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(An Association Unifying the Sciences, Engineering, and Applied Research)
ISSN (Online): 2279-0055
International Journal of Emerging Technologies in Computational and Applied Sciences (IJETCAS)
www.iasir.net

ECOLOGICAL STATUS AND CONSERVATION STRATEGIES OF LAKES - A CASE STUDY ON BANGALORE SOUTH

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Abstract: *The environmental condition of any lake system depends upon the nature of the wetland and its exposure to various environmental factors. These fragile ecosystems must maintain the state of environmental equilibrium with the existing condition of the surroundings. For the present study Physico-chemical analysis was carried out using APHA, 2005. Physical Examination of the lakes exposed major threats to the lakes viz Sewage entry, Encroachment, Exploitation of lake water, climate change and developmental activities. The Physico-chemical results reveal that five lakes namely Bandematta Hosakere, Odegerahalli Dobasipalyakere, Manganahalli haranakatte, Kannahalli, and Ramasandra Chikkakere were marginally polluted. Stakeholders, Localities, NGO's and Environmental Educationalists are significant for conservation of lakes and Lake Biodiversity.*

Keywords*: water quality; encroachment; conservation; exploitation; ecosystem;*

I. Introduction

The ecosystems function in variety of ways including movement of water through the Wetlands into streams or the ocean; decay of organic matter; release of nitrogen, sulphur, and carbon into the atmosphere; removal of nutrients, sediment and organic matter from water moving into the Wetlands; and the growth and development of all the organisms that require Wetlands for life. In addition, Wetlands can act as components of products such as fish, recreation; as a flood control system, ground water recharge and storm protection. Lakes help in microclimate regulation.

Wetlands are defined as 'lands transitional between terrestrial and aquatic eco-systems where the water table is usually at or near the surface or the land is covered by shallow water [11]. The value of the world's wetlands are increasingly receiving due attention as they contribute to a healthy environment in many ways. They retain water during dry periods, thus keeping the water table high and relatively stable. During periods of flooding, they mitigate flood and to trap suspended solids and attached nutrients. Thus, streams flowing into lakes by way of wetland areas will transport fewer suspended solids and nutrients to the lakes than if they flow directly into the lakes. The removal of such wetland systems because of urbanization or other factors typically causes lake water quality to worsen. In addition, wetlands are important feeding and breeding areas for wildlife and provide a stopping place and refuge for waterfowl. As with any natural habitat, wetlands are important in supporting species diversity and have a complex of wetland values [9].

The status of Bangalore Lakes and Wetlands in the course of time is critical. In recent time many Lakes and ponds of Bangalore have been lost in the process of various anthropogenic activities and population pressures leading to unplanned urbanization and horizontal expansion. Even though, the rest of the surviving Lakes are reduced to cesspools due to direct discharge of domestic and industrial effluents and unregulated dumping of solid wastes. Urbanization and anthropogenic stress in Bangalore City has paid a share in discontinuity of the drainage network due to loss of Wetlands [4].

II. Study Area

The selected Lakes for the study come under Vrishabhavathi valley, Byramangala Lake series. 5 studied Lakes are as follows;

Name of the Lake	Village & Hobli	Area of Lake	Latitude and Longitude
Bandematta Hosakere Lake	Valgerahalli, Kengeri	23.35 Ha	$12^0$55'28.27"N $77^0$28'51.71"E
Ramasandra Chikkakere Lake	Ramasandra, Kengeri	7.06 acres	$12^0$56' 48.00"N $77^0$28' 16.70"E
Kannahalli Lake	Kannahalli, Yeshwanthapura	117.16 acres	$12^0$57' 52.47"N $77^0$27' 29.99"E
Manganahalli Haranakatte	Manganahalli	6.22 acres	$12^0$57' 27.15"N $77^0$28' 22.44"E
Odigerahalli Dobasipalya	Odegerahalli, Kengeri	24.35acres	$12^0$55' 51.38"N $77^0$29' 43.46"E

III. Methodology

Ecological status: The Lake was surveyed to assess the environmental status, where the sources of the pollution were identified.

Sample collection: Samples were collected in clean and sterilized plastic bottles of 2 Litre capacities. The samples were collected 30 cm below the surface of water and brought to the laboratory for Physico-chemical parameters selected are pH, EC, Total Dissolved Solids, Dissolved Oxygen, Total Hardness, BOD, COD, Chlorides, Phosphates and Nitrates, analysed by following standard methods [3]

Statistical analysis: The obtained results were subject to Statistical Analysis, mean, Standard deviation and Pearson Correlation Coefficient to see the correlation between different physicochemical parameters using Microsoft offices excel 2010.

IV. Results and Discussion

Ecological status: Bandematta Hosakere Lake is polluted; Inlet is located at the northern and eastern side of the Lake. Sewage is entering mainly from the residential layouts. Northern and western side of the Lake there is agricultural land consisting of a variety of orchards such as Mangoes, Coconuts, Areca, Indian Date Palms, Teak, Acacia. A huge bund is towards the south of the Lake. Settlements are towards eastern side of the Lake. The *Cyperus spp.*, and *Ipomoea carnea* were dominant species found. A diversity of aquatic vegetation is seen along the catchment area.

Ramasandra Chikkakere Lake, is situated next to the NICE road, Lake Water appearance to be turbid. The Lake is having large Catchment area. Surface flow into the Lake is from the north eastern side of the Lake. The Lake has sparse Vegetation consisting of only Phoenix sylvestris in the bund area, the original vegetation may be lost due the development of NICE road. Towards Southern side of the Lake is the bund and towards western side of the Lake is the NICE road. *Typha spp.*, and *Ipomoea carnea* was found in the Lake littoral zone.

Kannahalli Lake is having huge catchment area. Lake is fairly shallow with an average depth of 10 to 15 feet near the Lake shore, the land is moderately slope and additional water enters the Lake from direct surface water runoff. There are two inlets from north side and another inlet from west side of the Lake. The west side of the Lake is surrounded by settlements. The domestic sewage from settlements is let directly into the Lake. we can find temple in the south west corner of the Lake, the religious activities which is carried out in the temple premises generate the waste and it is dumped into the Lake this intern affect the quality of Lake. There is a huge bund to the south part of the Lake. The outlet drains towards Southeast of the Lake. The Lake water is pumped to agricultural land next to Lake.

Manganahalli Haranakatte is one of the seasonal Lakes located in Vishveshvaraiah layout of Bangalore south. The Lake is situated adjacent to NICE road. Lake is likely to be naturally eutrophic that are naturally enriched with nutrients and have vigorous growth of aquatic plants. The Lake water appears to be green in colour. Water enters to the Lake through precipitation and surface runoff. Sewage enters the Lake through inlet from north side. Major threat of Lake is direct entry of sewage.

Odegerahalli Dobasipalya Lake is fenced and maintained by forest dept. Residential area is found on all sides of the Lake. Bund is found towards south western side of the Lake. Inside the boundary of the Lake towards Southern side UGD system is passing through. Inlet is seen towards North eastern side and western side of the Lake. The Lake water is greenish. Coconut plantation was observed towards Eastern side of the Lake. Water enters the Lake from direct surface flow. Bund is covered by thick vegetation.

Physico chemical analysis: The analysis of the water samples is tabulated in the Table 1, the results revealed that pH ranged from 7.5 – 8.8, 4 lakes water samples had crossed the standard limit. The three main processes affecting Lake pH are photosynthesis, respiration and nitrogen assimilation. The effect of photosynthesis and

respiration depends on carbonate, bicarbonate and carbon dioxide equilibrium. Most of the waters are slightly alkaline due to presence of carbonates and bicarbonates. Generally pH of water is influenced by geology of catchment area and buffering capacity of water. The mean value of pH was 8.34 and SD value was 0.56.

Electrical conductivity was maximum in Bandematta Hosakere 1125.3 µmohs/cm, and minimum was observed in 521 µmohs/cm, which was within the prescribed limit. The mean value of Electrical conductivity was 798.36 and SD value was 245.04. Normal surface water is expected to have a range between 50 and 1500 µmhos/cm [8]. Laboratory conductivity measurements are used to establish a degree of mineralization and physiological effects on aquatic biodiversity.[3]

Total Dissolved solids were maximum in Bandematta Lake having 685 mg/L which has crossed the prescribed standard of 500 mg/L as per ISI- IS. The mean value of Total Dissolved solids (TDS) was 497.6 and SD value was 116.31, a high level of dissolved solids elevates the density of water which influences osmoregulation of fresh water organisms reducing the solubility of gases like oxygen and utility of water for drinking, irrigation and for industrial purposes. Water can be classified based on the concentration of TDS [12]. Moreover, TDS range up to 3000mg/L are useful for irrigation while anything above 3000mg/L will not be suitable for both drinking and irrigation. [1]

Dissolved oxygen (DO) was below the prescribed standard 3.5 mg/L against 4 mg/L. The mean value of Dissolved oxygen was 4.86 and SD value was 0.91. Dissolved Oxygen is the fundamental fuel of life in water. DO in water is of great importance to all aquatic organisms and is considered to be the factor that reflects the biological activity taking place in a water body and determines the biological changes, which are brought about by the aerobic or anaerobic organisms [10]. Fish requires minimum DO of 3mg/L for their survival.

Total hardness ranged from 139.9 mg/L in Manganahalli Haranakatte to 320.8 mg/L in Bandematta Hosakere Lake, which has crossed the standard limit. . The mean value of Total Hardness was 210.08 and SD value was 72.54. [7] & [3] Water hardness basically a measure of the capacity of water precipitates soap. Calcium and magnesium are the principle cations causing hardness. Other elements such as Iron Aluminium, Manganese strontium and zinc are also responsible in contributing the Hardness of water. The principle anions are Carbonates and Bicarbonates. [8]Measurement of carbonates and bicarbonates below 300mg/L are harmless to fish in the water medium. Higher levels of hardness indicate a serious pollution of that water body system by elements other than calcium and magnesium.

Biological oxygen demand ranged from 1.6 -3.9 mg/L maximum was observed in Bandematta Lake. The mean value of Biological oxygen demand was 2.8 and SD value was 1.00 BOD determines the strength of organic waste (sewage, effluents and other pollutants) in water and provides data on the pollution load in all natural waters. Reason of high values of BOD may be due to agricultural and domestic discharge in water. [6]

Chemical Oxygen Demand ranged from 14.1 to 40.4 mg/L, maximum was observed in Ramasandra chikkakere. The mean value of Chemical Oxygen Demand was 24.6 and SD value was 9.68. [6]The increase in COD during Hot period is mainly attributed to the increase in the air and water temperatures, facilitating the decomposition and oxidation of organic matter and higher the COD is the Indication of increased organic loads due to increased household wastewater and waste discharges.

Chlorides ranged between 86 - 193.4 mg/L maximum were observed in Bandematta Lake. The mean value of Chlorides was 132.3 and SD value was 42.10. Chlorine in the form of chloride ion (Cl^-) is one of the major anions in water and waste water. Presence of chloride in water could be due to various sources like, natural weathering of rocks, domestic waste and through artificial or natural chemical reactions. Salty taste of water is produced by Cl- ions but the chemical composition and the abundance of some cations like Na+, Ca++ and Mg++ in water generally govern the taste.

Total Alkalinity ranged between 95.1 – 145.7 mg/L maximum was observed in Bandematta Lake. . The mean value of Total Alkalinity was 115.02 and SD value was 20.31. The higher value is due to the relative amounts of carbonates and bicarbonates

Phosphates ranged between 1 – 4.1 mg/L maximum were observed in Bandematta Hosakere lake, and minimum was observed in Odegerahalli Dobasipalya kere, Phosphorous occurs in the natural waters as phosphates. These are classified as Orthophosphates, condensed Phosphates and organically bound Phosphates. They occurs in solution, in the piratical detritus, or in the bodies of an aquatics organisms primarily, they arise from variety of sources such as raw sewages from domestic and industrial effluents; and also from agrochemicals and fertilizers in the form of run – offs and storm waters.[3]

Nitrates ranged between 3.7 – 9.6 mg/L maximum were observed in Bandematta Hosakere Lake, and minimum was observed in Ramasandra Chikkakere Lake. Nitrate is the oxidized form of nitrogen and end product of aerobic decomposition of organic nitrogenous matter. The presence of nitrate in fresh water bodies depends mostly upon the activity of nitrifying bacteria, domestic and agricultural source.

Table 1: Results of Physico Chemical analysis of lake water samples

	Unit	Standard	Bandematta Hosakere	Ramasandra Chikkakere	Kannahalli Lake	Manganahalli haranakatte	Odegerahalli Dobasipalyakere	Mean ± SD
pH		6.5 – 8.5*	8.8	8.0	7.5	8.7	8.7	8.34 ± 0.56
EC	µmohs/ cm	2250*	1125.3	901.5	521	852.5	591.5	798.36 ±245.04
TDS	mg/L	500*	685	453	483	499	368	497.6 ±116.31
DO	mg/L	4*	3.5	5.9	5	4.5	5.4	4.86 ±0.91
Total hardness as $CaCO_3$	mg/L	300*	320.8	242.6	181.9	139.9	165.2	210.08 ±72.54
BOD	mg/L	3*	3.9	1.9	3.1	3.5	1.6	2.8 ±1.00
COD	mg/L	250#	24.6	40.4	22.8	21.1	14.1	24.6 ±9.68
Chloride as Cl^-	mg/L	600*	193.4	149	101.7	131.4	86	132.3 ±42.10
Total Alkalinity as $CaCO_3$	mg/L	200#	145.7	122.7	95.1	112.3	99.3	115.02 ±20.31
Phosphate as PO_4^{3-}	mg/L	5#	4.1	1.5	2.1	1.4	1	2.02 ±1.22
Nitrate as $NO^{3-}N$	mg/L	50*	9.6	3.7	5.1	4.3	4.7	5.48 ±2.36

*ISI-IS: 2296 – 1982, # IS: 10500 -1992

Table 2: Pearson's correlation coefficient between Physico Chemical Parameters

	pH	EC	TDS	DO	Total hardness	BOD	COD	Chloride	Total Alkalinity	Phosphate	Nitrate
pH	1.000										
EC	0.312	1.000									
TDS	0.215	0.768	1.000								
DO	0.280	-0.564	-0.875	1.000							
Total hardness	0.608	0.743	0.753	-0.449	1.000						
BOD	-0.119	0.477	0.852	-0.891	0.305	1.000					
COD	0.919	0.433	0.150	0.331	0.456	-0.118	1.000				
Chloride	0.453	0.962	0.875	-0.612	0.844	0.579	0.495	1.000			
Total Alkalinity	0.384	0.977	0.818	-0.590	0.866	0.463	0.421	0.977	1.000		
Phosphate	0.273	0.650	0.951	-0.818	0.843	0.723	0.095	0.792	0.761	1.000	
Nitrate	0.023	0.591	0.871	-0.866	0.769	0.646	-0.165	0.681	0.708	0.948	1.000

Statistics analysis:

The statistical analysis (Table 2)showed pH strong positively correlated with chemical oxygen demand, moderately correlated with Total hardness, weakly correlated with EC, TDS, DO, Chlorides, Total Alkalinity, Phosphates and Nitrates, Negative weakly correlated with Biological oxygen demand. EC showed strongly correlated with Chlorides, and Total Alkalinity. TDS showed strongly correlated with Biological oxygen demand, Chlorides, Total Alkalinity, Phosphates and Nitrates and Negative strongly correlated with DO. DO showed negative strongly correlated with Phosphates and Nitrates. Total hardness showed strongly correlated with Chlorides, Phosphates and Total Alkalinity. Chloride showed strongly correlated with Total alkalinity. Phosphates showed strongly correlated with Nitrated.

V. Conclusions

Bangalore aquatic map continues to be threatened by encroachment and effluent discharge. Most lakes in Bangalore are rain fed directly by rains or through a series of cascading effects of flow and recharge channels. These channels have now been severely disintegrated, thanks to the rising demand for land, housing and other economic activities, thus causing a slow but gradual suffocation of these unique urban aquatic systems. Even restoration can cause a slow death of lakes. Blockage of storm drains into the lake has often been used and seen as the most convenient way of stopping pollution at end point. But these storm drains have been the life line of these fragile urban tanks and by solving the problem at end point; one has not solved the issue of environmental pollution at source point. Lack of proper management strategies will eventually lead to loss of lakes around Bangalore and concomitant permanent loss of our ground water resources all this due to our neglect of the lakes. The environmental pressure on our aquatic systems will only be properly tackled if the main issues of encroachment and management of domestic and industrial discharges were addressed. Solving the problem at end point is a temporary measure with more serious repercussions. The solution is to tackle this problem at source points with strict enforcement of our environmental laws and regulations

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Acknowledgments

The Authors would like to thank Environment Management and Policy Research Institute (EMPRI) for the financial support to conduct the research work.