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Phytoplankton diversity and seasonal variations in physico-chemical parameters of Kunigal tank, Tumkur district, Karnataka

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Abstract
Water is one of the most important natural resources needed for the existence and development of life on earth. The freshwater ecosystems like ponds, lakes, tanks and other small lentic ecosystems form an integral part of the biosphere and are considered as more significant in the analysis of biodiversity, limnology and global processes. It is important to know the physico-chemical and biological properties of water that determine the trophic status and contribute for the productivity of the aquatic ecosystems. Temperature regulates natural processes in aquatic ecosystem and affects biological reactions in water. pH of water is important for the biotic communities as most of the plant and animal species survive in narrow range of pH from slightly acidic to slightly alkaline condition. The quality of surface and ground water are being threatened by the anthropogenic activities such as siltation, untreated sewage fertilizers, insecticides, pesticides and industrial effluents as the runoff from surface areas. Seasonal variations in physico-chemical parameters have a significant effect on the distribution of periodicity, quantitative and qualitative composition of fresh water organisms. Phytoplanktons are the important primary producers and play a significant role in the aquatic food chain and retain the stability of the aquatic ecosystem. The production of phytoplanktons depends on pH, sunlight, some inorganic nutrients, CO_2, salinity, temperature etc. In the present study, for the analysis of physico-chemical parameters and phytoplanktons, on monthly basis, the surface water samples were collected from Kunigal tank between 7 am to 9 am for a period of one year from February-2015 to January-2016. The results indicated that the physico-chemical parameters were within the permissible limit as prescribed by Indian standards of drinking water: 2012 and showed rich species diversity of phytoplanktons. The tank water is suitable for drinking, agriculture and fish culture.

Keywords: ecosystem, physico-chemical parameters, seasonal variations, temperature, phytoplanktons

Introduction
Limnology deals with the study of biology of the continental inland waters and aimed at the evaluation of the water quality, biotic and abiotic factors. Water plays its unique role by providing habitat for numerous aquatic organisms as it is required by all organisms for their survival and to perform various metabolic activities. Fresh water ecosystems like lakes, tanks, reservoirs are facing environmental problems due to human activities of deforestation, disposal of domestic sewage, industrial effluents, agricultural runoff, industrialization, urbanization, mining etc., The perennial tanks play a vital role in rural and urban areas by providing multiple uses as a source of drinking water, irrigation, fish culture, recharge of ground water, control of floods etc., (Gurunathan, 2006) [1]. ('Water quality deals with the physical, chemical and biological features with respect to other hydrological properties (Chakraborty, 1998) [2]. The analysis of physico-chemical parameters is involved in the water quality analysis and assessment which indicate the biotic status of ecosystem (Mulani *et al.*, 2009) [3].
The study of water parameters is required to conduct ecological studies of aquatic ecosystems to attain better knowledge of the metabolic events in aquatic eco system. Physico-chemical parameters provide the basis for assessing the suitability of water for its designated use and to improve the existing status. Physico-chemical parameters are key components of the aquatic systems that determine structure and population dynamics of planktons (Hulyal and Kaliwal, 2009) [4].
The ecology of a lake can be studied through proper identification of freshwater species found in that particular lentic habitat. They constitute an integral part of the aquatic food web and contribute significantly to the biological productivity of the aquatic ecosystem (Nimbalkar *et al.*, 2013, Lalitha and Ramakrishna, 2021) [5,6]. Plankton diversity is one of the most important ecological parameters in water quality assessment. The community and composition of planktons can be used as a good indicator of the trophic status of an aquatic ecosystem (Blancher, 1984) [7]. Their rapid growth rate can provide meaningful and quantifiable indication of ecological change in short and long-time scales (Lalitha and Ramakrishna, 2021, Karuthapandi,2016) [6,8].
Phytoplankton is the important component of an aquatic food chain where phytoplankton density is directly associated with aquatic environmental productivity and physico-chemical components are directly related to their production. As the phytoplanktons are very sensitive to changes in the environment, they are used as biological indicators for the assessment of water quality status in the water bodies (Salman *et al.*, 2013; Luong

and Phan, 2014) [9, 10]. The quality of an aquatic ecosystem is dependent on the physico-chemical properties and biological diversity of water (Irfanullah, 2006) [11].

The phytoplankton community is strongly influenced by changes in the physico-chemical parameters of water and climate change (Hari Muraleedharan, 2010) [12]. The physico-chemical properties help to identify the sources of pollution for the further investigations on the eco-biological impacts and also for initiating the necessary steps for remedial actions in case of polluted aquatic bodies. This will help in assessing the water quality in future. Study of Phytoplanktons provides an optimal and convenient focus point for research on eutrophication and its adverse impact on aquatic ecosystems (Lalitha and Ramakrishna, 2021) [6]. Keeping this in view, present study has been undertaken to assess the seasonal variations of different physico-chemical parameters and phytoplankton diversity of Kunigal tank.

Study Area

Kunigal tank is one of the biggest tanks in Tumkur District situated in between Kunigal town and Kottagere village. It is situated between 13° 02′ N 77° 02′ E (Latitude of 13^0 01′ 30" Longitude of 77^0 01′ 30") at an elevation of 778.45 meters above the mean sea level. It is rain fed and perennial in nature. The sources of water for Kunigal tank are rain fall, Nagini and Hemavathi rivers. The tank is situated with an area of 1030 acres and the catchment area is found to be 339.14 sq. km. It is being utilized enormously for irrigation and fish culture. The satellite view of study area is shown in Fig. 1.

Fig 1: Satellite view of Kunigal Tank.

Materials and Methods

3.1 Physico-chemical parameters

In the present study, for the analysis of physico-chemical parameters, the surface water samples were collected on monthly basis from Kunigal tank between 7 am to 9 am for a period of one year from February-2015 to January-2016. Air temperature, water temperature and pH were measured in the field itself. Electrical conductivity, turbidity, total suspended solids, dissolved oxygen and free CO_2, were determined for all the samples in the laboratory by employing standard methods described in APHA (2005) and Trivedy and Goel (1986) [13,14]. Methods used in the analysis of physico-chemical parameters is given in Table.1

3.2 Phytoplanktons

For the analysis of phytoplanktons, surface water samples were collected between 7 am to 9 pm for a period of one year from February 2015 to January 2016. 50 liters of water sample were collected and filtered through 60µm mesh size plankton net. 50 ml of the concentrated water sample was fixed and preserved in 4% formalin. Taxonomic identification of planktons was based on morphological and taxonomic key characters described by Fritch (1959), Desikachari (1959), Prescott (1969), Needham and Needham (1941) and Adoni (1985) [15-19].

Statistical analysis

The data obtained during the study period has been subjected to Statistical analysis. Correlation between physico-chemical parameters and phytoplanktons was explained using Pearson's correlation co-efficient with the help of SPSS (21.0 version).

Table 1: The methods of analysis of physico-chemical parameters.

Sl. No	Parameters	Units	Method used
1.	Air temperature	^{o}C	Mercury thermometer
2.	Water temperature	^{o}C	Mercury thermometer
3.	pH		pH meter
4.	Turbidity	NTU	Nephelometric method
5.	Electrical conductivity	µs/cm	Conductivity meter
6.	Total suspended solids	mg/l	Gravimetric method
7.	Total dissolved solids	mg/l	Gravimetric method
8.	Dissolved oxygen	mg/l	Winkler's method
9.	Free CO_2,	mg/l	Titrimetric method

Results

The results of seasonal variations of physico-chemical parameters are presented in the Table. 2 and Fig.2. Indian Standard Drinking Water-Specification IS 10500:2012 is presented in Table.3. Correlation between physico-chemical parameters and phytoplanktons is represented in Table.4. Percentage occurrence of phytoplanktons is represented in Fig.3 and some representative species of phytoplanktons is given in Figure.4.

Table 2: Seasonal variations in Physico-chemical parameters of Kunigal tank during 2015-16

Sl. No	Parameters	Seasonal Mean values		
		Summer	Monsoon	Winter
1.	Air temperature (AT)	29.75 ±0.9146	28.65 ±0.7724	28.2±1.0708
2.	Water temperature (WT)	27.66 ± 0.848	25.87 ± 1.314	25.25 ± 1.258
3.	pH	7.3 ± 0.3464	6.65 ± 0.1914	7.3 ± 0.2
4.	Electrical conductivity (EC)	194.7 ± 20.755	184.32 ± 22.689	177.55 ± 7.1747
5.	Turbidity (TUR)	0.87± 0.3841	3.825 ± 0.3304	1.925±0.7973
6.	Total suspended solids (TSS)	29.5± 11.930	22 ± 11.775	44.5±12.897
7.	Total dissolved solids (TDS)	96.5±12.583	115.5±4.4347	112.5 ± 11.120
8.	Dissolved oxygen (DO)	7.675±0.6396	4.975 ± 0.6652	6.2±0.5164
9.	Free CO_2,	1.4± 0.5416	2.9 ±0.6218	3.875 ±1.8571

± Standard Deviation

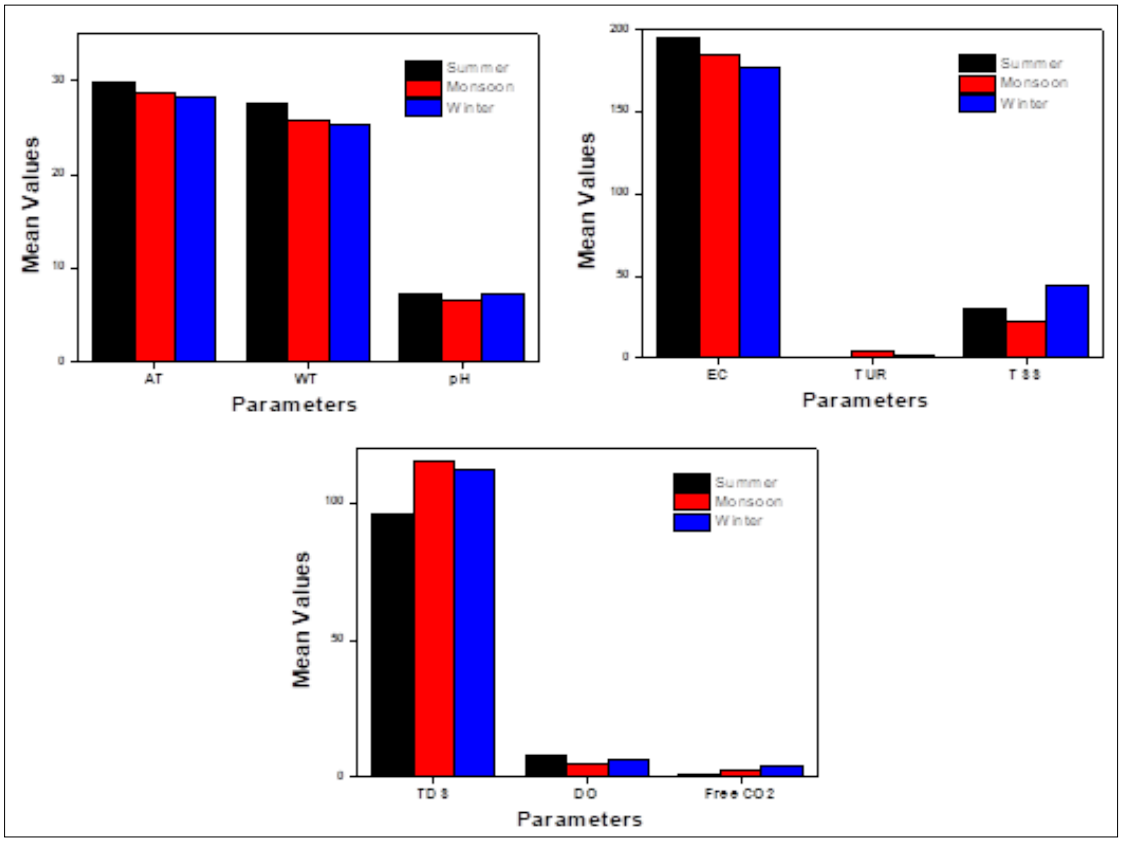


Fig 2: Seasonal variations in Physico-chemical parameters of Kunigal tank during 2015-16

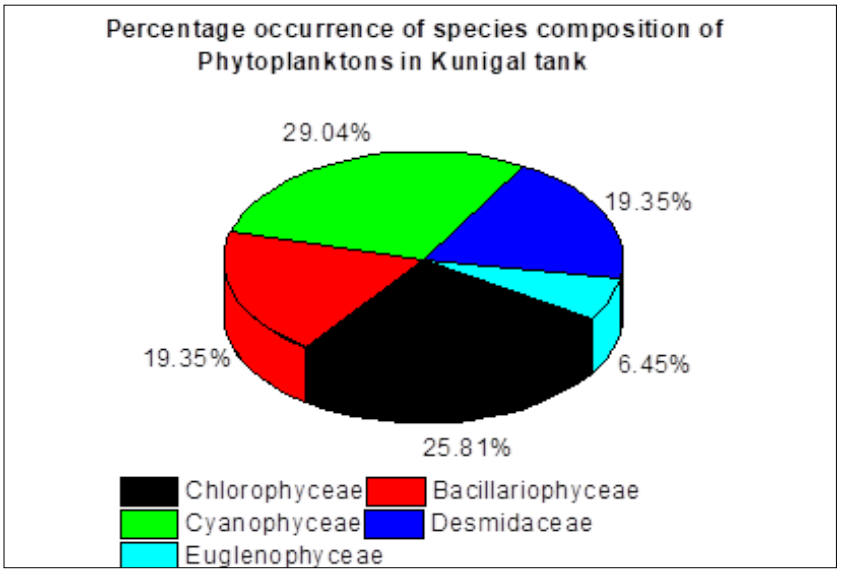


Fig 3: Percentage occurrence of species composition of phytoplanktons

Table 3: Indian Standard Drinking Water-Specification IS 10500:2012

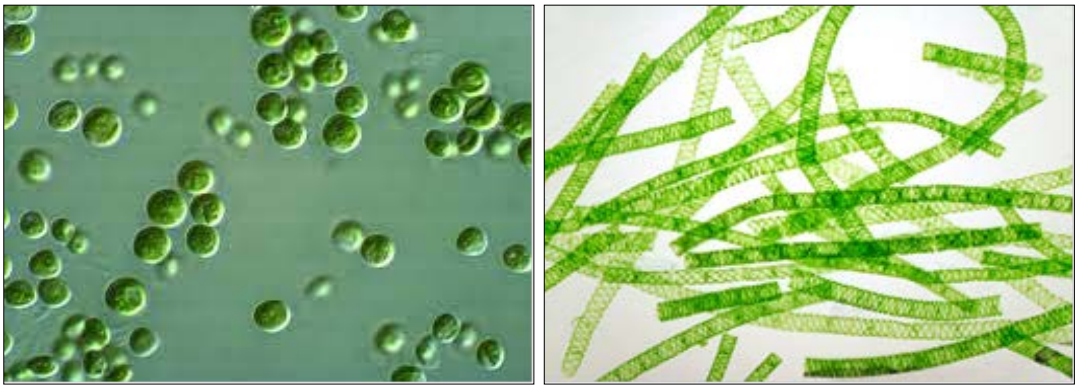
SL. NO.	Parameter	Requirement (Acceptable limit)	Permisible limit
1	P^H	6.5-8.5	No relaxation
2	Turbidity (NTU)	1	5
3	Total dissolved solids (mg/l)	500	2000
4	Chloride (mg/l)	250	1000
5	Sulphate (mg/l)	200	400
6	Nitrate (mg/l)	45	No relaxation
7	Total Alkalinity (mg/l)	200	600
8	Total Hardness (mg/l)	200	600
9	Calcium (mg/l)	75	200
10	Magnesium (mg/l)	30	100
11	Iron (mg/l)	0.3	No relaxation
12	Zinc (mg/l)	5	15
13	Lead (mg/l)	0.01	No relaxation
14	Cadmium (mg/l)	0.003	No relaxation

Table 4: Correlation matrix between physico-chemical parameters and phytoplanktons of Kunigal Tank during 2015-2016

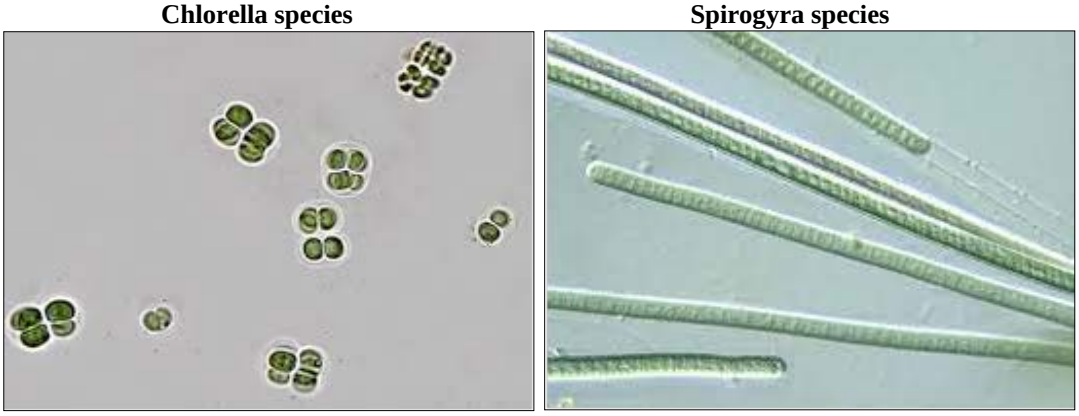
	AT	**WT**	**pH**	**Tur**	**EC**	**TSS**	**TDS**	**DO**	**CO2**	**CHL**	**BAC**	**CYA**	**DES**	**EUG**
AT	1													
WT	.970**	1												
pH	.179	.167	1											
Tur	-.212	-.211	-.795**	1										
EC	.054	-.034	.178	-.169	1									
TSS	.210	.298	.458	-.263	-.471	1								
TDS	-.258	-.287	-.413	.603*	.170	.076	1							
DO	.239	.251	.597*	-.841**	.368	.114	-.491	1						
CO2	-.267	-.218	-.024	.439	-.099	.497	.724**	-.316	1					
CHL	.619*	.554	.060	-.387	.417	-.412	-.562	.569	-.720*	1				
BAC	.619*	.557	.071	-.375	.407	-.406	-.565	.532	-.706*	1.000**	1			
CYA	.630*	.584*	.229	-.55	.404	-.296	-.633*	.664*	-.702*	.982**	.981**	1		
DES	.608*	.539	.006	-.306	.403	-.446	-.531	.472	-.700*	.998**	.997**	.962**	1	
EUG	.629*	.578*	.185	-.492	.407	-.328	-.616*	.629*	-.706*	.991**	.990**	.998**	.976**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).



Chlorella species **Spirogyra species**



Gloeocapsa species **Lyngbya species**

Fig 4: Some representative species of phytoplanktons.

4.1 Physico-chemical Parameters

Air Temperature: (AT)

During the study period, seasonal mean and standard deviation values recorded were 29.75 ±0.91°C during summer, 28.65 ±0.77°C during monsoon and 28.2±1.07°C during winter.

Water Temperature: (WT)

During the study period, seasonal mean and standard deviation values recorded were 27.66 ± 0.84°C during summer, 25.87 ± 1.314°C during monsoon and 25.25 ± 1.25°C during winter.

pH

During the study period, seasonal mean and standard deviation values recorded 7.3 ± 0.34 during summer, 6.65 ± 0.1914 during monsoon and 7.3 ± 0.2 during winter.

Electrical Conductivity: (EC)

During the study period, seasonal mean and standard deviation values recorded 194.7 ± 20.75 µs/cm during summer, 184.32 ± 22.68 µs/cm during monsoon and 177.55 ± 7.17 µs/cm during winter.

Turbidity: (TUR)

During the study period, seasonal mean and standard deviation values recorded 0.87± 0.3841 NTU during summer, 3.825 ± 0.3304 NTU during monsoon and 1.925±0.7973 NTU during winter.

Total Suspended Solids: (TSS)

During the study period, seasonal mean and standard deviation values recorded 29.5± 11.930mg/l during summer, 22 ± 11.775mg/l during monsoon and 44.5±12.897mg/l during winter.

Total Dissolved Solids: (TDS)

During the study period, seasonal mean and standard deviation values recorded 96.5±12.58 mg/l during summer, 115.5±4.43 mg/l during monsoon and 112.5 ± 11.12 mg/l during winter.

Dissolved Oxygen: (DO)

During the study period, seasonal mean and standard deviation values recorded 7.675±0.63 mg/l during summer, 4.975 ± 0.66mg/l during monsoon and 6.2±0.51mg/l during winter.

Free CO_2

During the study period, seasonal mean and standard deviation values recorded 1.4± 0.54mg/l during summer, 2.9 ±0.62 mg/l during monsoon and 3.875 ±1.85 mg/l during winter.

4.2 Diversity of Phytoplanktons

In the present study, 62 species of phytoplanktons have been identified under five groups- Chlorophyceae, Bacillariophyceae, Cyanophyceae, Desmidaceae and Euglenophyceae. Among these, Chlorophyceae shows its dominance. Chlorophyceae is represented by 16 species belonging to 15 genera, Bacillariophyceae is represented by 12 species belonging to 9 genera, Cyanophyceae is represented by 18 species belonging to 17 genera, Desmidaceae is represented by 12 species belonging to 8 genera and Euglenophyceae is represented by 4 species belonging to 2 genera.

Discussion

Air Temperature

Temperature is one of the most important parameters in aquatic ecology as it influences the biota of water body by affecting activities such as behaviour, respiration and metabolism. It is very important in the determination of solubility of dissolved oxygen, carbon dioxide, bicarbonates, carbonates equilibrium, determination of pH and conductivity. Harney *et al., (*2013) [20] were of the opinion that rise in temperature will speed up the biochemical reactions and reduce the solubility of gases.

In the present study, air temperature was found maximum in summer and minimum in winter.

In Hattikuni reservoir, Siddaram *et al*., (2016) [21] found that the average air temperature in the reservoir was maximum during pre-monsoon season and less during post-monsoon season. Gayathri *et al.,* (2014) [22] also observed high temperature in May (summer) and low temperature in January (winter) in Shoolkere Lake. Whereas, Shinde *et al.,* (2010) [23] recorded maximum atmospheric temperature in April (summer) and minimum in December (winter) in Harsool savangi dam. All these observations were correlated with the results of present investigation. High atmospheric temperature recorded during summer may be due to the long duration of day and high light intensity.

Water Temperature

The water temperature plays as an important factor which influences the chemical, bio-chemical characteristics of water body. All metabolic and physiological activities and life processes such as feeding, reproduction, movements and distribution of aquatic organisms are greatly influenced by water temperature (Senthilkumar *et al.,* 2008) [24].

In the present study, water temperature was found maximum in summer and minimum in winter.

In Harsool savangi dam, Shinde *et al.,* (2010) [23] recorded the maximum water temperature in summer and minimum water temperature in winter. Manjare *et al.,* (2010) [25] also observed maximum water temperature in summer and minimum in winter. These results were similar to the present work. In summer, water temperature was high due to low water level, high temperature and clear atmosphere. Low temperature recorded during winter was due to high water level and low atmospheric temperature.

pH

pH is the measure of concentration of hydrogen ions in the solution and shows the intensity of the acidic or basic character of a solution at given temperature.

In the present study, the water was found to be slightly alkaline throughout the study period except few months which are near to neutral.

Harney *et al., (*2013) [20] reported maximum pH value during summer seasons and minimum during monsoon season in their investigative reports on the seasonal variations of physico-chemical parameters on Pindavani pond. Rajashekhar *et al., (*2009) [26] also observed the higher pH during summer in Karanja reservoir (Karnataka) due to high rate of evaporation and photosynthetic activity. High values of pH were observed in summer while the values were near to neutral in winter was reported by Rajashekhar *et al., (*2010) [27] in their study on the seasonal variations of zooplankton community in freshwater reservoir Gulbarga District.

In the present study, high values of pH during summer might be due to evaporation of water and concentration of nutrients in water. The decreased pH values during monsoon were due to dilution caused by the rainwater. The values of the pH were within the permissible limits (6.5 - 8.5) of IS 10500:2012 which indicated the suitability of water for all the purposes.

Electrical Conductivity

Conductivity is a numerical expression of the ability of an aqueous solution to carry electric current. This ability depends on the presence of ions, their total concentration, mobility, relative concentrations and the temperature of measurement.

In the present study, Electrical conductivity was found maximum in summer and minimum in monsoon.

Kedar *et al*., (2007) [28] recorded the maximum conductivity during the summer and minimum during the monsoon season in Yedshi Lake in Mangarulpir tahsil of Washim District, Maharashtra. Savitha and Yamakanamardi, (2011) [29] also recorded more conductivity values during summer season in Dalvoy Lake. But,

Deepthi and Yamakanamardi, (2014) [30] observed highest value of conductivity during rainy season at Giribettethe Lake. The reason for the high values of conductivity could be due to high concentration of ionic constituents present in water bodies.

Turbidity

Turbidity is an expression of light scattering and light absorbing property of water caused by wide variety of suspended matter, range in size from colloidal to coarse dispersion depending upon the degree of turbulence and also ranges from pure inorganic substances to those that are highly organic in nature.

Savitha and Yamakanamardi, (2011) [29] observed high turbidity values in Alanahally Lake during summer. This is in accordance with the view of Sharma and Capoor, (2010) [31] who have reported high turbidity during summer season in lake water of Patna bird sanctuary, Agra.

High values of turbidity in monsoon are due to influx of rain water from catchment areas, muddiness, washes silts, high organic matter and low transparency due to suspended inert particulate matter. However, low values of turbidity in summer are due to clear atmosphere, evaporation of water. The turbidity values recorded in the present study were within the permissible limits (5 NTU) of IS 10500: 2012.

Total Suspended Solids

Total suspended solids (TSS) include the solids that are suspended in water bodies in the form of inorganic and organic particles of immiscible liquid. They also reduce light penetration which reduces the ability of algae to produce food and oxygen.

In the present study, TSS was found maximum in winter and minimum in monsoon.

The results of the present work were similar to the findings of Savitha and Yamakanamardi, (2011) [29] who observed high values of TSS in winter at Alanahalli lake. But, Deepthi and Yamakanamardi, (2014) [30] observed high values of TSS in summer and low during the winter in Varuna, Madappa and Giribettethe Lake.

An increase in TSS during summer may be attributed to low water level and high rate of evaporation of water. Low levels of TSS may be due to less rain fall and low inflow of water.

Total Dissolved Solids

Total dissolved solids denote various types of minerals present in water. The solids which are dissolved in water are carbonates, bicarbonates, sulphate, chloride, phosphate and chloride of calcium, magnesium, sodium, potassium, iron and manganese.

In the present study, TDS was found maximum in monsoon and minimum in summer.

The present investigations were supported by investigations in Hattikuni reservoir by (Siddaram *et al*., (2016) [21] where maximum TDS was recorded during monsoon season comparatively less during pre- monsoon season. But, Jawale and Patil, (2009) and Salve and Hiware, (2008) [32,33] recorded low total dissolved solids in winter season and maximum value in monsoon. High values of TDS during monsoon season may be due to siltation, addition of domestic waste, deterioration and mixing of runoff water which carried mud, sand etc, mixed in the tank water. The minimum value of TDS during winter season may be due to the lower hardness owing to the presence of carbonates and large amount of dead aquatic plants.

The TDS values studied in the present investigation were within the acceptable. limits (500 mg/l) prescribed by IS 10500: 2012 and hence the water is good for drinking and irrigation purpose.

Dissolved Oxygen

Dissolved oxygen is essential to maintain biological life in water and plays an important role in the determination of water quality. Its level depends upon physical, chemical and biological activities occurring in the water bodies.

In the present study, DO was found maximum in summer and minimum in monsoon.

Manjare *et al.,* (2010) and Simpi *et al.,* (2011) [25, 34] reported maximum values of DO summer in Tamdalge tank and Hosahalli tank respectively

The high DO in summer is due to increase in temperature and duration of bright sunlight. The long days and intense sunlight during summer seems to accelerate photosynthesis by phytoplankton, utilizing CO_2 and giving off oxygen. Low DO values during monsoon might be due to less temperature which decreases the photosynthetic activity and reduces the release of O_2.

Free CO_2

Free carbon dioxide is the indicator of the biological respiration activities of aquatic ecosystem. High value of free CO_2 is due to the presence of high amount of organic matter which on microbial decomposition release large amount of free CO_2 as by product of their metabolic activity.

In the present study, free CO_2 was found maximum in winter and minimum in summer.

Manjare *et al.,* (2010) and Simpi *et al.,* (2011) [25, 34] reported maximum value of free CO_2 in the month of December (winter) and minimum value in the month of February in Tamdalge tank and Hosahalli tank.

In the present study, the percentage occurrence of phytoplankton species during the year 2014-2015 in Kunigal tank was Chlorophyceae 25.8%, Bacillariophyceae 19.35 %, Cyanophyceae 29.04%, Desmidaceae 19.35% and Euglenophyceae 6.45%

The results of the present study were supported by Jayabhaye *et al.,* (2007) [35] who recorded 43 species of phytoplanktons from Parola dam, Hingoli (M.S). Begum and Narayana (2006) [36] identified 34 species of Phytoplanktons under four classes and maximum density was recorded by Bacillariophyceae followed by Chlorophyceae, Cyanophyceae and Euglenophyceae in four lentic water body in and around Davangere city. Shekhar *et al.,* (2008) [37] studied the water quality status of river Bhadra and reported a total of 45 species of phytoplankton belonging to 5 classes (Chlorophyceae-19 species, Bacillariophyceae - 16 species, Cyanophyceae-07 species, Euglenophyceae-2 species and Chrysophyceae-1 species). Veerendra *et al.,* (2006) [38] have reported a total 34 species of phytoplankton amongst Chlorophyceae with 13 species, Bacillariophyceae with 11 species, Cyanophyceae with 7 species and Euglenophyceae with 3 species in Mani reservoir. Sharma *et al.,* (2015) [39] found 27 taxa of phytoplanktons belonging to 4 families Chlorophyceae (47%), Cyanophyceae (27%), Bacillariophyceae (23%) and Euglenophyceae (3%) in river Narmada.

Pandey *et al.,* (1995) [40] observed a positive correlation between phytoplanktons and physico-chemical parameters like pH, dissolved oxygen, bicarbonate, phosphate, and transparency. Bhat and Pandit (2005) [41] also found a close relationship between physicochemical characters of water and phytoplankton. In Euphrates River, Salman *et al.,* (2013) [9] and Ishaq *et al.,* (2013) [42] showed a significant positive correlation between phytoplanktons with pH, dissolved oxygen, nitrate and significant negative correlation among phytoplankton with BOD. Sharma *et al.,* (2015) [39] analysed various physico-chemical parameters of water depicted a positive correlation with diversity and distribution of Phytoplankton.

In the present study, phytoplanktons showed significant correlation with physico-chemical parameters. Chlorophyceae showed significant positive correlation with Atmospheric temperature and significant negative correlation with CO_2. Bacillariophyceae showed significant positive correlation with Atmospheric temperature and significant negative correlation with CO_2. Cyanophyceae showed significant positive correlation with Atmospheric temperature water temperature, DO and significant negative correlation with turbidity, TDS and CO_2. Desmidaceae showed significant positive correlation with Atmospheric temperature. Euglenophyceae showed significant positive correlation with Atmospheric temperature, Water temperature, DO and significant negative correlation with TDS and CO_2.

Conclusion

The present investigation summarizes the seasonal fluctuations in physico-chemical parameters and phytoplankton diversity in Kunigal tank. The physico-chemical properties of water help to identify the pollution status of the tank and helpful in initiating the necessary steps in monitoring the tank to improve water quality, plankton diversity and fish diversity. In the present study, all the physico-chemical parameters were within the permissible limit prescribed by IS 10500:2012 making the tank least polluted with good quality of water. The study reveals that the tank exhibits high productivity and abundance phytoplanktons. Finally, it is concluded that the water of Kunigal tank is suitable for drinking, agriculture and fish culture.

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