Multiplicity of Diatoms as Ecological Indicators of Madenahally Lake and Honnayakanahalli Lake of Mandya District, Karnataka, India

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Abstract

Water is among the most precious of natural resources available on our mother Earth. It is one of the most imperative natural assets for all life on earth. The present investigation is an effort to know the pollution freight through diatoms as water pollution indicators, species diversity and their seasonal hesitancy in Madenahally and Honnayakanahalli lake ecosystems of Mandya District, Karnataka, India. Anthropogenic eutrophication, habitat demolition and water flow variations were the key stressors to freshwater, bullying the quality and availability of water and biodiversity. Results of the present study cautions the haphazard dumping and discharge of pollutants into the lakes which may lead to serious environmental deterioration which could be considered as a nascent source of hazard to biotic life. On the whole the identified diatoms in two lakes were predicted as water quality indicators. *Synedra ulna* and *Nitzschia microcephala* were considered as the most important pollution indicators. *Nitzschia microcephala* proved as organic pollution indicator in both sites of Madenahally lake lacking anthropogenic pollution. In case of Honnayakanahalli lake organic pollution indicators did not exist in all the three sites but was loaded with *Synedra ulna* and *Navicula minima* causing anthropogenic pollution. Our findings tinted that diatom species diversity was rich in both the lakes and analysis of all the values obtained in each lake revealed that Madenahally lake was polluted by organic pollution whereas Honnayakanahalli lake was polluted by anthropogenic eutrophication.

Keywords: Mandya, Madenahally lake, Honnayakanahalli lake, *Nitzschia microcephala*, *Navicula minima*, *Synedra ulna*.

I. INTRODUCTION

Water is everywhere, gravely making up more than 70 percent of the planet's surface without which we can't continue to subsist. To keep up with all things water check out the most interesting discoveries related to water, from the stuff we drink, to the droplets that make up the planets ocean, to water itself in all its glorious strangeness. Researchers in India have revealed that microscopic aquatic creatures could be used as the ecological equivalent of a canary in a coalmine for assessing inland freshwater lakes and ponds. Script in World Review of Science, Technology and Sustainable Development the team explains how diatoms respond badly to pollutants and sewage contamination (Lant, 2019). Robust biological indicators such as diatoms that are indicative of specific water quality and state the actual "Health" and ecological status of lake ecosystems of India is the need of the hour (Purushotham and Anupama, 2018b). Diatoms are also rousing new research into the past and how to reinstate more pristine ecological conditions in the future. Freshwater communities are very much susceptible to environmental variations (Darchambeau *et al*., 2017). Phytoplankton dynamics influence trophic levels and portability of water for human uses (Fisher *et al*., 2009 and Sharma *et al*., 2013). Monitoring of water quality with regards to physical and chemical parameters reflects instantaneous measurements while, biotic parameters developed during the recent years have dole out excellent tool in the area of water pollution studies and provides healthier evaluation of environmental changes (Kalyoncu and Serbetci, 2013).

Diatoms are latent indicators of water quality owed to their sensitivity and strong reaction to physico-chemical and biological changes (Suphan *et al*., 2012) and are the ideal means by which progress towards integrated water resource management can be monitored (Purushotham and Anupama, 2018e). Many workers Bharathi and Hosamani (1975), Palidebnath and Mukherjee (2011), Hosmani *et al.* (2011), Venkataramaiah (2011) have published their work on environment and ecology of phytoplanktons in fresh water in different lakes of our subcontinent. Fresh water lakes play an imperative role in hydrobiological, biological and bio-geochemical facet of the environment. Therefore, the management and the practices must be integrated on the basis of ecological values and sustainability to create long term vision. Microalgae have attracted significant interest with respect to biodiesel production. More than half of the total primary production at the base of the food chain worldwide is accounted for by micro algae (Guschina and Hardwood, 2006). Over 200,000 species of microalgae have been identified (Richmond, 2000). The phytoplankton in aquatic systems has been subjected to various ecological studies to enable us to harvest them efficiently. Water quality assessment based on the use of diatoms is now well developed and their value predicted at international level. Diatom assemblages support pale

ecological investigation, historical reconstruction of water quality and the determination prevailing water quality conditions. Diatoms provide a fine level of diagnostics resolution of the causes under laying changes in water quality and environmental conditions (Harding *et al.*, 2004). The ability to use diatoms as environmental indicators to their greatest utility is dependent on accurate, with lower prediction errors in occurring analysis (Sarah *et al.*, 2002). Currently ecological indicators are primarily used to evaluate the condition of the environment, as early warning sign of ecological problems and as barometers for trends in ecological resources. Thus, the present study was undertaken to know the diversity of diatoms in lakes where people use its water for drinking and domestic purposes. A thorough analysis of diatom community structures will behove our understanding of their ecology which in turn open new path to reap diatoms to benefit humanity.

II. MATERIALS AND METHODS

2.1 Study Area

Karnataka State is in the South Western region of India, located in 11° 30' North and 18° 30' North latitude and 74° East and 78°30' East longitude. Mandya is an Administrative District of Karnataka, India, bordered on the South by Mysore district. Mandya is famous for being one of the biggest sugarcane producing regions in India. Close to 2 million people live in an area spanning 4,900 square kilometers. Mandya is also famously called as ***"Sakkare Naadu"*** i.e. land of sugarcane.

More land area in Mandya district is put to agriculture use and about 94,779 hectares of land is used for irrigation. Sugarcane is the major crop in the taluk followed by Pulses and Ragi. Other crops include Paddy, Jowar and some oilseeds. Mandya District is multitude for several places of tourism interest including Bird Sanctuaries namely Kokkare Belluru and Ranganathittu near Srirangapatna and Thonnur lake "Fig. 1".

2.2 Sampling

Sampling was made in the month of January and February 2018. The water was sampled from two (or) three different sites of two lakes i.e., Madenahally lake and Honnayakanahalli lake with an interval of 15 days. The sampling was made in the early morning from different locations of both the lakes by scrubbing the upper surface of water collected from 1-2 feet depth "Fig. 2".

2.3 Photographs showing geographical location of Mandya Taluks

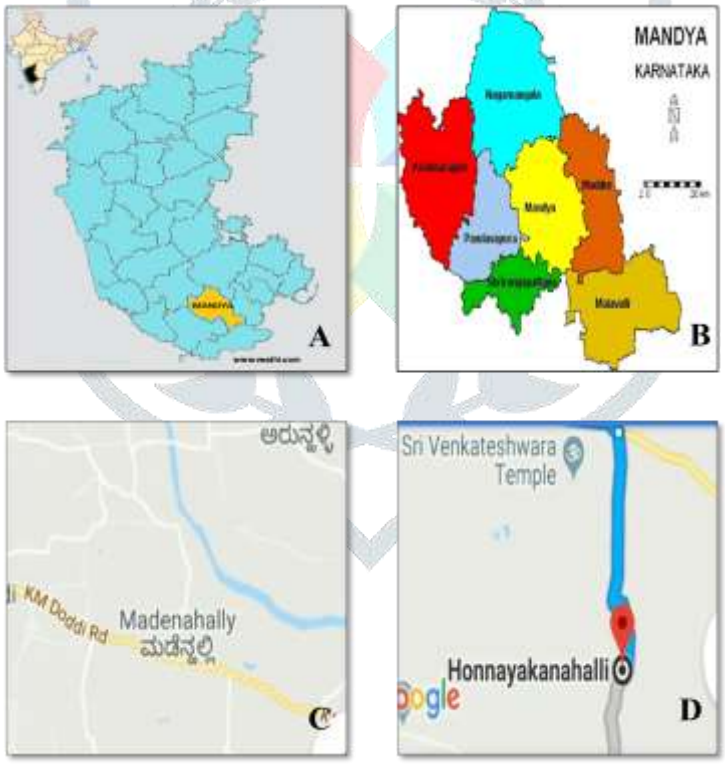

Figure 1: Map showing geographical locations of

A) India - Karnataka - Mandya Dist ; B) Taluks of Mandya District;

C) Map showing Madenahally ; D) Map showing Honnayakanahalli

2.4 Photographs showing views of sampling sites of Madenahally Lake, Maddur Taluk

Figure 2: Views of sampling sites A) Sampling Site -1; B) Sampling Site -2

2.5 Madenahally Lake, Maddur Taluk

Madenahally lake is situated in Madenahally village, Maddur taluk and Mandya District. It is situated 10 kilometers towards North part from the Taluk of Malavalli away from the Mandya District. It is located in the Northern part Madenahally village "Fig. 2". The lake covers about 101 hectares. This lake is located in "12° 28' 55" N Latitude" and "77 ° 4' 50" E Longitude". The total population is about 850 people. Nearby villages are Kandegala, Kembutagere, Kalluviranahalli etc. The famous temple of this village is Mattitaleshwara temple. This village lake water is used for various purposes like irrigation and agriculture *viz.*, for cultivation of major crops like Ragi, Pulses, Oilseeds, Paddy etc.

2.6 Photographs showing views of sampling sites of Honnayakanahalli Lake, Mandya Taluk

Figure 3: Views of sampling sites

A) Sampling Site-1; B) Sampling Site-2; C) Sampling Site-3

2.7 Honnayakanahalli lake, Mandya Taluk

This lake is situated in Honnayakanahalli village, Mandya Taluk and Mandya District. It is located 26 km towards East from Mysore District and head quarters Mandya. This lake is located in 12° 58' 52" N Latitude and 77° 4' 62" E Longitude. Honnayakanahalli is surrounded by Maddur taluk towards north, Mandya Taluk towards east and T. Narasipur Taluk towards south. This village has a total population about of 790 and 179 number of houses, with the village literacy rate of 66.8%. Hari-Hareshwara and Sri Chamundeshwari temples are present.

This lake water is very much necessary for the purposes of drinking and irrigation. The lake covers about 98 hectares of the land and the level of water capacity is 7-10 mcft. This lake water is potable and used for agriculture and irrigation. The major crops growing in surrounding areas by utilizing this lake water are mainly paddy and other pulses.

2.8 Assessment of water sample for indicator organisms

The samples were taken to the laboratory and preserved by adding 4% formaldehyde for 100 ml each samples and about 4ml of Lugo 's Iodine solution is added to each sample bottles to sustain the color of organisms for the purpose of identification and it is kept for 1-2 days for segmentation process. After segmentation the supernatant is decanted and the remaining lower portion of the solution is transferred into a clean bottle and observed the samples under microscope (10X and 40X) magnification.

A drop of segmented sample was taken on a clean slide with a drop of Safranin stain and observed with preferred magnification using microscope. The identified diatoms were converted into diatoms per liter (1 ml 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).

2.9 Analysis of ecological values for Madenahally and Honnayakanahalli lakes

Based on the assessment of diatoms as indicator organisms, the data obtained was tabulated by using Van Dam software for monitoring analysis of ecological values for different sites sampled for different variables in both the lakes.

2.10 Taxonomic guidance

For analyzing the data to identify the organisms taxonomic guides consulted includes, Avinash, Associate Professor, Department of Biotechnology, SBBR Mahajana First Grade College, Jayalakshmipuram, Mysore. The two lakes selected for the present study are Madenahally and Honnayakanahalli lakes. Here the diatoms from water samples were identified and subjected to Van Dam *et al*., (1994) software for obtaining ecological conditions of the each lake.

2.11 Statistical analysis

The data of the present study were analyzed in the months of January and February 2018. The ecological condition of the lakes with respect to present environmental conditions was identified based on the data given by Van Dam *et al*. (1994). Identification of diatoms was done with respect to their valves and through the data given by Kelly (2003).

2.12 Van Dam software

Van Dam software for monitoring diatoms as ecological indicators is used. This software has an inbuilt ecological data for about more than 10000-15000 diatom species along with complete name, reference, family type, sensibility, p^H, salinity, oxygen requirement, saprobity, trophic state, moisture retention, indicators & percentage of organic pollution, indicators & percentage of anthropogenic eutrophication.

III. RESULTS

In order to assess the water quality of Madenahally and Honnayakanahalli Lake of Mandya District Van Dam *et al.* (1994) software were used, which includes all the ecological values. In the present study diatoms were identified in both the lakes and their ecological values were determined by using the data of Van Dam *et al.* (1994) software. Classification of ecological values (Van Dam *et al*., 1994) for 2 sites of this lake is shown in Table 3. Diatoms identified in both the sites of Malavalli lake along with the acronyms represented in Table 4.2 and their ecological values are represented in Table 4.3. So also the diatoms identified in three sites of Honnayakanahalli lake along with the acronyms represented in Table 5.2 and their ecological values are represented in Table 5.3.

Table 3 Classification of ecological indicator values (Van Dam, Martens and Sinkeldam, 1994)

Table 3.1: p^H values

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

Table 3.2: Salinity 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 3.3 : Nitrogen uptake metabolism values

1	Nitrogen autotrophic taxa tolerating very small concentrations of originally bound nitrogen
2	Nitrogen autotrophic taxa tolerating elevated concentrations 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

Nitrogen uptake metabolism values are one of the ecological data, here the taxa was given to autotrophic, heterotrophic nitrogen tolerance. It was facultative or obligative nitrogen metabolism.

Table 3.4: Moisture retention 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

The above table shows that ecological values of moisture tolerance. It is mainly occurring in water bodies, sometimes on wet places, wet and moist temporarily dry places and also nearly exclusively occurring outside water bodies. These are the moisture retention values.

Table 3.5: Trophic State

1	Oligotrophic
2	Oligo-mesotrophic
3	Mesotrophic
4	Meso-eutrophic
5	Eutrophic
6	Hypereutrophic
7	Oligo to eutrophic (Hypoeutraphentic)

This type of ecological values, comes under Van Dam software which includes about 7 types of trophic states, on the basis of nature of diatoms. They are, Oligotrophic, Oligo-mesotrophic, Mesotrophic, Meso-eutrophic, Eutrophic, Hypereutrophic, and Oligo-eutrophic (Hypoeutraphentic).

Table 3.6: Oxygen requirements 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)

The above table shows the oxygen requirement values, it represents the % saturation of oxygen required for organisms that lived in aquatic body.

Table 3.7: Saprobity 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

Tables 3.1 to 3.7 give the ecological data regarding the diatoms. This data was given by Van Dam and Martens and Sinkeldam, 1994. It includes the values of p^H from 1-6, it indicates acidobiontic, alkaliphilous, 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, brakish. Nitrogen uptake metabolism includes the identified Taxa, whether autotrophic (or) facultative (or) obligate. Moisture retention value includes depending upon the water bodies such as wet (or) dry. Trophic state is also one of the ecological values included under this software. Here the organisms come under oligo, meso and eutrophic state were identified. Oxygen requirement is another important factor which explains about the percentage of saturation. Saprobity explains water quality class, oxygen saturation and Biological Oxygen Demand (BOD). These ecological values are adapted to assess water quality of lakes of Madenahally and Honnayakanahalli Lakes of Mandya District.

4. Diatoms of Madenahally Lake, Maddur Taluk

In two different sites of Madenahally Lake of Maddur Taluk, 7 genera and 7 species of diatoms were identified. The identified species were *Cymbella affinis* (CAFF), *Navicula indicum* (NIND), *Pinnularia gibba* (PGIB), *Achnanthes brevipes* (ABRE), *Nitzschia microcephala* (NMIC), *Fragilaria pinnata* (FPIN) and *Surerilla ovalis* (SOVA) Fig. 4. Here *Navicula indicum* (NIND) is the most abundantly found species in all 2 different locations of Lake and is showing 7160 population and *Surerilla ovalis* (SOVA) was the least species found in this lake, with an average of 2300 population. The other species are moderately found in all sites Table 4.2

4.1 Microscopic views of identified diatoms in two sites of Madenahalli Lake

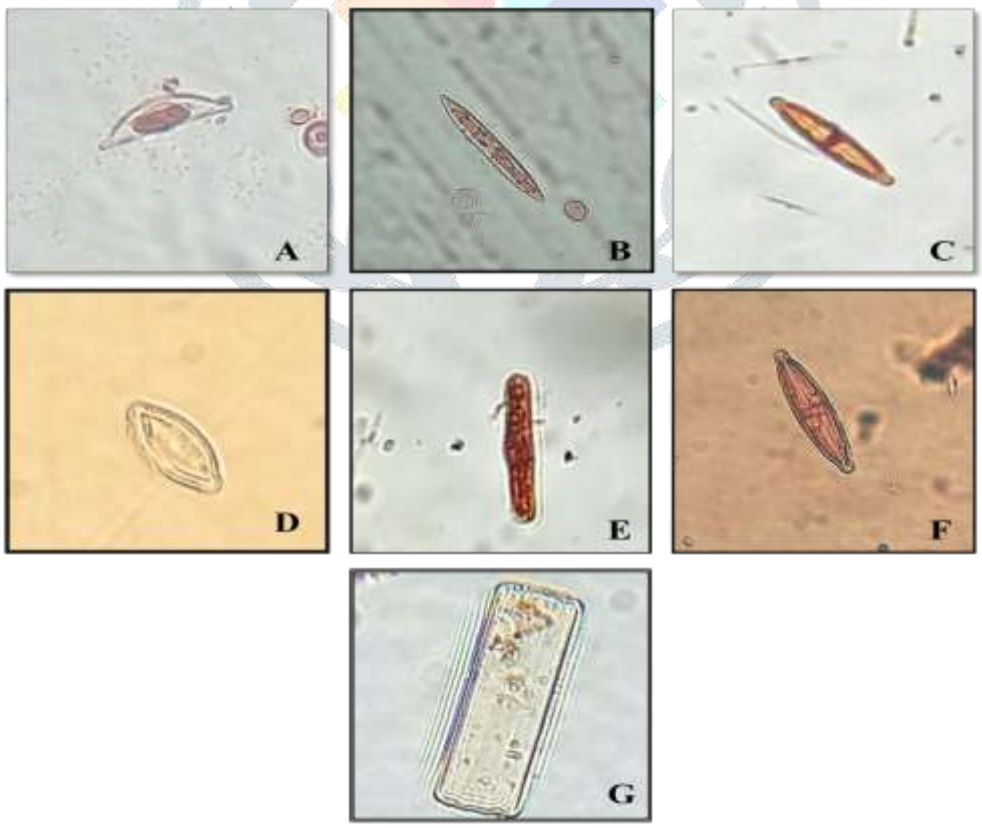

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Figure 4: A) *Cymbella affinis* (CAFF); B) *Nitzschia microcephala* (NMIC); C) *Navicula indicum* (NIND); D) *Surerilla ovalis* (SOVA); E) *Pinnularia gibba* (PGIB); F) *Achnanthes brevipes* (ABRE); G) *Fragilaria pinnata* (FPIN).

Table 4.2 Distribution of Diatom in Site 1 and Site 2 of Madenahally lake, Maddur Taluk

No:	Species	Site 1	Site 2
1	*Cymbella affinis* (CAFF)	2590	2200
2	*Navicula indicum* (NIND)	4360	2800
3	*Pinnularia gibba* (PGIB)	4160	2600
4	*Achnanthes brevipes* (ABRE)	3120	2540
5	*Nitzschia microcephala* (NMIC)	4100	2880
6	*Fragilaria pinnata* (FPIN)	2200	1400
7	*Surirella ovalis* (SOVA)	1500	800

Table 4.3 Ecological values for Site 1 and Site 2 of Madenahally Lake, Maddur Taluk

No:	Variables	Site 1	Site 2
1	No. of species	**7**	7
2	Population size	22030	15220
3	Diversity %	2.73	2.71
4	Evenness %	0.97	0.97
5	No. of genera	7	7
6	p^H (R)	4	4
7	Salinity (H)	2	2
8	Heterophilic	2	2
9	Oxygenation (O)	3	3
10	Saphrophytes (S)	3	3
11	Statotrophic	5	5
12	Aerophilic	2	2
13	IDSE/5%	3.53 low	3.50 moderate
14	Organic pollution %	18.61	18.92
15	Indicative organisms	NMIC	NMIC
16	Anthropogenic eutrophication %	0.0	0.0
17	Indicative organisms	Non existent	Non existent

4.4 Ecological values for Site 1 of Madenahally Lake

The ecological values were given for the identified diatoms in site 1 of Madenahally Lake of Maddur Taluk in Mandya District. In this site the p^H range is alkaliphous, mainly occurring at p^H >7 and it is fresh water, hence there is no salinity which is < 0.9, chloride content is also less. Here the nitrogen tolerating autotrophic species are commonly found, about 50 % saturation was seen & the trophic status is eutrophic. It includes alpha mesosaprobous water quality, biological oxygen demand is 4-13. Moisture tolerance is another ecological value is mainly occurring in water bodies, sometimes on wet places. Index of diatoms saprobic eutrophication (IDSE) was 3.53 %. Here organic pollution indicators were found and organic pollution % was 18.61% and anthropogenic eutrophication indicator was nil. Indicator of organic pollution was *Navicula microcephala* (NMIC) and, anthropogenic eutrophication was absent. Here about 22,030 populations were found, in that 7 genera and 7 species were identified with a good diversity of about 2.73% Table 4.3.

4.5 Ecological values for Site 2 of Madenahally Lake

Here p^H range was alkaliphous, mainly occurring at p^H >7 and it is fresh water, hence there is no salinity which is <0.9, chloride content is less. Here the nitrogen tolerating autotrophic species are commonly found. About 50% saturation was seen and the trophic status is eutrophic. Saprobity values are alpha mesosprobous and the water quality was class III. The biological oxygen demand was 4-13. Moisture tolerance was mainly occurring on water bodies sometimes on wet places. Index of diatom sapropbic eutrophication (IDSE) is 3.50%. As in site 1, here also organic pollution % 18.92. Anthropogenic eutrophication is not found. Organic pollution indicative organism is *Nitzschia microcephala* (NMIC). About 15,220 populations were identified in this site, in that 7 genera and 7 species were identified with a considerable diversity of 2.71% Table 4.3.

5. Diatoms of Honnayakanahalli Lake, Maddur Taluk

The identified diatoms in three different sites of Honnayakanahalli Lake of Mandya Taluk include 7 genera and 8 species and the number of population of all those species varied from one site to another. The species identified in this lake were *Mastigloia recta* (MREC), *Synedra ulna* (SULN), *Navicula minima* (NMIN), *Melosira varians* (MVAR) *Cymbella affinis* (CAFF), *Pinnularia gibba* (PGIB), *Craticula cuspidata* (CCUS) and *Pinnualaria acrosphaeria* (PCAR) Fig. 5. *Pinnularia gibba* (PGIB) was most abundantly found species, with its population in all the 3 sites of 10160 and *Pinnularia acrosphaeria* (PCAR) was the least species found in these sites and it could be seen only in two sites and completely absent in other site, with an average of 1660 population. The other species were moderately found in all sites Table 5.2.

5.1 Microscopic views of identified diatoms in three sites of Honnayakanahalli Lake

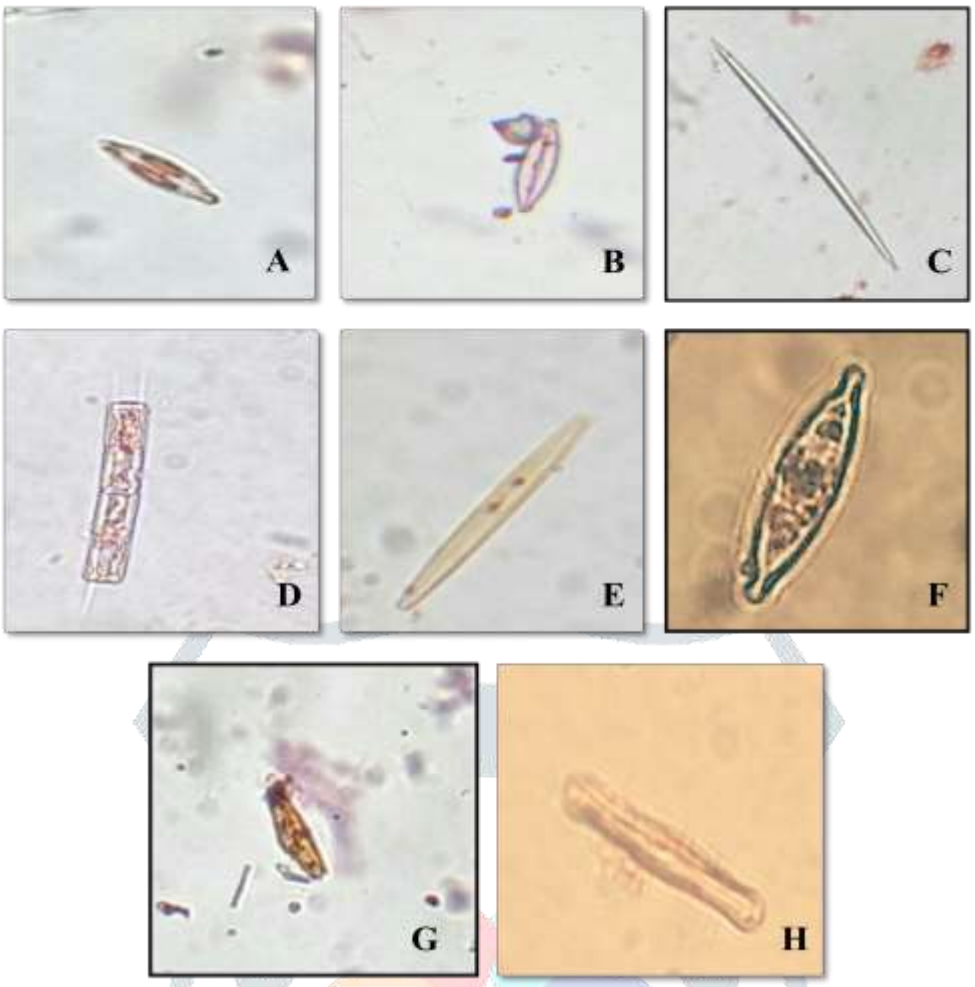

Figure 5: A) *Mastogloia recta* (MREC); B) *Synedra ulna* (SULN); C) *Navicula minima* (NMIN); D) *Melosira varians* (MVAR); E) *Cymbella affinis* (CAFF); F) *Pinnularia gibba* (PGIB); G) *Craticula cuspidata* (CCUS); H) *Pinnularia acrosphaeria* (PCAR).

Table 5.2 Distribution of Diatoms in Site 1, Site 2 and Site 3 of Honnayakanahalli Lake, Mandya Taluk

No:	Species	Site 1	Site 2	Site 3
1	*Mastogloia recta* (MREC)	3260	1860	1200
2	*Synedra ulna* (SULN)	3400	2800	1000
3	*Navicula minima* (NMIN)	4800	2500	1000
4	*Melosira varians* (MVAR)	2800	1400	1200
5	*Cymbella affinis* (CAFF)	2600	1100	1000
6	*Pinnularia gibba* (PGIB)	4160	3800	2200
7	*Craticula cuspidata* (CCUS)	2600	1000	400
8	*Pinnularia acrosphaeria* (PCAR)	1000	660	00

Table 5.3 Ecological values for Site 1, Site 2 and Site 3 of Honnayakanahalli Lake, Mandya Taluk

No:	Variables	Site 1	Site 2	Site 3
1	No. of species	8	8	6
2	Population size	24620	15120	5800
3	Diversity %	2.90	2.80	2.52
4	Evenness %	0.97	0.93	0.97
5	No. of genera	7	7	6
6	p^H (R)	4	4	4
7	Salinity (H)	2	2	2
8	Heterophilic	2	2	3
9	Oxygenation (O)	3	3	4
10	Saphrophytes	3	4	4
11	Statotrophic	7	7	5
12	Aerophilic	2	2	2
13	IDSE/5%	3.65	3.52	3.00
14	Organic pollution %	0.00	0.0	0.0
15	Indicative organisms	Non existent	Non existent	Non existent
16	Anthropogenic eutrophication %	13.81	35.05	34.48
17	Indicative organisms	SULN	NMIN, SULN	NMIN ,SULN

5.4 Ecological values for Site 1 of Honnayakanahalli Lake, Mandya Taluk

The ecological values for the identified diatom in site 1 are represented in table 5.3. About 17 ecological data values are predicted in the above table. The p^H range of this site is alkaliphilous, mainly occurring at p^H >7, salinity is fresh water and < 0.9 and chloride content < 500, about 50 % saturation was done because of moderate oxygenation. Autotrophic taxa is found at the elevated levels of organic bound nitrogen tolerance. Its trophic status is hyper eutraphentic. Oxygenation is the moist condition and hence the organisms are occurring on water bodies or sometimes on wet places. It is alpha mesosaprobous with water quality class III and biological oxygen demand is 4-13, and it has 3.65 % index of diatom saprobic eutrophication (IDSE). Here organic pollution % was absent. The organic indicative organisms were nonexistent. Anthropogenic indicative organism was *Synedra ulna* (SULN) and it is 13.81%. The total population found in this site was about 24, 620 diversity among those is 2.90% with total number of 8 species and 7 genera Table 5.3.

5.5 Ecological values for Site 2 of Honnayakanahalli Lake, Mandya Taluk

As compared to Site 1, here p^H value was alkaliphilous, mainly occurring at p^H >7, salinity was fresh water and < 0.9 with chloride content < 500, and about 50 % saturation was done because of moderate oxygenation. Nitrogen tolerating autotrophic taxa, and also includes alpha/ meso/polysaprobous by the biological oxygen demand is 13-22 the water quality class is III-IV. Moisture tolerance species are found on moist places i.e., aerophilic. Index of diatom saprobic eutrophication (IDSE) is 3.52%. The organic indicative organism was absent. Anthropogenic eutrophication was about 35.05% caused by *Synedra ulna* (SULN) and *Navicula minima* (NMIN). The population of about 15120 was identified among which 7 genera and 8 species having diversity of about 2.80% Table 5.3.

5.6 Ecological values for Site 3 of Honnayakanahalli Lake of Mandya Taluk

The values are same as compared to that of the Site 1 values from p^H values to salinity was similar. It is alkaliphilous, mainly occurring at p^H >7, salinity is 1.8-1.9 and chloride content is greater than 1000 and brackish water. About 30 % saturation found in oxygenation, taxa includes nitrogen tolerance heterotrophic level. Alpha /meso /polysaprobous saprobity is can be seen. Moisture tolerance species is found on wet places. Index of diatom saprobic eutrophication (IDSE) is 3.00%. Organic pollution was not found as the indicative organisms are nonexistent and anthropogenic eutrophication was found and it was about 34.48%. The anthropogenic pollution indicator were same as in site 2 i.e. *Synedra ulna* (SULN) and *Navicula minima* (NMIN) with a total population 5800 of 6 species and 6 genera with a diversity of 2.52% Table 5.3.

IV. DISCUSSION

Diatoms are popularly known as the Jewels of the Plant Kingdom and are microalgae belonging to Division Heterokontophyta and Class Bacillariophycophyta, They are a significant taxonomic group in the global carbon cycle and account for approximately 15% of the Earth's net annual prime production. Moreover, they control pathways of carbon flow via the formation of dominant species, and are expansively used for monitoring of water quality (Bere *et al.*, 2014). Other studies established the relationship between diatoms and environment, to analyze the water quality by Bellinger (2006), Basavarajappa (2011), Josette (2011), Catherine (2013), Brajesh (2017) and Purushotham and Anupama (2018a) etc.

In the present study the different types of diatoms were identified in both Madenahally and Honnayakanahalli Lakes. In lake 1 about 7 genera and 7 species were recorded, and in lake 2 about 7 genera and 8 species were recorded. Species recorded in more numbers were the two species each of *Navicula minima* (NMIN) and *Navicula indicum* (NIND). Species recorded in least

numbers were in single i.e. *Surerilla ovalis* (SOVA), *Fragellaria pinnata* (FPIN), *Synedra ulna (*SULN), *Craticula cuspidata* (CCUS), *Melosira varians* (MVAR) and *Achnanthes brevipes* (ABRE). Diatoms assessment are valuable indicators of environmental conditions in rivers and streams, because they respond directly and sensitive to many physical, chemical and biological changes in river and stream ecosystems. The specific sensitivity of diatom physiology to many habitat conditions is manifested in great variability in biomass and species composition of diatom assemblages in rivers and streams (Stevenson *et al.*, 2002). Diatom as indicator of water pollution in the coastal zone of the gulf diatoms were the basis of the estimation of water quality taking into consideration its salinity, trophic state and saprobity. The result indicated that the dominating groups included oligohalobous and mesohalobous taxa, characteristic of highly eutrophic waters Bozena *et al*. (2001).

Seasonal disparity of diatoms density and species richness were studied, where diatoms structure depends on variety of environmental factors that include biological parameters as well as physico-chemical parameters (Patil *et al.*, 2013). The ecological data of both the lakes were slightly differing from one another where we could observe both acidobiontic and alkaliphilous p^H value range in Madenahally lake, the p^H in case of Honnayakanahalli lake it was alkaliphilous. This p^H value depends upon presence of species in both the lakes. The lakes studied were brackish, with more chloride content greater than 1000 with high salinity. As same to salinity both the lakes included heterophilic, oxygenation was different about 30% saturation in Madenahally lake and 50% saturation in Honnayakanahalli lake. Alpha/meso/polysaprobous type of saprobity was seen along with water quality class III-IV similar to diatom community structure analysis at Kengeri Lake yielded six genera with *Navicula* showing the most abundance Harini, 2013.

Our results are in agreement with the results obtained by Purushotham and Anupama, (2018c) and Mursaleen *et al.* (2018) where physicochemical parameters and diatoms characteristics illustrated seasonal variation and distribution of the diatoms species in the water bodies was strongly influenced. Statotrophic and aerophilic state were found in the lakes and the species occuring were mainly on water bodies and in some cases they were observed on wet places. Index of diatom saprobic eutrophication value differed in 2 sites of Madenahally lake. In Site1 -3.53% and Site 2 -3.50 %. Whereas incase of Honnayakanahalli lake the value of IDSE in Site 1- 3.65 % Site 2- 3.52 % and Site 3- 3.00 %. Organic pollution was found in Madenahally Lake of Site-1 was 18.61% and 18.92 % in Site-2. Organic indicative organisms were common in both the sites of Madenahally lake and the species were *Nitzschia microcephala* (NMIC). There were no anthropogenic indicative organisms in Madenahally lake. In Honnayakanahalli lake organic pollution was not found in all the 3 sites. The anthropogenic pollution was present in all the sites i.e., Site1- 13.81%, Site2- 35.05% and Site3- 34.48% with most common indicative organisms *Synedra ulna* (SULN) and *Navicula minima* (NMIN). Even though anthropogenic eutrophication was observed in Honnayakanahalli lakes but in case of Madenahally lake the anthropogenic eutrophication was absent. By comparing the values of both lakes, we wind up that species diversity was rich in Honnayakanahalli compared to Madenahally lake. Organic pollution % was maximum in Madenahally lake whereas it was absent in Honnayakanahalli lake. More number of diatoms were identified in Honnayakanahalli lake and hence p^H was alkaliphilous in this lake. Other data was almost similar in both the lakes. By analyzing all the values obtained in Madenahally lake and Honnayakanahalli lake the results predicts that the diatoms serves as an influential indicator of organic as well as anthropogenic pollution. Bio-monitoring has been proven to be necessary and hence the importance of diatoms as ecological indicators of water quality is stressed (Purushotham and Anupama, (2018c) and Sawaiker and Rodrigues, 2017).

V. SUMMARY AND CONCLUSION So far as India is concerned, most of the research work available with reference to diatoms is taxonomical and our ecological knowledge about these indicators has just begun. Efforts are being made to bridge this gap. Unfortunately, eco-assessment with diatom based indices is evidently lacking in the Indian scenario. The diatom data of Indian lakes will help to classify its stress, and shall be useful for deciding their best possible use. There is a crystal-clear potential for the use of numerical diatom indices as indicators of general water quality and the usefulness of these indices should be verified by further studies that cover a broader geographical area and a broader range of variables. The interpretation in terms of impact severity would immensely help to establish priorities for pollution control efforts in our country. To enfold there is an urgent need to see the sights, be conscious, predict and mitigate future environmental change scenarios to protect this sole ecosystem. In this regard, monitoring programmes and/or paleo-limnological approach using diatoms as environmental indicators could be used as early caution of environmental changes. They are right tools for bio- monitoring, as indicator value of diatoms is well accepted and highly used across the continents, which is an ideal resource by which progress towards integrated water resources management can be screened. The administration and neighbouring people should take utmost quality heed besides upkeep of various species which is vital to nation and water bodies.

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