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RESEARCH ARTICLE

DIATOM MISCELLANY BY SEASONAL VARIATIONS IN MELURU LAKE 1, MELURU LAKE 2, KARPURAVALLI LAKE AND SALIGRAMA LAKE OF KRISHNARAJA NAGARA TALUK, MYSURU DISTRICT, KARNATAKA, INDIA

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ABSTRACT

Water is and has always been a prized but scarce commodity. It is one of the most vital natural wealth for all life on earth. The present investigation is an attempt to know the pollution load through diatom as water pollution indicators, species diversity and their seasonal fluctuations in lake Ecosystem of four lakes of K.R.Nagar Taluk, Mysore District. Anthropogenic eutrophication, habitat destruction and water flow alterations were the key stressors to freshwater, threatening the quality and availability of water and biodiversity. Overall identified diatoms in four lakes are predicted as water quality indicators. *Synedra ulna* and *Synedra acus* were proved to be anthropogenic indicators in Meluru lake 1. In Meluru lake 2 *Navicula halophila* was responsible for organic pollution. Karpuravalli lake was dominated by *Stauroneis phoeicenteron* indicating anthropogenic activity. Saligrama lake was contaminated by *Synedra acus* and *Navicula halophila* causing both anthropogenic and organic pollution indicators. Results of the present study cautions the indiscriminate dumping and discharge of pollutants into the lakes which may lead to serious environmental deterioration which could be considered as a potential source of threat to biotic life.

Key words: K.R.Nagar, Mysuru, water quality, ecological indicators, *Stauroneis phoeicenteron*, *Navicula halophila*, *Synedra ulna*, *Synedra acus*.

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INTRODUCTION

Environmental monitoring makes use of the fact that polluted or stressed communities are characterized by a change in the species abundance (Kumari *et al*., 2018). Anthropogenic eutrophication and global warming have dramatic impacts on marine phytoplankton and are likely to continue for many centuries Xiao *et al.* (2018). Diatoms have one of the shortest generation times of all biological indicators. They produce and respond rapidly to environmental change and provide early measures of both pollution and habitat restoration, thus they give short term reflections of water quality (U.S. EPA, 2002). India is facing a serious problem of natural resource scarcity, especially that of water in view of population growth and economic development. Most of fresh water bodies all over the world are getting polluted, thus decreasing the potability of water.

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All life is depend on water and exists in nature in many forms like ocean, river, lake, clouds, rain, snow and fog etc. However, strictly speaking chemically pure water does not exist for any appreciable length of time in nature. Pollution taking place in surface water may bring about on enrichment of algal nutrients in water due to man's amplified activities. The release of domestic wastes, solid waste, industrial waste, agricultural runoff from surrounding areas which enter into the river bodies through different drains and channels of rivers may cause the river pollution, Suresh (2015). Physico-chemical analysis is the chief consideration to weigh up the quality of water for its best handling (Basavarajappa *et al*., 2010). Life in aquatic environment is largely governed by physico-chemical characteristics and their stability where chemical and biological factors cannot be separated from each other. Physico-chemical factors are very important to know the pollution strength. Many investigators stressed the importance of temperature in the periodicity of diatoms and several others pointed out that low temperature is favourable to the growth and development of diatom populations Srinivas *et al.* (2018).

The utilization of lentic water bodies for domestic use like, drinking purpose has assumed importance in developing countries. The disposal of agricultural waste and untreated sewage into water bodies adversely affect the plant and animal life. Sukumaran (2002) is of the opinion that the constant discharge of sewage into the aquatic system enriches the organic content, leading to eutrophication and deterioration of the quality of water. In India, inland water bodies attracted the attention of various workers leading to the studies on water quality and distribution of phytoplankton from time to time (Ratha *et al.,* 2003).

MATERIALS AND METHODS

Study area: Karnataka is located in 11º 30' North and 18º 30' North latitudes and 74º East and 78º 30' East longitude. Karnataka State is in the western part of India. The State extends to 805 km from north to south and about 283 km from east to west. The total area of the State is 192,493 sq km. Mysuru District is located between latitude 11°45' to 12°40' north and longitude 75°57' to 77°15' east. It is bounded by Mandya District to the south-east, Kerala State to the south, Kodagu District to the west and Hassan District to the north. It has an area of 6,845 km².

In this, K.R.Nagar town is situated as one of the Taluk of the Mysuru District, Karnataka State, India which coordinates 12.46° north and 76.39° east of latitude and longitude. K.R.Nagar was founded between 1925 and 1930 as new town, when flood by river Kaveri damaged the nearby old town called as Yadatore. For water quality assessment 4 lakes are selected which were located in K.R.Nagar Taluk and they are Meluru lake 1, Meluru lake 2, Karpuravalli lake and Saligrama lake Fig 1.

Sampling: The sampling was made in the winter (October 2015) and summer (March 2016). Water was sampled from four different lakes of K.R.Nagar Taluk ie., Meluru lake 1, Meluru lake 2, Karpuravalli lake and Saligrama lake. The sampling was made in the early morning from the above lakes. By scrubbing the upper surface of water, the samples were collected from about 1-2 feet depth. All these lakes are located in K. R. Nagar surroundings with different distances. These lakes are used for many purposes ie., domestic uses like bathing, washing and drinking and some lakes were used for fish culturing. Fishermen got permission from Pisciculture Department. Different varieties of small fishes introduced into the lakes in the month of June and July.

Photographs showing geographical location of K.R.Nagar Taluk

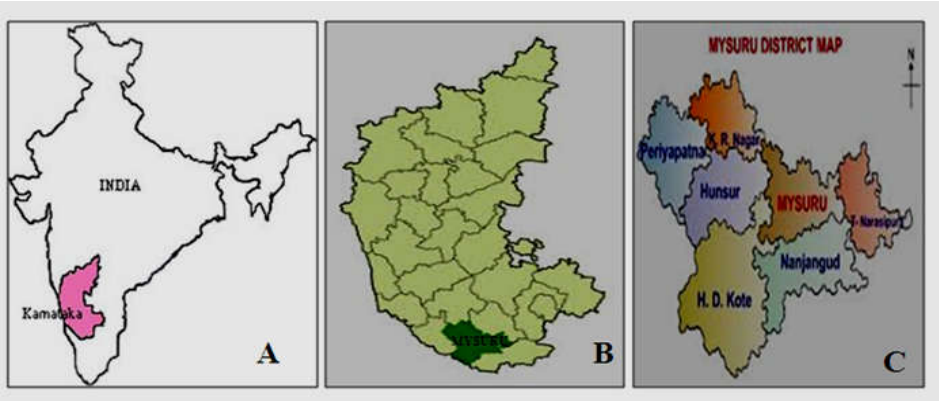

Fig. 1. Map showing geographical location of A) India-Karnataka; B) Karnataka-Mysuru; C) Mysuru Dist - K. R. Nagar

Photographs showing satellite maps of K.R.Nagar Taluk Lakes

Fig. 2. A) Meluru Lake 1; B) Meluru Lake 2; C) Karpuravalli Lake; D) Saligrama Lake

They allow fishes to grow and after attaining specific size, they harvested and marketed either locally or outside places through the department of fisheries. The varieties of fish reared in the lakes are Grass crap, Silver crap, Catla catla, Tilapia, Labeorohita etc. These lakes are also important for agriculture purposes, mainly for Coconut plantations and major crops like Potato, Maize, Ragi and other vegetable crops Table 1. Satellite locations and Sampling sites of these lakes are shown in Fig 2 and Fig 3.

Photographs showing views and sampling sites

Fig. 3. A) Meluru Lake 1; B) Meluru Lake 2; C) Karpuravalli Lake; D) Saligrama Lake

Table 1. Showing sampling sites of four Lakes

Lakes	Distance from K.R.Nagar (km)	Longitude	Latitude	MSL (ft)	Shape	Size (acres)	Location	Storage capacity (q secs)	Uses
1. Meluru lake 1	29	76° 17'	12° 36'	2736	Oval shape	8 acre	South	21 q secs	Agriculture Domestic uses
2. Meluru lake 2	29.5	76° 17'	12° 36'	2736	Square shape	4 acre	South	12 q secs	Domestic uses
3.Karpuravalli lake	25	76° 15'	12° 35'	2690	Triangle shape	5.3 acre	South	16 q secs	Domestic uses
4.Saligrama lake	24	76° 16'	12° 33'	2590	Half rectangle - square	14 acre	South	50 q secs	Domestic uses

Assessment of water sample for indicator organisms

The water samples were taken by adding 30ml of 4% formaldehyde for 1000 ml of each sample. About 10 ml of Lugol's iodine solution is added to each sample in plastic bottles to sustain the colour of organisms for the purpose of identification and it is kept for one day in undisturbed manner for sedimentation process. After sedimentation the supernatant is decanted and the remaining lower portion about 150 ml of the solution is transferred into a clean bottle and observed the samples under microscope (10X and 40X). A drop of sedimented sample taken on a clean glass slide observed with the preferred magnification using microscope. The identified Diatoms are converted into Diatoms per litre (1ml equals to 28 drops). The recorded data was tabulated by using Van Dam software for monitoring diatoms as ecological indicators (Van Dam *et al*., 1994).

Analysis of ecological values: Based on the assessment of diatoms as indicator organisms, the data obtained is tabulated by using Van Dam software for monitoring analysis of ecological values for two different seasons and three different variables in all lakes.

Taxonomic guidance: While analysing the data to identify the organisms taxonomic guides consulted includes, Hosmani *et al*. (2011) and Karthick *et al*. (2010). The four lakes selected for present study are K.R.Nagar Taluk lakes. The identified diatoms were subjected to Van Dam *et al*. (1994) software for obtaining the ecological condition of each lake.

Statistical analysis: The data of the present study in the months of October (2015) to March (2016) analyzes the ecological condition of the lakes with respect to present environmental conditions based on the data given by Van Dam *et al*. (1994). Identification of diatoms was done with respect to their values through the data given by Kelly *et al*. (2009).

RESULTS

In order to assess the water quality of Meluru lake 1, Meluru lake 2, Karpuravalli lake and Saligrama lake of K.R.Nagar Taluk, Mysuru District, in the present study diatoms were identified in all the lakes and their ecological values were determined using the data of Van Dam. The ecological values are represented in Table 2.

Table 2. Classification of ecological indicator values (Van Dam, Martens and Sinkeldam, 1994)

Table 1. To identify p^H (R) values

No	Classes	p^H range
1	Acidobiontic	Optimal occurrence at p^H <5.5
2	Acidophilous	Mainly occurring at p^H<7
3	Circumneutral	Mainly occurring at p^H values above 7
4	Alkaliphilous	Mainly occurring at p^H >7
5	Alkalibiontic	Exclusively occurring at p^H >7
6	Indifferent	No apparent optimum

Table 2.2. To identify Salinity (H) values

No:	Salinity	Chloride	Salinity
1	Fresh	< 100	< 0.2
2	Fresh brackish	< 500	< 0.9
3	Brackish fresh	500 - 1000	0.9 - 1.8
4	Brackish	1000 - 5000	1.8 - 1.9

Table 2.3. To identify Nitrogen uptake metabolism (N) values

1	Nitrogen autotrophic taxa tolerating very small concentrations of organically bound nitrogen
2	Nitrogen autotrophic taxa tolerating elevated levels of organically bound nitrogen
3	Facultative bound nitrogen heterotrophic taxa needing periodically elevated concentrations of organically bound nitrogen
4	Obligate nitrogen heterotrophic taxa needing continuously elevated concentrations of organically bound nitrogen

Table 2.4. To identify Moisture retention (M) values

1	Never or only very rarely occurring outside water bodies
2	Mainly occurring in water bodies, sometimes on wet places
3	Mainly occurring in water bodies also rather regularly on wet and moist places
4	Mainly occurring on wet and moist or temporarily dry places
5	Nearly exclusively occurring outside water bodies

Table 2.5. To identify Trophic (T) state

1	Oligotrophic
2	Oligo - mesotrophic
3	Mesotrophic
4	Meso - eutrophic
5	Eutrophic
6	Hyper eutrophic
7	Oligo - eutrophic (Hyper eutraphentic)

Table 2.6. To identify Oxygen requirements (O) values

1	Continuously high (about 100% saturation)
2	Fairly high (above 75% saturation)
3	Moderate (about 50% saturation)
4	Low (above 30% saturation)
5	Very low (about 10% saturation)

Table 2.7. To identify Saprobity (S) values

No:	Saprobity	Water quality class	Oxygen saturation (%)	BOD 20(mg/l)
1	Oligosaprobous	I/II– III	>85	2
2	B- Mesosaprobous	II	70 – 85	2 – 4
3	Alpha mesosaprobous	III	25 – 70	4 – 13
4	Alpha/ meso/ polysaprobous	III- IV	10 – 25	13 – 22
5	Polysaprobous	IV	<10	22

The above tables give the ecological data regarding diatoms. This data was given by Van Dam, Martens and Sinkeldam, 1994. It includes the values of p^H from 1-6, it indicates acidobiontic, acidophilous, circumneutral, alkaliphilous, alkalibiontic etc. Salinity is another ecological value it includes chloride content of the water sample or it may be fresh/fresh brackish/brackish fresh etc. Nitrogen uptake metabolism includes the identified Taxa are autotrophic or facultative or obligate. Moisture retention value depending upon the water bodies such as wet or dry. Trophic state is also one of the ecological values included under the software. Here the organisms come under oligo, oligomeso, eutrophic, mesoeutropic and oligoeutropic states were identified. Oxygen requirement explains about the percentage of saturation. Saprobity is the last ecological value. Here, the water quality class, percentage of oxygen saturation and Biological Oxygen Demand can be clearly illustrated. This ecological value is adapted in water analysis of Meluru lake1, Meluru lake 2, Karpuravalli lake and Saligrama lake of K.R. Nagar Taluk, Mysuru District.

Diatoms of Meluru Lake (1)

Table 3. Distribution of Diatoms in Meluru Lake (1) during winter (2015) and summer seasons (2016)

No:	Species	Winter season	Summer season
1	*Synedra acus* (SACU)	16,800	25,200
2	*Pinnularia acrosphoria* (PASA)	8,400	16,800
3	*Eunotia arcus* (EARC)	21,000	25,200
4	*Synedra ulna* (SULN)	16,800	21,000
5	*Fragilaria brevistriata* (FBRE)	000	12,600

The above Table 3 shows the analysed data of identified species in two different seasons of Meluru lake (1) of K.R. Nagar Taluk, Mysuru district. In this lake about 4 genera and 5 species were identified. The identified species are *Synedra acus* (SACU), *Pinnularia acrosphoria* (PASA), *Eunotia arcus* (EARC), *Synedra ulna* (SULN) and *Fragilaria brevistriata* (FBRE). *Eunotia arcus* (EARC) is the most frequent and abundantly found species having 46,200 population and *Fragilaria brevistriata* (FBRE) is the least species found in this lake and is noted only in one site and in other sites it is completely absent, with an average of 12,600 population. The other species are moderately found in all the sites and are significantly different.

Ecological values of Winter and Summer seasons in Meluru Lake (1): In the above Table 4, 16 ecological values for the identified diatoms in the Meluru lake (1) are predicted. In both winter and summer seasons the p^H range of this site is Acidobiontic because of its range is < 5.5. Salinity is less because of fresh/ fresh brakish water and about 50% saturation is done because of moderate oxygenation.

Diversity of diatoms in four different Lakes of K.R. Nagar Taluk

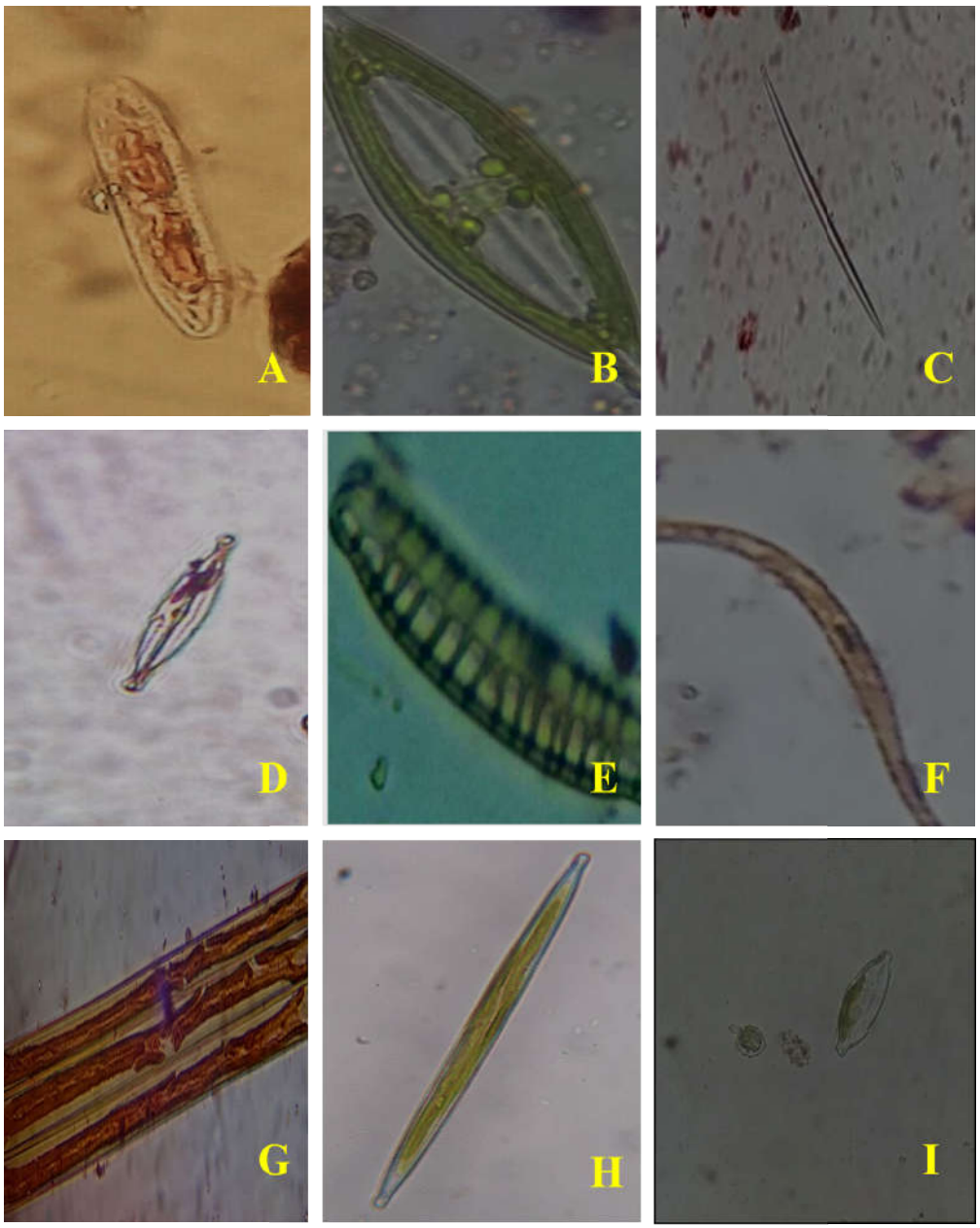

Fig 4. A) *Pinnularia acrosphoria* (PASA); B) *Navicula halophila* (NHAL); C) *Synedra ulna* (SULN); D) *Gomphonema gracile* (GGRA); E) *Eunotia arcus* (EARC); F) *Gyrosigma acuminatum* (GYAC); G) *Fragilaria construens* (FCON); H) *Synedra acus* (SACU); I) *Achanthes exigua* (AEXI)

Table 4. Ecological values of Winter and Summer seasons in Meluru Lake 1 of K.R.Nagar Taluk, Mysuru District

No:	Ecological indicators	Ecological values of winter season	Ecological values of summer season
1	Number of species	4	4
2	Population	63,000	1,00,800
3	Diversity	1.57	2.26
4	Evenness	0.99	0.97
5	Number of genera	3	3
6	p^H (R)	Acidobiontic, optimal occurrence at p^H <5.5	Acidobiontic, Optimal occurrence at p^H <5.5
7	Salinity (H)	Fresh, chloride is <100, Salinity <0.2	Fresh brackish, chloride is < 500 & salinity 0.9
8	Nitrogen uptake metabolism (N)	Nitrogen-autotrophic taxa tolerating very small concentrations of organically bound nitrogen.	Nitrogen autotrophic taxa tolerating elevated levels of organically bound nitrogen
9	Oxygen requirement (O)	Moderate (about 50% saturation)	Moderate(about 50% saturation)
10	Saprobity(S)	Oligosaprobous[Water quality class is I, Oxygen saturation is >85, BOD20 (mg/l) is <2]	Oligosaprobous [Water quality class is I, Oxygen saturation is >85, BOD20 (mg/l) is <2]
11	Trophic state	Oligo - mesotrophic	Oligo-Eutrophic
12	Moisture retention(M)	Mainly occurring in water bodies also rather regularly on wet and moist places.	Mainly occurring in water bodies, sometimes on wet places
13	IDSE \ % (Louis - Lecreoq index)	3.72 % (low)	3.62 % (low)
14	% Indicators of organic pollution	0.0	0.0
15	% indicators of anthropogenic eutrophication	66.67 % (high)	44.44 % (moderate)
16	Indicator organisms	SACU, SULN	SACU, SULN

In winter season, its trophic status was Oligo-mesotrophic, moisture condition is wet and hence organisms occurring in moist places. It consists of oligosaprobous, biological oxygen demand is high, water quality class is I, oxygen saturation is > 85% and it has 3.72% (low) of Index of Diatom Saprobic Eutrophication (IDSE). Here, organic pollution is not found and hence there are no organic pollution indicators. About 66.67% indicators of anthropogenic eutrophication are predicted in high number. *Synedra acus* (SACU) and *Synedra ulna* (SULN) are the two important indicators of anthropogenic eutrophication.

Diatoms of Meluru Lake (2)

found species having 50,400 and 50,400 population and *Gyrosigma acuminatum* (GYAC) is the least species found in this lake and it is noted only in one site and in other sites it is completely absent, with an average of 21,000 population. The other species are moderately found in all sites and are significantly different Fig 4.

Ecological values of Winter and Summer seasons in Meluru Lake (2): From the above table the ecological values for the identified diatoms in the Meluru lake (2) are represented.

Table 5. Distribution of Diatoms in Meluru Lake (2) during winter (2015) and summer seasons (2016)

No:	Species	Winter season	Summer season
1	*Gomphonema gracile* (GGRA)	12,600	21,000
2	*Gyrosigma acuminatum* (GYAC)	4,200	16,800
3	*Pinnularia acrosphoria* (PASA)	21,000	29,400
4	*Achnanthes exigua* (AEXI)	8,400	16,800
5	*Navicula halophila* (NHAL)	25,200	25,200

Table 6. Ecological values of Winter and Summer seasons in Meluru lake 2 of K.R.Nagar taluk, Mysuru District

No:	Ecological indicators	Ecological values of winter season	Ecological values of summer season
1	Number of species	5	5
2	Population	71,400	1,09,200
3	Diversity	2.10	2.15
4	Evenness	0.90	0.93
5	Number of genera	5	5
6	p^H (R)	Acidobiontic, optimal occurrence at p^H <5.5	Acidobiontic, optimal occurrence at p^H<5.5
7	Salinity (H)	Fresh brackish, chloride < 500 & salinity 0.9	Fresh brackish, chloride < 500 & salinity 0.9
8	Nitrogen uptake metabolism (N)	Nitrogen-autotrophic taxa tolerating elevated concentrations of organically bound nitrogen	Nitrogen autotrophic taxa tolerating very small concentrations of organically bound nitrogen
9	Oxygen requirement (O)	Continuously high (about 100% saturation)	Fairly high(above 75% saturation)
10	Saprobity (S)	Oligosaprobous[Water quality class is I, Oxygen saturation is >85, BOD 20 (mg/l) is <2]	Oligosaprobous[Water quality class is I, Oxygen saturation is >85, BOD 20 (mg/l) is <2]
11	Trophic state	Eutrophic	Oligo -mesotrophic
12	Moisture retention(M)	Mainly occurring in water bodies also rather regularly on wet and moist places.	Mainly occurring in water bodies also rather regularly on wet and moist places
13	IDSE \ % (Louis –Lecreoq index)	4.04 % (low)	4.01 % (low)
14	% Indicators of org.Pollution	31.82 % (moderate)	31.58 % (moderate)
15	% indicators of anthropogenic eutrophication	0.0	0.0
16	Indicator organisms	NHAL	NHAL

The total population found in this lake is 63000 and diversity is 1.57% and total number of genera are 4 with 5 species. In summer season, its trophic status is oligo-eutrophic (Hyper eutraphentic), moisture condition is slight lower than winter season. It consists of oligosaprobous, biological oxygen demand is high, water quality class is I, oxygen saturation is > 85% and it has 3.62% (low) of Index of Diatom Saprobic Eutrophication (IDSE). Here organic pollution is not found and hence there are no organic pollution indicators. About 44.44% moderate indicators of anthropogenic eutrophication are predicted ie., *Synedra acus* (SACU) and *Synedra ulna* (SULN) and these are the two important indicators of anthropogenic eutrophication here. The total population found in this lake is 1,00,800 and diversity is 2.26% and total number of genera are 4 with 5 species Fig 4. The above Table 5 gives the data of identified species in two different seasons of Meluru lake (2) of K.R.Nagar Taluk, Mysuru District. In this lake about five genera and five species were identified. The identified species are *Gomphonema gracile* (GGRA), *Gyrosigma acuminatum* (GYAC), *Pinnularia acrosphoria* (PASA), *Achnanthes exigua* (AEXI) *and Navicula halophila* (NHAL). The *Pinnularia acrosphoria* (PASA) and *Navicula halophila* (NHAL) was the most common and abundantly

About 16 ecological values are predicted in the above table. In both winter and summer seasons the p^H range of this site is Acidobiontic because of its range is < 5.5. Salinity is less because of Fresh brackish water, chlorine below 500, salinity 0.9 and about 100% saturation is done because of continuous high/ fairly high oxygenation. In winter season, the trophic status is Eutrophic, moisture condition is wet hence organisms occurring in moist places and in water bodies. It consists of oligosaprobous, biological oxygen demand is high, water quality class is I, oxygen saturation is > 85% and it has 4.04% (low) of Index of Diatom Saprobic Eutrophication (IDSE). Here, organic pollution is 31.82%. There was no anthropogenic eutrophication. Organic indicator predicted was *Navicula halophila* (NHAL). The total population found in this lake was 71,400 with the diversity of 2.10% and total number of genera is 5 with 5 species. In summer season, its trophic status is Oligo-mesotrophic, moisture condition is slightly lower than winter season. It consists of oligosaprobous, biological oxygen demand is >75%, water quality class is I, oxygen saturation is >85%. It has 4.01% (low) of Index of Diatom Saprobic Eutrophication (IDSE). Here, the organic pollution is 31.58% (moderate) and there was no anthropogenic eutrophication.

Diatoms of Karpuravalli Lake

Table 7. Distribution of diatoms in Karpuravalli Lake during winter (2015) and summer seasons (2016)

No:	Species	Winter season	Summer season
1	*Pinnularia acrosphoria* (PASA)	12,600	21,000
2	*Gomphonema gracile* (GGRA)	16,800	21,000
3	*Stauroneis phoeicenteron* (SPHO)	12,600	16,800
4	*Pinnularia acrosphaeria* (PACR)	16,800	16,800
5	*Fragilaria brevistriata* (FBRE)	12,600	21,000

Table 8. Ecological values of Winter and Summer seasons in Karpuravalli Kake of K.R.Nagar taluk, Mysuru District

No	Ecological indicators	Ecological values of winter season	Ecological values of summer season
1	Number of species	5	5
2	Population	71,400	96,600
3	Diversity	1.99	1.95
4	Evenness	1.0	0.98
5	Number of genera	4	4
6	p^H (R)	Acidobiontic, optimal occurrence at p^H <5.5	Acidobiontic, Optimal occurrence at p^H<5.5
7	Salinity(H)	Fresh brackish, chloride < 500 & salinity 0.9	Fresh brackish, chloride < 500 & salinity 0.9
8	Nitrogen uptake metabolism(N)	Nitrogen-autotrophic taxa tolerating very small concentrations of organically bound nitrogen.	Nitrogen autotrophic taxa tolerating very small concentrations of organically bound nitrogen
9	Oxygen requirement(O)	Moderate(About 50% saturation)	Continuously high(about 100% saturation)
10	Saprobity(S)	Oligosaprobous [Water quality class is I, Oxygen saturation is >85, BOD20 (mg/l) is <2]	Oligosaprobous [Water quality class is I, Oxygen saturation is >85, BOD20 (mg/l) is <2]
11	Trophic state	Meso - eutrophic	Oligo - eutrophic (Hyper eutraphentic)
12	Moisture retention(M)	Mainly occurring in water bodies also rather regularly on wet and moist places	Mainly occurring in water bodies also rather regularly on wet and moist places.
13	IDSE / % (Louis -Lecreoq index)	4.14 % (low)	4.22 % (low)
14	% Indicators of org.Pollution	0.0	0.0
15	% indicators of anthropogenic eutrophication	26.67 % (moderate)	13.2 % (low)
16	Indicator organisms	SPHO	SPHO

Diatoms of Saligrama Lake

Table 9. Distribution of diatoms in Saligrama Lake during winter (2015) and summer seasons (2016)

No:	Species	Winter season	Summer season
1	*Synedra acus* (SACU)	12,600	21,000
2	*Pinnularia acrosphoria* (PASA)	8,400	16,800
3	*Gamphonema gracim* (GGRA)	12,600	8,400
4	*Gyrosigma acuminatum* (GYAC)	8,400	37,800
5	*Fragilaria construens* (FCON)	4,200	8,400
6	*Achanthes exigua* (AEXI)	16,800	21,000
7	*Navicula halophila* (NHAL)	4,200	8,400

Organic pollution indicator is *Navicula halophila* (NHAL). The total population found in this lake was 1,09,200 and diversity was 2.15% and total number of genera 5 including 5 species Fig 4. The above Table. 7 gives the data of identified species in two different seasons of Karpuravalli lake of K.R.Nagar Taluk, Mysuru District. In this lake about 4 genera and 5 species were identified. The identified species were *Pinnularia acrosphoria* (PASA), *Gomphonema gracile* (GGRA), *Stauroneis phoeicenteron* (SPHO), *Pinnularia acrosphaeria* (PACR) and *Fragilaria brevistriata* (FBRE). The *Gomphonema gracile* (GGRA) is the most common and abundantly found species having 37,800 population and *Stauroneis phoeicenteron* (SPHO) is the least species found in this lake and is noted only in one site and in other sites it is completely absent, with an average of 29,400 population. The other species are moderately found in all the sites and are significantly different Fig 4.

Ecological values of Winter and Summer seasons in Karpuravalli lake: In the above table about 16 ecological values for the identified diatoms are predicted. In both winter and summer seasons the p^H range of this lake was Acidobiontic because of its range is < 5.5. Salinity is less because of fresh brackish water and about 90% saturation is done because of continuous high oxygenation. In winter season, its trophic status is Meso-eutrophic, moisture condition is wet and hence organisms were occurring in water bodies. It consists of oligosaprobous, biological oxygen demand is high, water quality class is I, oxygen saturation is > 85% and it has 4.14% (low) of Index of Diatom Saprobic Eutrophication (IDSE). Here, the organic pollution is not found and hence there is no organic pollution indicator. About 26.67% (moderate) indicators of anthropogenic eutrophication are predicted ie., *Stauroneis phoeicenteron* (SPHO) is the important indicator of anthropogenic eutrophication. The total population found in this lake is 71,400 and diversity is 1.99% and total number of genera is 4 with 5 species Fig. 4. In summer season, its trophic status is oligo-eutrophic (Hyper eutraphentic), moisture condition is same as that of winter season. It consists of oligosaprobous, biological oxygen demand is high, water quality class is I, oxygen saturation is > 85% and it has 4.22% (low) of Index of Diatom Saprobic Eutrophication (IDSE). Here organic pollution is not found and hence there are no organic pollution indicators.

Table 10. Ecological values of Winter and Summer seasons in Saligrama Lake of K.R.Nagar Taluk, Mysuru District

No:	Ecological indicators	Ecological values of winter season	Ecological values for summer season
1	Number of species	7	7
2	Population	67,200	1,21,800
3	Diversity	2.41	2.58
4	Evenness	0.93	0.92
5	Number of genera	7	7
6	p^H (R)	Acidophilous, mainly occuring at p^H <7	Acidobiontic, Optimal occurrence at p^H<5.5
7	Salinity (H)	Fresh brackish, chloride < 500 & salinity 0.9	Fresh brackish, chloride < 500 & salinity 0.9
8	Nitrogen uptake metabolism (N)	Nitrogen-autotrophic taxa tolerating very small concentrations of organically bound nitrogen	Nitrogen autotrophic taxa tolerating very small concentrations of organically bound nitrogen
9	Oxygen requirement (O)	Continuously high (about 100% saturation)	Fairly high (above 75% saturation)
10	Saprobity (S)	Oligosaprobous[Water quality class is I, Oxygen saturation is >85, BOD20(mg/l) is <2]	B- mesosaprobous[water quality class is II,oxygen saturation is 70-85%, BOD 20(mg/l) is 2-4.
11	Trophic state	Mesotrophic	Eutrophic
12	Moisture retention (M)	Mainly occurring in water bodies also rather regularly on wet and moist places	Mainly occurring in water bodies, sometimes on wet places.
13	IDSE \ % (Louis - Lecreoq index)	3.85 % (low)	3.83 % (low)
14	% Indicators of org.Pollution	0.0	6.90 % (low)
15	% indicators of anthropogenic eutrophication	21.43 % (moderate)	17.24 % (low)
16	Indicator organisms	SACU	NHAL, SACU

About 13.2% (low) indicators of anthropogenic eutrophication are predicted i.e. *Stauroneis phoeicenteron* (SPHO), this is the important indicator of anthropogenic eutrophication. The total population found in this lake is 96,600 and diversity is 1.95% and total number of genera was 4 with 5 species. The above Table 9 gives the data of identified species in two different seasons of Saligrama lake of K.R.Nagar Taluk, Mysuru District. In this lake about seven genera and seven species can be identified. The identified species are *Pinnularia acrosphoria* (PASA), *Gomphonema gracile* (GGRA), *Synedra acus* (SACU), *Gyrosigma acuminatum* (GYAC), *Fragilaria construens* (FCON), *Achanthes exigua* (AEXI) and *Navicula halophila* (NHAL). *Gyrosigma acuminatum* (GYAC) was the most common and abundantly found species with a population of 46,200. *Fragilaria construens* (FCON) and *Navicula halophila* (NHAL) are the least species found in this lake and is noted only in one site and in other sites it is completely absent, with an average of 12,600 and 12,600 population. The other species are moderately found in all the sites and are significantly different Fig. 4.

Ecological values of Winter and Summer seasons in Saligrama Lake: The ecological values for the identified diatoms in the Saligrama Lake are represented in table 10. About 16 ecological values are predicted in the above table. In both winter and summer seasons the p^H range of this site is Acidophilous/ Acidobiontic because of its range is < 7/ < 5.5. Salinity is less because of fresh brackish water ie., 0.9 and about 100% saturation is done because of continuous high oxygenation. In winter season, its trophic status is Mesotrophic, moisture condition is wet and hence organisms occurring in moist places and in water bodies. It consists of oligosaprobous, with high biological oxygen demand, water quality class is I, oxygen saturation is >85% and it has 3.85% (low) of Index of Diatom Saprobic Eutrophication (IDSE). Here, there were no organic pollution indicators. About 21.43% (moderate) indicators of anthropogenic eutrophication are predicted ie., *Synedra acus* (SACU) is the important indicator of anthropogenic eutrophication. The total population was found in this lake is 67,200 and diversity is 2.41% and total numbers of genera are 7 with 7 species. In summer season, its trophic status is eutrophic, moisture condition is slightly lower than winter season. It consists of B-mesosaprobous, biological oxygen demand is moderate, water quality class is II, oxygen saturation is 70-85%, and it has 3.83% (low) of Index of diatom Saprobic Eutrophication (IDSE). Here the organic pollution is 6.90%, about 17.24% (low) indicators of anthropogenic eutrophication are predicted ie., *Synedra acus* (SACU) anthropogenic and *Navicula halophila* (NHAL) organic, are the two important indicators of pollution. The total population found in this lake was 1,21,800 and with diversity of 2.58% having total number of 7 genera with 7 species Fig 4.

DISCUSSION

The availability and eminence of water has always played an imperative component in determining not only where people can live, but also their quality of life. 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. Ample of work is done either on taxonomic account or limnological account, but studies on the combined aspects is lacking. Information on the algal biodiversity and related aspects pertaining to the water bodies in Karnataka State is unavailable. The present study reveals the importance of physic-chemical parameters and their effect on algal biodiversity in selected fresh water Lakes of K. R. Nagar Taluk. Microclimate and seasonal change in a particular area also play an important role in the presence and absence of some species (Sharma and Kumari, 2018) which may function as indicators of pollution (Suresh, 2015). The values of physico-chemical parameters in lake are always below the drinking water quality standards (Shreelakshmi and Shailaja, 2018). Our results are in accordance with the observations of Srinivas *et al*. (2018) with physico-chemical parameters and results obtained by Karthikeyan *et al.* (2018) with heighted polluted cavery river due to discharge of untreated sewage disposal and industrial effluents into the lake causing anthropogenic and organic pollution. Species diversity of our lakes correlates with the species obtained with work done by Zelnik *et al*. (2018). Decreases in water quality in our studied lakes are in line with the results of Sidabutar *et al*. (2017) due to human activities. The values recorded for environmental variables and distribution of samples indicated for seasonal variation by natural fluctuation, p^H, dissolved oxygen and nutrients with changes in temperature are in relation to reports

of Quevedo *et al*. (2018). Our results are in parallel with the results gained by Jadav *et al*. (2016) that the diversity of diatoms varies seasonally which are higher in winter season and lower during summer indicating more pollution in the lakes.

Summary and Conclusion

To wrap up, there is an urgent need to see the sights, be aware of, predict and mitigate future environmental change scenarios to preserve this unique ecosystem. In this regard, monitoring programmes and/or paleo-limnological approaches using diatoms as environmental indicators could be used as early warnings of environmental changes. Sensitivity and adaptability of diatoms to environmental change are also dependent on endogenous factors such as genetic diversity, phenotypic plasticity, species traits, population density, fitness, dispersal ability, persistence, which are probable to modulate a disparity in diatom responses to external threats and consequently their vulnerability and future distribution. The government and local people should take utmost quality heed besides conservation of various species which is critical to village economy and water bodies.

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