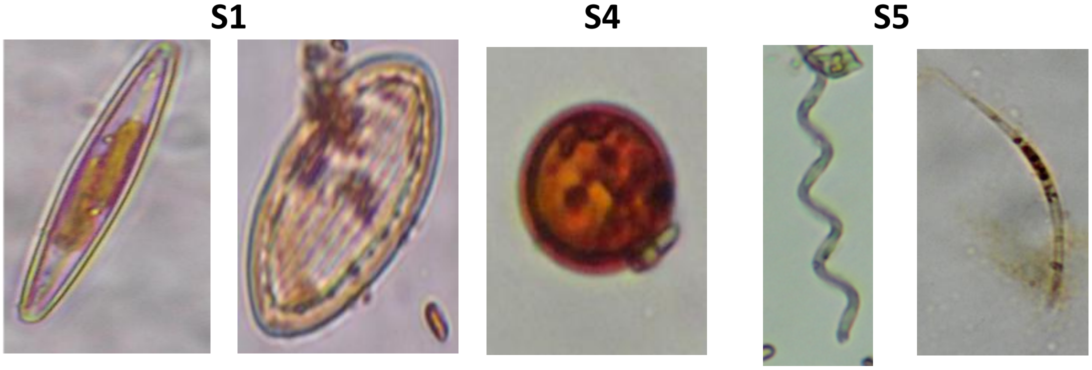
The study area, Kaverinisargadhama is located at 75°.52′E and 12°.35′N; Abbey falls at 75°.71′E and 12°.45′N; Bhagamandala at 75°.52′E and 12°.41′N; Talakaveri at 72°.26′E to 75°.33′E and 12°.17′N to 12°.27′N; Iritty river at 75°.59′E and 11°.90′N and Pazhassi dam at 75°.66′E and 11°.98′N. They differ in shape and size and in the usage. Except Iritty river all other spots are the tourist spots, but human interference can be seen in all the spots. Samples for the estimation of phytoplanktons were collected from surface water for a period of two year. For every even month sample collection was done. Collection, preservation and identification were done following the methods described by Hosmani (2010). Algae in fresh waters have numerous environmental functions and are based upon the recycling of nutrients. Urbanization has led to the pollution of surface water bodies resulting in decline/extinction of some species. On the other hand, some species have increased enormously making water unfit for drinking and recreation.

One litre of the surface water sample was allowed to stand with 4% of 15 ml formaldehyde solution and 10 ml of Lugol’s iodine solution (Potassium iodide 10 g, iodine 5 g, distilled water 100 ml). The mixture is allowed to settle for 24 h. Later the supernatant is discarded and the settled part of the solution is transferred to a capped bottle. The solution is observed under Labomed microscope.

III. RESULTS AND DISCUSSION

The increased concentration of the factors such as calcium, magnesium, phosphate, nitrogen and which in turn disturbs the biology of the waterbody and results in ecological imbalance and act directly on the growth of the phytoplanktons and other microorganisms. During the present investigations, 53 species of phytoplanktons were identified and classified into six following classes *viz*., Bacillariophyceae, Chlorophyceae, Cyanophyceae, Desmidaceae, Euglenophyceae and Ulvophyceae. Among these Bacillallariophyceae group dominated followed by Desmidaceae, Chlorophyceae, Euglenophyceae, Cyanophyceae and Ulvophyceae (Fig.1, Table 1).

S1 **S4** **S5**



Synedra ulna *Cocconeis placentula* *Trachelomonas* *Spirulina* sp. *Closterium cornu*

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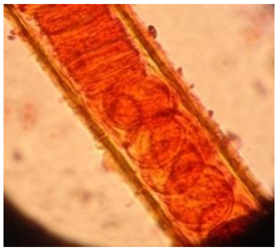
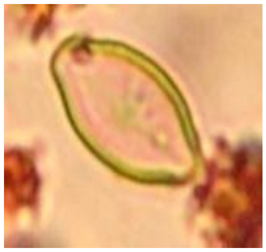
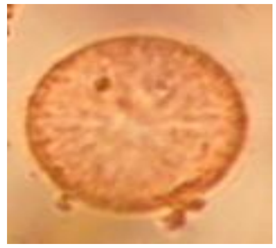
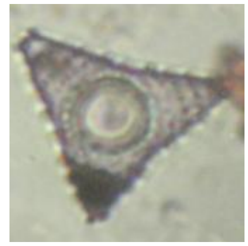
S2


Oscillatoria subbrevis

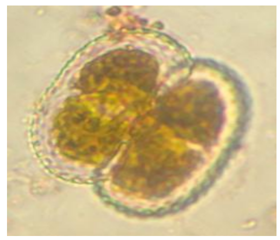

Diploneis ovalis


Cyclotella glomerata


Stousrastrum sp.


Euglena minuta


Stauroneis angulare


Cosmarium angulare


Gomphonema gracile


Cyclotella catenata


Stousrastrum sp.


Tetraedron tribolatum


Navicula sp.


Gomphonema gracile


Navicula cincta

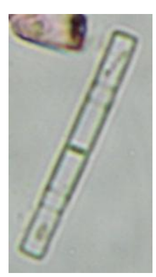

Gyrosigma silinarium


Tabellaria sp.


Scenedesmus arcuatus


Navicula spp.


Closterium lunata


Melosira


Epithemia zebra

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granulate

Cocconeis placentula

Gyrosigma acuminatum

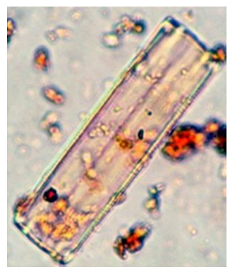
Synedra acus

Synedra ulna

Fragilaria brevistriata

Cymbella affinis

Navicula sphaerophora



A. ovalis

S. ulna

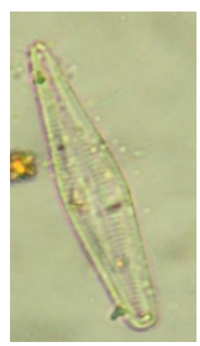
S3

Trachelomonas churkowenisis

Melosira sp.

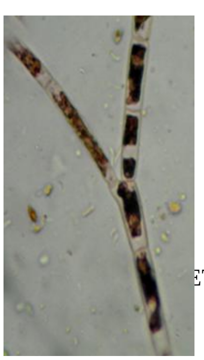
Surirella robusta

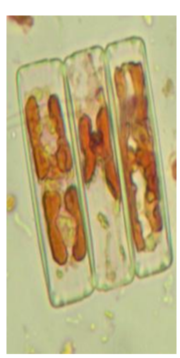
E. polymorpha



Stauroneis angulare

S6





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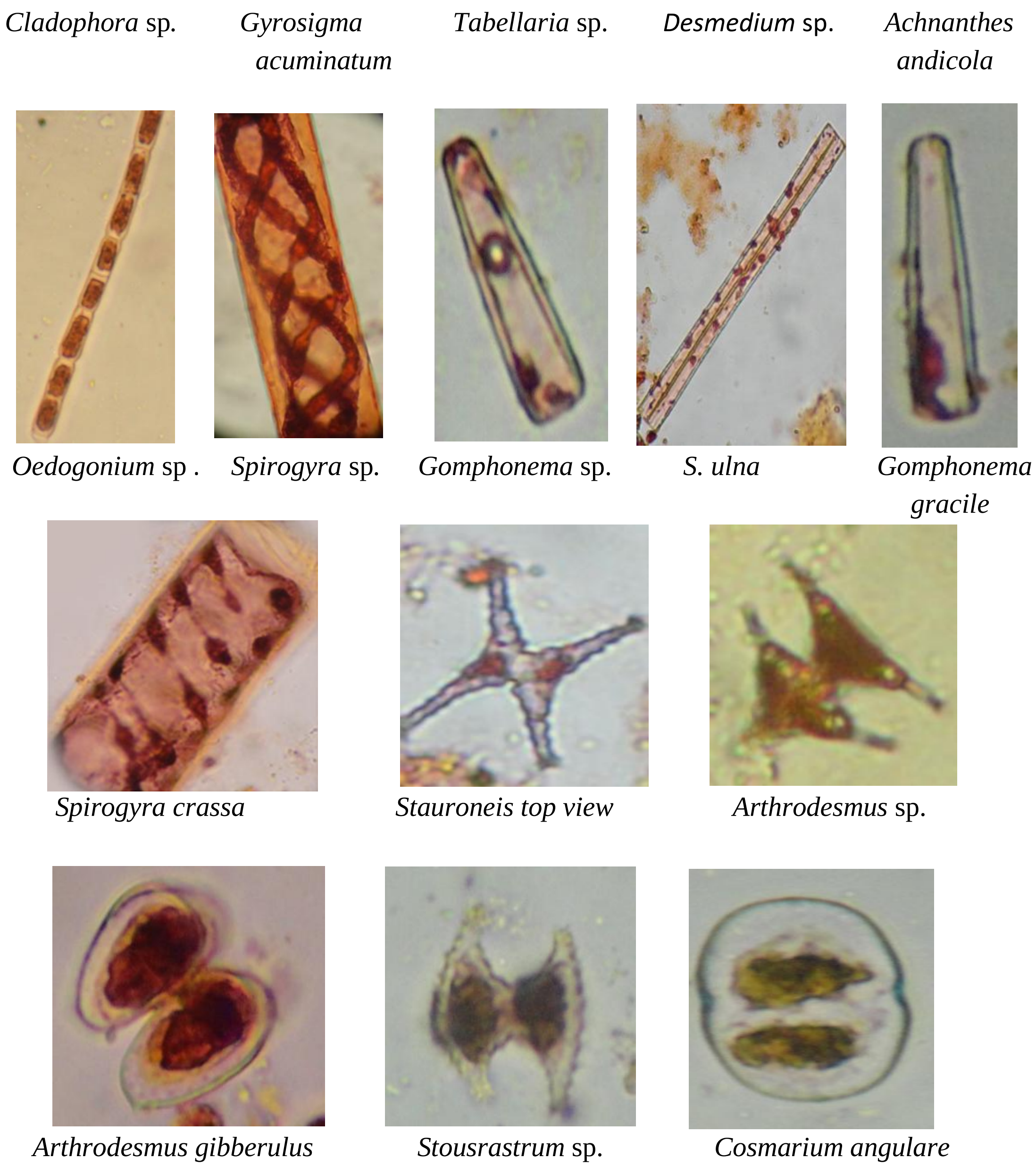

Fig. 1 Species in all the surface water sampling spots

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Table I Occurrence of Phytoplankton Groups in Water Sampling Sites

Phytoplanktons	Sampling sites					
	S1	S2	S3	S4	S5	S6
Bacillariophyceae						
Achnanthes andicola	–	–	–	–	–	+
Amphora coffeaeformis	–	+	–	–	–	–
A. ovalis	–	+	–	–	–	–
Cocconeis placentula	+	+	+	–	–	–
Cocconeis sp.	–	–	+	–	–	–
Cymbella affinis	+	+	–	–	–	+
Cyclotella glomerata	–	+	–	–	–	–
C. catenata	–	+	–	–	–	–
Diploneis ovalis	–	+	–	–	–	–
Epithemia zebra	–	+	–	–	–	–
Eunotia major	–	+	–	–	–	–
Fragilaria brevistriata	–	+	–	–	–	–
F. contruens	–	+	–	–	–	–
F. pinnata	–	+	–	–	–	+
Gyrosigma acuminatum	+	–	–	–	–	+
G. silinarium	–	+	–	–	–	–
Gomphonema gracile	–	+	–	–	–	+
Gomphonema sp.	–	+	–	–	–	–
Melosira granulate	–	+	–	–	–	+
Melosira sp.	–	+	+	+	+	+
Navicula sphaerophora	+	+	–	–	–	–
N. cincta	–	+	–	–	–	+
Navicula sp.	–	+	+	–	–	+
Stauroneis angular	–	+	–	–	–	+
S. phoenicentron	–	–	+	–	–	
Stauroneis top view	–	+	–	–	–	+
Surirella robusta	+	+	–	+	–	–
S. splendid	–	–	+	–	–	–
Synedra acus	–	+	–	–	–	+
S. ulna	+	+	+	–	–	+
Tabellaria sp.	–	–	+	–	–	+
Chlorophyceae						
Ankistrodesmus falcatus	–	–	+	–	–	–
Oedogonium sp.	–	–	–	+	–	+
Pediastrum sp.	–	–	–	+	–	–
Scenedesmus arcuatus	–	+	+	–	–	–
Spirogyra crassa	–	–	+	–	–	–
Spirogyra sp.	–	–	+	–	–	–
Tetraedron tribolatum	–	+	–	–	–	–
Cyanophyceae						
Oscillatoria subbrevis	–	+	–	–	–	–

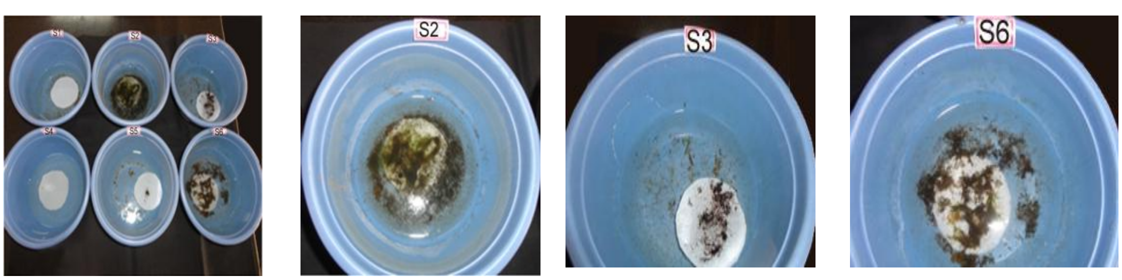
Spirulina sp.	–		–	–	–	–
S. nordestedtii	–	+	–	–	–	–
Desmidaceae						
Arthrodesmus gibberulus	–	–	–	–	–	+
Arthrodesmus sp.	–	–	–	–	–	+
Cosmarium angular	–	–	–	–	–	+
C. marginatum	–	–	–	–	–	+
C. lundelli	–	–	–	–	–	+
Closterium lunata	–	+	–	–	–	+
C. cornu	–	–	–	–	+	+
Desmedium sp.	–	–	–	–	–	+
Stousrastrum sp.	–	–	–	–	–	+
S. protestum	–	+	–	–	–	+
Euglenophyceae						
Euglena minuta	–	+	+	–	–	+
E. polymorpha	–	–	+	–	–	–
Trachelomonas churkowenisis	–	–	+	–	–	–
T. volvocina	–	–	–	–	–	+
Lepocinclis ovum	+	–	–	–	–	–
Ulvophyceae						
Cladophora sp.	–	–	–	–	–	+

+ = present; – = absent

An attempt to investigate the primary development of algal biofilm by using an artificial substrate for easy attachment of the organism in laboratory conditions was made. As per the investigators knowledge and the review done, this experimentally first done in Karnataka and Kerala states, western ghats.

Several factors affected the development of biofilm using an artificial substrate. The pH, temperature, the exposure time (incubation) and the quality of water (nitrate and phosphate). In this investigation only the primary formation of the biofilm was observed and identified the algal species that are responsible for the formation but not concentrated on mature periphyton community development.

Good growth of biofilm was observed in a duration of six to eight weeks in summer and also in monsoon but in winter it took still longer time. In S2 and S6, formation of algal biofilm was remarkable, whereas in S3 it was medium (Figs. 2a-d). In other three samples of the sampling sites did not show biofilm formation. Algal species belonging to four classes were identified *viz*., Bacillariophyceae followed by Desmidaceae, Euglenophyceae, Chlorophyceae and Cyanophyceae (Table 2).



(a) (b) (c) (d)

Fig. 2 (a) Formation of algal biofilm in laboratory condition using artificial substrate; (b), (c) and (d): Growth seen in S2, S3 and S6

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Table II Comparison of Algal Species Forming Biofilm from Species Identified in Surface Water Samples

Species		Sampling sites					
		S1	S2	S3	S4	S5	S6
Bacillariophyceae							
Achnanthes andicola	-	-	-	-	-	-	-
Amphora coffeaeformis	-	-	-	-	-	-	-
A. ovalis	-	-	-	-	-	-	-
Cocconeis placentula	-	-	-	-	-	-	-
Cocconeis sp.	-	-	-	-	-	-	-
Cymbella affinis	*Cymbella affinis*	-	+	+	-	-	+
Cyclotella glomerata	-	-	-	-	-	-	-
C. catenata	-	-	-	-	-	-	-
Diploneis ovalis	-	-	-	-	-	-	-
Epithemia zebra	-	-	-	-	-	-	-
Eunotia major	-	-	-	-	-	-	-
Fragilaria brevistriata	-	-	-	-	-	-	-
F. contruens	-	-	-	-	-	-	-
F. pinnata	-	-	-	-	-	-	-
Gyrosigma acuminatum	-	-	-	-	-	-	-
G. silinarium	-	-	-	-	-	-	-
Gomphonema gracile	-	-	-	-	-	-	-
Melosira granulate	-	-	-	-	-	-	-
Melosira sp.	-	-	-	-	-	-	-
Navicula sphaerophora	*Navicula sphaerophora*	-	+	+	-	-	+
N. cincta	*N. cincta*	-	+	+	-	-	+

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Navicula sp.	*Navicula* sp.	-	+	+	-	-	+
Stauroneis angular	-	-	-	-	-	-	-
S. phoenicentron	-	-	-	-	-	-	-
Surirella robusta	-	-	-	-	-	-	-
S. splendid	-	-	-	-	-	-	-
Synedra acus	*Synedra acus*	-	+	+	-	-	+
S. ulna	*S. ulna*	-	+	+	-	-	+
Tabellaria sp.	*Tabellaria* sp.	-	+	+	-	-	+
Chlorophyceae							
Oedogonium sp.	*Oedogonium* sp.	-	+	+	-	-	+
Pediastrum sp.	-	-	-	-	-	-	-
Scenedesmus arcuatus	-	-	-	-	-	-	-
Spirogyra crassa	-	-	-	-	-	-	-
Spirogyra sp.	*Spirogyra* sp.	-	+	+	-	-	+
Tetraedron tribolatum	-	-	-	-	-	-	-
Cyanophyceae							
Oscillatoria subbrevis	-	-	-	-	-	-	-
Spirulina sp.	*Spirulina* sp.	-	+	+	-	-	+
S. nordestedtii	-	-	-	-	-	-	-
Desmidaceae							
Arthrodesmus gibberulus	-	-	-	-	-	-	-
Arthrodesmus sp.	-	-	-	-	-	-	-
Cosmarium angular	-	-	-	-	-	-	-
C. lundelli	*C. lundelli*	-	+	+	-	-	+
Closterium lunata	*Closterium lunata*	-	+	+	-	-	+
C. cornu	*C. cornu*	-	+	+	-	-	+

Stousrastrum sp.	*Stousrastrum* sp.	-	+	+	-	-	+
S. protestum	*S. protestum*	-	+	+	-	-	+
Euglenophyceae							
Euglena minuta	*Euglena minuta*	-	+	+	-	-	+
E. polymorpha	*E. polymorpha*	-	+	+	-	-	+
Trachelomonas churkowenisis	-	-	-	-	-	-	-
T. volvocina	*T. volvocina*	-	+	+	-	-	+
Lepocinclis ovum	-	-	-	-	-	-	-
Ulvophyceae							
Cladophora sp.	-	-	-	-	-	-	-

+ = present; – = absent

Nitrates and nitrites are widespread in the environment, they are found in most foods, in the atmosphere and in many water sources. Some nitrates in the environment are produced by fixation of atmospheric nitrogen. The productivity of natural waters in terms of algal growths is related to the fertilizing matter that gains entry in to them. Also, reduced forms of nitrogen are oxidized in natural waters, thereby affecting the dissolved oxygen resource.

Seasonal variations of phytoplankton showed maximum density in summer which indicates that the temperature of these months played an important role in increasing the population of phytoplankton. Similar observations were made by Nandan and Kumavat (2003) and the dominance of various phytoplankton species was less in monsoon months. This may be due to dilution of water on account of rain as well as greater water movement and flooding due to heavy rain. As an evidence in the present investigation, as mentioned earlier, cyclone effect in the western belt interrupted the planktonic growth in monsoon and winter of both the years of study period. Dwivedi *et al*. (2005) also obtained similar observations.

Several studies have discussed the effect of environmental factors on phytoplankton dynamics (Boney, 1989; De Huszar and Caraco, 1998; Kagalou *et al*., 2001; Hassan *et al*., 2004; Susanne *et al*., 2005). The influence of various factors on the seasonal appearance of phytoplankton differs significantly, with physical factors (such as temperature and light intensity) being the most important and chemical (DO, pH, salinity, total hardness, EC and nutrient level) being of lesser importance (Reynolds, 1984).

In the present study some of the pollution tolerant algal species *viz., Euglena, Navicula* and *Oscillatoria* were recorded in S2, S3, S5 and S6 indicating high organic content. Similar observations were emphasized by Hosmani and Bharathi (1980) who studied certain polluted and unpolluted ponds in Karnataka state. Growth of algae such as *Spirulina* sp. and *Cladophora* sp. leads to loss of recreational value of the fresh waterbody. They also impact bad odour to water and increase sludge deposition in water treatment.

Artificial substrate used for the formation of algal biofilm in the laboratory must be in place for a sufficient time to allow representative communities to develop on substrate surface (Aloi, 1990). Sekar *et al*. (2004) proved that the surface wettability and roughness as well as the presence of organic and bacterial films markedly influenced the adhesion of all examined species (Bacillariophyceae, Chlorophyceae and Cyanobacteria). This is agreement with our present investigation where algal species from class Bacillariophyceae, Chlorophyceae, Cyanophyceae, Desmidaceae and Euglenophyceae were observed. Most of the published literature on algal biofilms deals with the diatom communities. This is part due to the fact that diatoms are ubiquitous, diverse and have defined ecological characteristics (Stevenson and Lowe, 1986; Aloi, 1990). This is in good agreement with the present findings. Diatoms dominated as was observed in the raw surface water samples from all the sampling sites. Some doubts are still existing about the correct usage of artificial substrates, the materials selected and the factors affecting the settlement of organisms upon them. This is of a special importance when the artificial substrates should represent the composition of organisms on naturally occurring substrates.

The occurrence of algal species observed in algal biofilm formed showed relatively less number of species when compared to species observed from surface water samples collected from the sampling sites is mainly due to the lack of supply of essential nutrients like nitrate, phosphates and effect of light and temperature. This held behind the good growth and the formation of biofilm in the laboratory condition.

IV.CONCLUSION

The concentration of dissolved oxygen was found to be high in all selected sampling sites. It is one of the important factors that influences the growth and development of diatoms. Diatoms were abundant in the winter season in all the sampling sites which is related to the high temperature. Desmids are the sensitive organisms and act as an indicator of water quality. There are different types of opinion with regard to the factors influencing the population of Desmids in water. The water temperature ranging from 20°C to 30°C is favourable for the growth. The pattern of distribution was found more during the summer and winter seasons and relatively low in monsoon season. Out of several factors TDS explains the variations in Desmids population to a maximum extent. They are also sensitive to physical and chemical characteristics of water, the increase in the concentration of COD, nitrate and turbidity reduce the density of desmids. The higher concentration of dissolved oxygen supported small number of Chlorophyceae members. Cyanophycean members are the causal organisms which inhabit in almost all the aquatic ecosystems. The influence of dissolved oxygen on Euglenoids is of considerable interest. The low dissolved oxygen show a profound effect on the multiplication of Euglenophyceae members. Bright sunshine coupled with high temperature has been found to be highly significant in regulating the multiplication of Euglenoids leading to the formation of water blooms. Nutrients such as phosphorus and nitrogen are important factors controlling the growth of Ulvophyceae members. Low phosphate level has been cited as one of the major limiting factors for growth of *Cladophora* sp.

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