AGONY OF CHIKKABETTAHALLI LAKE, VIDYARANYAPURA, BRUHAT BANGALORE

Encroachment, inflow of sewage, city waste dumps, pollution, building debris, …

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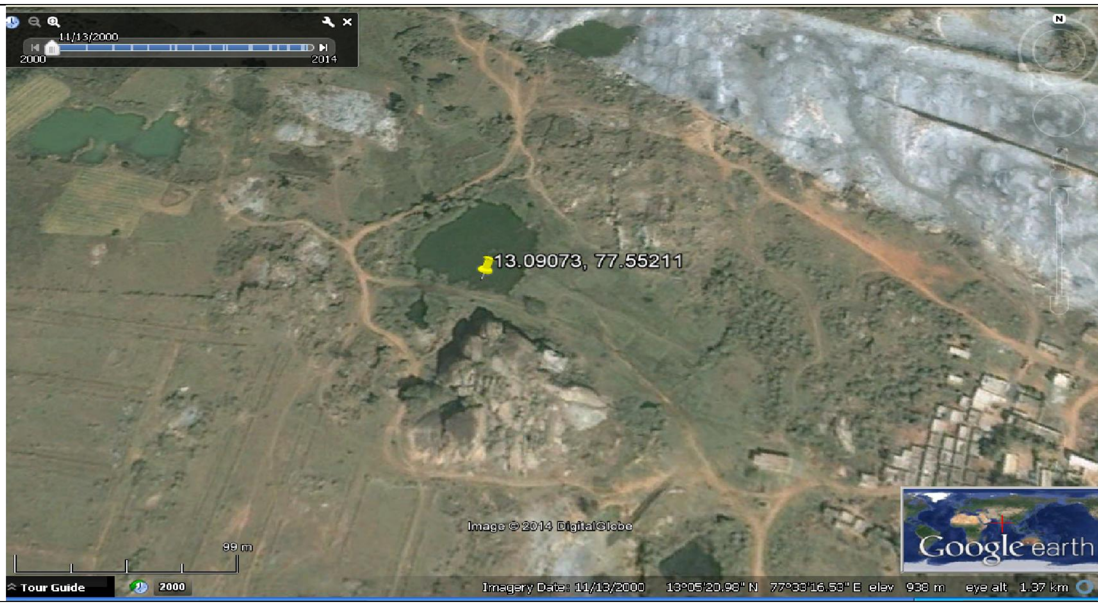

Status of lake in 2000

Status of lake in 2014

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1.0 SUMMARY

Wetlands are most important freshwater resource on Earth. They help in maintaining the ecological balance of the region. Wetlands, natural and manmade, freshwater or brackish, provide numerous ecological services. They provide habitat to aquatic flora and fauna, as well as numerous species of birds, including migratory species. Wetlands are under threat from drainage and conversion for agriculture and human settlements, besides pollution. They are the most threatened and fragile ecosystems that respond very quickly even to a little change in the composition of abiotic and biotic factors. This study was done to understand the ecosystem prevailing the Chikkabettahalli Lake which is located in Adityanagar, Vidyaranyapura, Bengaluru, Karnataka. The physico-Chemical and Biological composition of the lake was studied using standard protocols. Nutrient availability in Chikkabettahalli lake water is high which is evident from the results of physico- chemical analysis, the presence of fully covered varied macrophyte species and pollution tolerant algal species. Hence, the light penetration is obstructed and dissolved oxygen (DO) level is depleted in the lake. Reduction in the lake area was observed due to dumping of building debris and solid waste and also encroachment.

The loss of ecologically sensitive wetlands in Bangalore is due to the uncoordinated pattern of urban growth. This is due to a lack of good governance and decentralized administration evident from a lack of coordination among many para-state agencies, which has led to unsustainable use of the land and other resources. Failure to deal with water as a finite resource is leading to the unnecessary destruction of lakes and marshes that provide us with water. This failure in turn is threatening all options for the survival and security of plants, animals, humans, etc. There is an urgent need for **conservation and sustainable management of wetlands**, which requires;

- Removal of solid waste dumps and building debris from the lake bed;
- Remove all encroachments immediately;
- Penalise polluters (Polluter Pays Principle);

- Implementation of bioremediation method for detoxification of polluted lake;
- Treating sewage through Integrated Wetlands Ecosystem (Ramachandra et.al, 2014);
- Letting only treated sewage through wetland (consisting of reed beds like *Typha* and *Cyperus* sp.) and algae pond;
- Demarcating the lake boundary after verification with historical survey records and cadastral maps.
- Fencing of lake to prevent illegal activities of encroachment, dumping of solid waste, etc.
- Take up planting of riparian vegetation in the buffer zone (200 m) of the lake.

Keywords: wetlands, encroachment, pollution, nutrients enrichment

2.0 INTRODUCTION

Wetlands constitute vital components of the regional hydrological cycle. They are highly productive, support exceptionally large biological diversity, and provide a wide range of ecosystem services such as food, fibre, and waste assimilation, water purification, flood mitigation, erosion control, groundwater recharge, and microclimate regulation. They also enhance the aesthetics of the landscape and support many significant recreational, social, and cultural activities, aside from being a part of our cultural heritage. It was acknowledged that most urban wetlands are seriously threatened by conversion to non-wetland purposes, encroachment of drainage through landfilling, pollution (discharge of domestic and industrial effluents, disposal of solid wastes), hydrological alterations (water withdrawal and inflow changes), and overexploitation of their natural resources. This results in loss of biodiversity and disruption in goods and services provided by wetlands

Wetlands, natural and manmade, freshwater or brackish, provide numerous ecological services. They provide habitat to aquatic flora and fauna, as well as numerous species of birds, including migratory species. The density of birds, in particular, is an accurate indication of the ecological health of a particular wetland. Several wetlands have sufficiently unique ecological character as to merit international recognition as Ramsar Sites. Wetlands also provide freshwater for agriculture, animal husbandry, and domestic use, drainage services, and provide livelihoods to fisher-folk. Larger wetlands may also comprise an important resource for sustainable tourism and recreation.

Wetlands are under threat from drainage and conversion for agriculture and human settlements, besides pollution. They are the most threatened and fragile ecosystems that respond very quickly even to a little change in the composition of abiotic and biotic factors. Anthropogenic stress has severely affected these fragile ecosystems to a great extent which had led to a decline in the quality of water and reduction in the lake area (Ramachandra et al., 2001). The major threats to water resources are from point sources (sewage, industrial effluents, etc.) and from non-point sources (agriculture, urban, etc.). Apart from these, dumping of solid wastes, chemical spills, thermal pollution, acid precipitation, mine drainage, etc. also contribute. Pollution affects the quality of the water and then destroys the other aquatic communities, disrupting the food web in these aquatic ecosystems (Ramachandra et al., 2007).

Urbanization is a form of metropolitan growth that is a response to an often-bewildering sets of economic, social, and political forces and to the physical geography of an area. It is the increase in the population of cities in proportion to the region's rural population. The 20th century is witnessing "the rapid urbanisation of the world's population," as the global proportion of urban population rose dramatically from 13% (220 million) in 1900, to 29% (732 million) in 1950, to 49% (3.2 billion) in 2005, and is projected to rise to 60% (4.9 billion) by 2030 (U.N., 2005). Urban ecosystems are the consequence of the intrinsic nature of humans as social beings to live together (Ramachandra et al. 2012a; Ramachandra & Kumar 2008). The process of urbanization contributed by infrastructure initiatives, consequent population growth, and migration results in the growth of villages into towns, towns into cities, and cities into metros.

Urbanization and urban sprawl have posed serious challenges to the decision makers in the city planning and management process involving a plethora of issues like infrastructure development, traffic congestion, and basic amenities (electricity, water, and sanitation) (Kulkarni & Ramachandra 2006). Apart from this, major implications of urbanization are:

- **Loss of wetlands and green spaces:** Urbanization has telling influences on the natural resources such as decline in green spaces (vegetation) including wetlands and/or depleting groundwater table. Quantification of trees in the region using remote sensing data with field census reveal 1.5 million trees and human population is 9.5 million, indicating one tree for seven persons in the city.
- **Floods:** Conversion of wetlands to residential layouts has compounded the problem by removing the interconnectivities in an undulating terrain. Encroachment of natural drains, alteration of topography involving the construction of high-rise buildings, removal of vegetative cover, and reclamation of wetlands are the prime reasons for frequent flooding even during normal rainfall post-2000.
- **Decline in groundwater table:** Studies reveal the removal of wetlands has led to the decline in water table. The water table has declined to 300 m from 28 m over a period of 20 years after the reclamation of lakes with its catchment for commercial activities. In addition, groundwater table in intensely urbanized areas, such as Whitefield, has now dropped to 400-500 m.
- **Heat island:** Surface and atmospheric temperatures are increased by anthropogenic heat discharge due to energy consumption, increased land surface coverage by artificial materials having high heat capacities and conductivities, and the associated decreases in vegetation and water-pervious surfaces, which reduce surface temperature through evapotranspiration.
- **Increased carbon footprint**: Due to the adoption of inappropriate building architecture, the consumption of electricity has increased in certain corporation wards drastically. The building design conducive to tropical climate would have reduced the dependence on electricity. Higher energy consumption, enhanced pollution levels due to the increase of private vehicles, and traffic bottlenecks have contributed to carbon emissions significantly. Apart from these, mismanagement of solid and liquid wastes has aggravated the situation.

Unplanned urbanization has drastically altered the drainage characteristics of natural catchments, or drainage areas, by increasing the volume and rate of surface runoff. Drainage systems are unable to cope with the increased volume of water, and are often blocked due to indiscriminate disposal of solid wastes. Encroachment of wetlands, floodplains, etc. obstructs flood-ways causing loss of natural flood storage.

Wetlands due to their bioremediation potential could be a viable alternative to conventional wastewater treatment plants, which are capital and energy intensive. The dumping of solid and hazardous waste nearby to the lakes may lead to severe pollution, leading to adverse health impacts and there will be a reduction in the economic value of their environmental services. The inadvertent introduction of some alien species of flora in wetlands has also degraded their ecology.

The current study attempts to understand the prevailing conditions and threats faced by the Chikkabettahalli Lake which is located in Adityanagar, Vidyaranyapura, Bengaluru, Karnataka.

3.0 OBJECTIVES

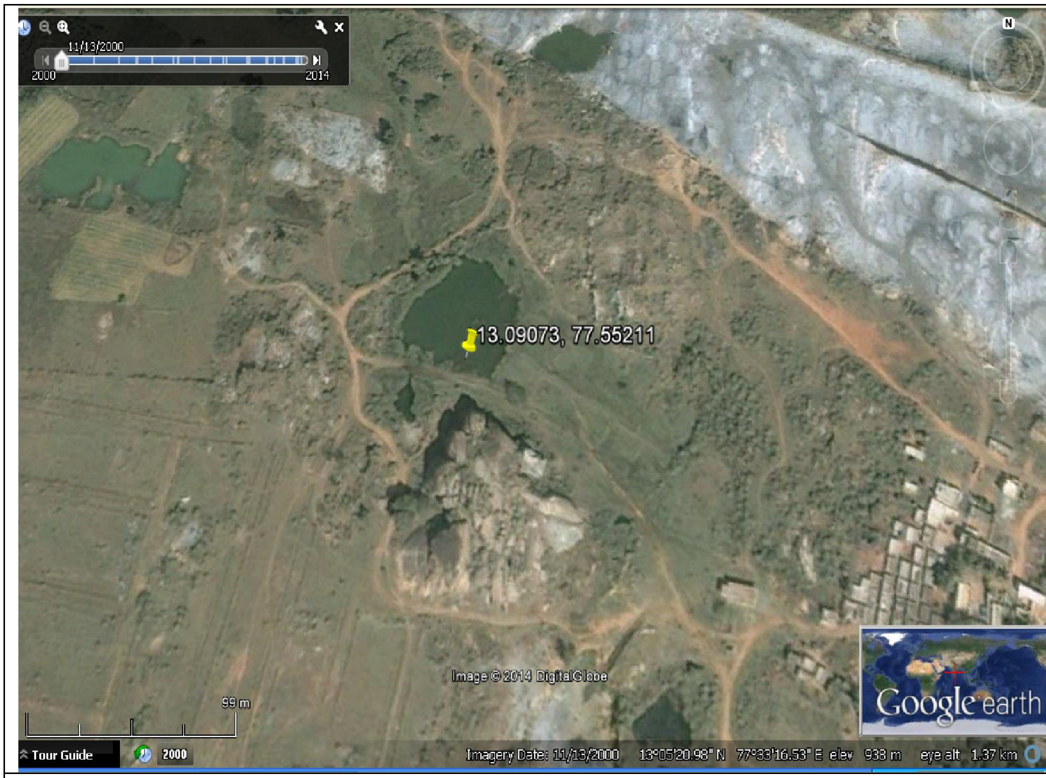
Objectives of the current study are

a) To assess the physico-chemical and biological composition of the Chikkabettahalli Lake water.
b) To suggest remedial measures to protect the lake from further deterioration.

4.0 MATERIALS AND METHODS

4.1 Study area

Chikkabettahalli Lake is located in Adityanagar, Vidyaranyapura ward of Greater Bengaluru, Karnataka. Greater Bangalore (77°37'19.54'' E and 12°59'09.76'' N) enjoys a salubrious climate all year round with the summer temperature ranging from 18°C – 38°C and the winter temperature ranging from 12°C – 25°C (Ramachandra and Kumar, 2008). Figures 1.1 and 1.2 depict the status of lake during 2000 and 2014.



2000

Figure 1.1: Status of lake in 2000

2014

Figure 1: Status of lake in 2000 and 2014

Figure 2: Water Sampling sites

4.2 Water Quality Assessment

Analysis of physico-chemical parameters: Water samples were collected at inlet and outlet of the lake in November 2014. Water quality parameters analysed include water temperature, pH, electrical conductivity (EC) and dissolved oxygen (DO) which were determined on spot at the time of sampling. Other parameters like nitrate, orthophosphate, total alkalinity, calcium and magnesium hardness, total hardness, chlorides, COD (Chemical oxygen demand), sodium and potassium were analysed in the laboratory using standard protocol as per Trivedi and Goel (1986) and APHA (1998).

Qualitative and quantitative analysis of phytoplankton: The qualitative and quantitative analysis of phytoplankton is done by Lackey's drop method. The algal species were identified based on their key morphological features, according to Prescott (1954), Desikacharya (1959).

Macrophyte collection and identification: Macrophyte samples were collected and washed to get rid of adhering materials. They were identified using Cook CDK (1996).

Figure 3: Threats faced by Chikkabettahalli Lake

5.0 RESULTS AND DISCUSSION

Physico-chemical parameters of lake: Table 1 lists physic-chemical parameters of water samples collected from Chikkabettahalli lake. Parameters that were analysed are:

Temperature: It is an important factor for aquatic life as it regulates the maximum dissolved oxygen concentration of the water, controls the rate of metabolic activities, reproductive activities and therefore, life cycles. The temperature of Chikkabettahalli lake ranges between 23.4^{0}C (S1) to 22.8^{0}C (S2).

Dissolved Oxygen: Dissolved oxygen (DO) helps in aquatic respiration as well as detoxification of complex organic and inorganic matters (through oxidation). The presence of organic wastes imposes a very high oxygen demand on the receiving water, leading to oxygen depletion with severe impacts on the water ecosystem. The effluents also constitute heavy metals, organic toxins, oils, volatile organics, nutrients and solids. DO of the analysed water samples varied between 2.44 to 2.85 ppm. The lower DO values are indicative of fast oxidising chemicals in the immediate vicinity. The DO was very low which indicates water pollution. The macrophyte cover is also responsible for low DO values.

Table 1: Physico-chemical parameters of Lake

Water quality Parameters	Sites		Water quality Standard IS 10500, 1991-2011	
	S1	S2	Desirable	Permissible
Water temperature (^{0}C)	23.4	22.8	-	-
TDS (mg/l)	875	518	500	2000
EC (µS)	1148	862	-	-
pH	7.06	7.36	6.5-8.5	No relaxation
DO (mg/l)	2.44	2.85	-	-
COD (mg/l)	28	24	-	-
Alkalinity (mg/l)	272	321.33	200	600
Chloride (mg/l)	294.41	195.96	250	1000
Total Hardness (mg/l)	556	308	300	600
Ca Hardness (mg/l)	183.57	92.45	75	200
Mg Hardness (mg/l)	90.5	52.38	30	100
Phosphate (mg/l)	0.529	0.494	-	-
Nitrate (mg/l)	0.5	0.767	45	100
Sodium (mg/l)	494	197.6	-	-
Potassium (mg/l)	137.6	43.2	-	-

Total Dissolved Solids (TDS): TDS in water impacts the domestic water usage for cleaning, bathing etc as well as drinking purposes. Total dissolved solids originate from organic sources such as leaves, silt, plankton, industrial waste and sewage. Other sources come from runoff from urban areas, road salts used on street, fertilizers and pesticides used on lawns and farms (APHA, 1998). Surface as well as groundwater with high dissolved solids are of inferior flavor and induce an unfavorable physiological reaction to the dependent population. TDS values in the collected water samples, ranged from 518 to 875 ppm across the lake. It was higher in S1 (closer to the inflow) and reduced in S2 of the lake. The TDS was higher in the S1 than S2 due to macrophyte and plankton cover.

pH: pH is a numerical expression that indicates the degree to which water is acidic or alkaline, with the lower pH value tends to make water corrosive and higher pH provides taste complaint and negative impact on skin and eyes. The pH value ranged from 7 to 7.36.

Chlorides: Chlorides are essentially potential anionic radical that imparts chlorosity to the waters. An excess of chlorides leads to the formation of potentially carcinogenic and chloro-organic compounds like chloroform, etc. Chloride values in samples ranged from 195-294 ppm. The value of chlorides was high in S1.

Sodium: Sodium (Na) is one of the essential cations that stimulate various physiological processes and functioning of nervous system, excretory system and membrane transport in animals and humans. Increase of sodium ions has a negative impact on blood circulation, nervous coordination, hence affecting the hygiene and health of the nearby localities. In this study, the concentration of sodium ranged from 197 to 494 ppm. The Sodium value was high in S1.

Potassium: Potassium (K) is an essential element for both plant and animal nutrition, and occurs in ground waters as a result of mineral dissolution, decomposing of plant materials and also from agricultural runoff. Potassium ions in the plant root systems helps in the cation exchange capacity to transfer essential cations like Ca and Mg from the soil systems into the vascular systems in the plants in replacement with the potassium ions (APHA, 1998). Incidence of higher potassium levels in soil system affects the solute transfer (active and passive) through the vascular conducting elements to the different parts of the plants. The potassium content in the water samples ranges between 43-137 ppm. The potassium value was higher in S1 due to decomposition of plant materials.

Alkalinity: Alkalinity is a measure of the buffering capacity of water contributed by the dynamic equilibrium between carbonic acid, bicarbonates and carbonates in water. Sometimes, excess of hydroxyl ions, phosphate and organic acids in water causes alkalinity. High alkalinity imparts bitter taste. The acceptable limit of alkalinity is 200 ppm. The alkalinity of the samples was in range of 272-321 ppm.

Total hardness: Hardness is the measure of dissolved minerals that decides the utility of water for domestic purposes. Hardness is mainly due to the presence of carbonates and bicarbonates. It is also caused by a variety of dissolved polyvalent metallic ions, predominantly calcium and magnesium cation although, other cations like barium, iron, manganese, strontium and zinc also contribute to Hardness. In the present study, the total hardness ranged between 308 to 556 ppm. It was higher in S1. High values of hardness are probably due to the regular addition of sewage and detergents.

Calcium: Calcium (Ca) is one amongst the major macro- nutrients which are needed for the growth, development and reproduction, in case of both plants and animals. The presence of Ca in water is mainly due to its passage through deposits of limestone, dolomite, gypsum and other gypsiferous materials (APHA, 1998). These contribute to the total hardness of the water. Ca concentration in all samples analysed periodically ranged between 92-183 ppm.

Magnesium: Magnesium (Mg) in one of the most essential macro-nutrients that helps as a co-factor in the enzyme systems and in the central metal ions that constitutes the chlorophyll molecule essential for plant photosynthesis. According to WHO guidelines, the maximum admissible limit is 50 ppm. In this study, the concentration of Magnesium ranged from 52-90 ppm.

Nutrients (nitrates and phosphates): Nutrients essentially comprise of various forms of N and P, which readily dissolve in solutions that are assimilated by microbes and plant root systems in the form of inorganic mineral ions. Accumulation of N as nitrates and P as inorganic P in aquatic ecosystems causes significant water quality problems leading to higher net productivity. Together with phosphorus, nitrates in excess amounts in streams and other surface waters can accelerate aquatic plant growth causing rapid oxygen depletion or eutrophication in the water. Nitrates at high concentrations (10 mg/l or higher) in surface and groundwater used for human consumption are particularly toxic to young children affecting the oxygen carrying capacity of blood cells (RBC) causing cyanosis (methemoglobinemia). In the present study, nitrate values ranged from 0.5 to 0.77 ppm and phosphate values ranged between 0.5 to 0.53 ppm.

Chemical oxygen demand (COD): COD is important parameter that indicates contamination with organic wastes. Chemical oxygen demand (COD) determines the oxygen required for chemical oxidation of most organic matter and oxidizable inorganic substances with the help of strong chemical oxidant. COD test is helpful in indicating toxic conditions and the presence of biologically resistant organic substances. In this study the COD values ranged from 24-28 mg/l.

Macrophyte diversity in the lake: Macrophytes, the aquatic macroscopic plants confine themselves to the shallow euphotic zone of the water bodies. In the littoral zone, macrophytes are the exploiters of plant nutrients from the sediments, which otherwise, are lost temporarily from the water. They assimilate nutrients directly into their tissues. The nutrients so logged in the body material are released only after death, decay and subsequent mineralization, thus, they play a role in nutrient dynamics and primary productivity of shallow systems. Therefore, seasonal growth rate patterns and population dynamics of macrophytes are very important. When there is enough room for colonization and abundant availability of nutrients, macrophytes show a high growth rate. Profuse growth and spread of macrophytes was noticed in this lake due to the availability of nutrients with the sustained inflow of untreated sewage. There were mainly 9 species found in the lake. *Alternanthera philoxeroides, Alternanthera sessilis, Ludwigia perennis, Typha angustata, Cyperus* sp*, Solanum* sp*, Lemna gibba, Eichhornia crassipes, Spirodela polyrhiza* were the main macrophyte species found in the lake. *Alternanthera philoxeroides, Alternanthera sessilis* and *Solanum* sp were the dominant macrophytes present in the lake (figure 4).

Algae as pollution indicators: Algae, the primary producers present in aquatic ecosystems forms an important component of biological assessment for evaluating water quality. Algae are indicators of different ecosystem conditions because they respond quickly to a wide range of physico-chemical as well as biological conditions, which will be evident both in their species composition and densities.

Table 2 lists macrophyte species of Chikkabettahalli Lake. Common pollution-tolerant genera (Figure 5) that are present in the lake are *Euglena* sp. (Mahapatra et al., 2013a; Jafari et al., 2006), *Lepocinclis* sp. (Mahapatra et al., 2013a), *Nitzschia* sp. (Karthick et al., 2009; Jafari et al., 2006; Venkatachalapathy et al., 2013), *Oscillatoria* sp. (Jafari et al., 2006; Singh et al., 2011), *Pandorina* sp., and *Phacus* sp., *Cyclotella* sp., *Fragilaria* sp. (Singh et al., 2011; Venkatachalapathy et al., 2013), *Gomphonema* sp. (Karthick et al., 2009; Venkatachalapathy et al., 2013), *Navicula* sp. (Hosmani, 2012; Singh et al., 2011), *Pinnularia* sp. (Hosmani, 2012) and *Trachelomonas* sp. (Solorzano et al., 2011).

Figure 4: Macrophytes of the lake

Table 2: Algal species found in Lake

	Algae	S1	S2
1	*Cyclotella* sp.	+	-
2	*Euglena* spp.	+++	+++
3	*Fragilaria* sp.	+	-
4	*Gomphonema* sp.	+	+
5	*Gyrosigma* sp.	-	+
6	*Lepocinclis* sp.	++	+
7	*Navicula* sp.	+	+
8	*Nitzschia* sp.	+	+
9	*Oscillatoria* sp.	-	+
10	*Pandorina* sp.	+	-
11	*Phacus* spp.	++	++
12	*Pinnularia* sp.	+	+
13	*Stauroneis* sp.	-	+
14	*Trachelomonas* sp.	-	+

***+++/++: Dominant species; +: Rare ; -: Absent**

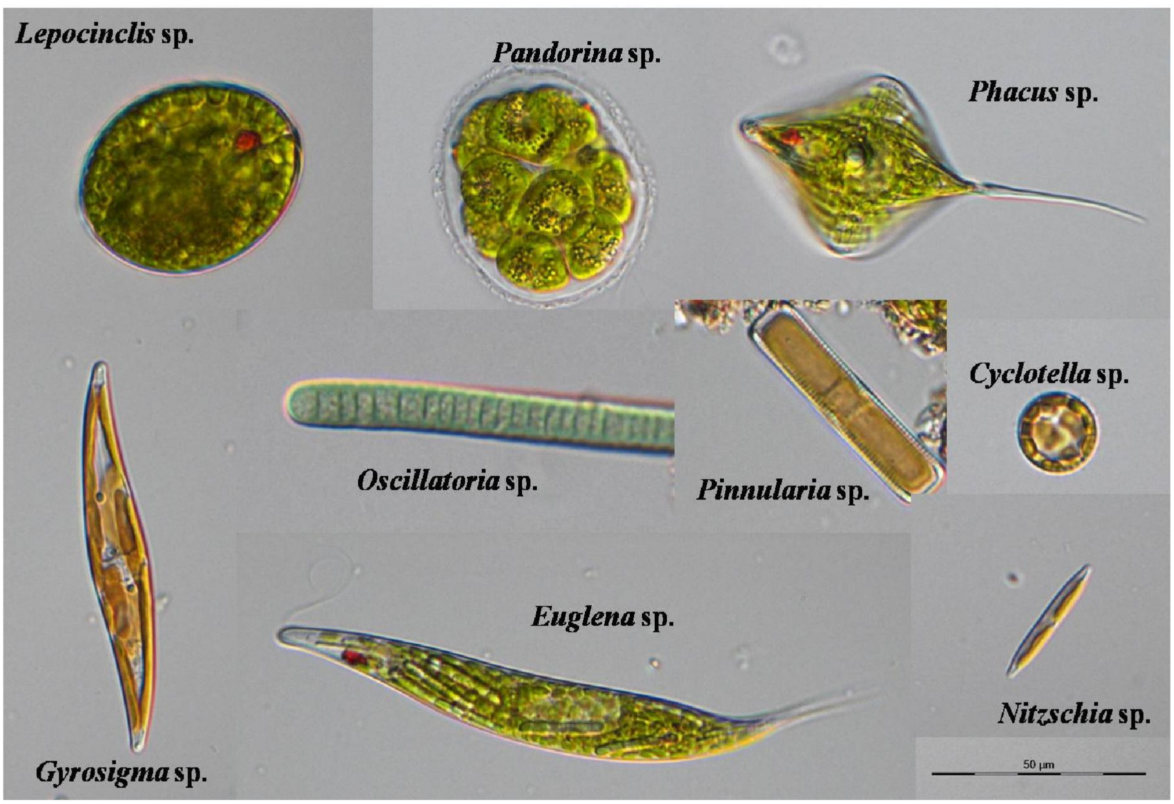


Figure 5: Microscopic images of algae in 40X

Euglenoids grow profusely under anoxic conditions in sewage fed lakes with high organic loads (Mahapatra et al., 2013b). *Nitzschia palea* is typically found in phosphate enriched or organically polluted waters. Taxa that are moderately tolerant to phosphorus enrichment, includes *Gomphonema* sp. and *Navicula* sp. (Bellinger et al., 2006; Karthick et al., 2009). *Cyclotella meneghiniana* is resistant to extreme pollution present in eutrophic and electrolyte rich water bodies (Karthick et al., 2009).

6.0 CONCLUSION

Chikkabettahalli lake is facing survival crisis due to shrinkage of water spread area (encroachment, dumping of building debris) with the sustained inflow of untreated sewage. Nutrient concentration in Chikkabettahalli lake water is high, evident from physico- chemical analysis, the presence of fully covered varied macrophyte species and pollution tolerant algal species. This has resulted in the obstruction of light penetration and lower dissolved oxygen (DO) values. Deliberate dumping of building debris and solid waste have reduced the spatial extent of the lake. Unabated dumping of solid waste, building debris and sustained inflow of contaminants (sewage, etc.) further highlights the apathy of local administration in the conservation of natural resources. Agony of the lake is evident from encroachments, dumping of solid and liquid waste, which highlights the nexus among polluters, land mafia and decision makers.

7.0 RECOMMENDATIONS

The loss of ecologically sensitive wetlands in Bangalore is due to the uncoordinated pattern of urban growth. This is due to a lack of good governance and decentralized administration evident from a lack of coordination among many para-state agencies, which has led to unsustainable use of the land and other resources. Failure to deal with water as a finite resource is leading to the unnecessary destruction of lakes and marshes that provide us with water. This failure in turn is threatening all options for the survival and security of plants, animals, humans, etc. There is an urgent need for **conservation and sustainable management of wetlands**, which requires;

- Mapping the spatial extent of the lake (water bodies).

- Identify the buffer zone (200 m) and any clearances of riparian vegetation and buffer zone vegetation (around lake) have to be prohibited.
- Remove encroachment.
- Penalise polluters (Polluter Pays Principle).
- Removal of dumps and building debris from the lake bed.
- Implementation of bioremediation method for detoxification of polluted lake.
- Treating sewage through Integrated Wetlands Ecosystem (Ramachandra et.al, 2014)
- Letting only treated sewage through wetland consisting of reed beds like *Typha* and *Cyperus* sp.
- Demarcating the lake boundary only after verification with survey record and cadastral maps.
- Appropriate technologies for point and non-point sources of pollution and in situ measures for lake restoration shall be compatible to local ethos and site condition as well as objectives of Aquatic Ecosystem Restoration Action Plan (AERAP).
- Improvement of infra-structural facilities such as water supply, sewerage, solid waste disposal, energy recovery systems and transportation in an integrated manner.
- Promoting the use of indigenous building materials and appropriate construction technologies by revising building and planning codes supporting small scale production, skill up-gradation of artisans and people oriented delivery systems.
- Recycling of existing building stock to save green open compounds and save building material.
- Classification, zoning and allotment of land for designated uses such as agriculture, forestry, grassland, green areas, industrial activities, catchment areas and watersheds and human settlements based on assessment of their capabilities and environmental considerations.
- Protection of land near water bodies and prevention of construction there upon.
- Measures to ensure equitable access to and responsibility for sustainable use of land and water resources.
- Measures for water conservation, recycling and optimal conjunctive use of surface and ground water for specific uses.

- Stringent measures for prevention and control of pollution due to indiscriminate disposal of solid wastes, effluents and hazardous substances in land and water courses.
- Classification, zoning and regulations for maintaining the quality of the water bodies to protect and enhance their capabilities to support the various designated uses.
- Public needs to be better informed about the rational, goal and methods of ecosystem conservation and restoration. In addition, the need was realized for scientist and researchers with the broad training needed for aquatic ecosystem restoration, management and conservation.

Conservation and sustainable management of wetlands helps in

- **Restoring and conserving the actual source of water**—the water cycle and the natural ecosystems that support it—are the basis for sustainable water management.
- **Reducing the environmental degradation that is preventing us from reaching goals** of good public health, food security, and better livelihoods worldwide.
- **Improving the human quality of life** that can be achieved in ways while maintaining and enhancing environmental quality.
- **Reducing greenhouse gases to avoid the dangerous effects of climate change** is an integral part of protecting freshwater resources and ecosystems.

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