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Water Quality Assessment of Lakes in Mysuru, India - A Case Study

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***Abstract*: Mysuru district lies in the southern part of Karnataka (12° 18' 26'' North Latitude and 76° 38' 59'' East Longitude). Presently the city is supplied with Cauvery river as source though sufficient quantum of bulk water is available, due to inadequate distribution network, the water distribution is not uniform wherein some areas getting excess and many areas receiving very less quantity of water supply. Mysuru district comprises of many lakes which can also be used as a source for distribution of water during periods of shortage. Research work aims to bring out the assessment of quality of lakes in Mysore; result shows that lakes are polluted due to the disposal of sewage or through the industrial effluents.**

Due to rapid increase in population, exponential industrialization and urbanization, etc. several water bodies, in and around Mysuru exposed to various forms of environmental degradations. This leads to aggregations of phytoplankton, macro algae and occasionally colourless heterotrophic protists can discolour the water giving rise to foam. Due to this, there is reduction in DO (Dissolved Oxygen) level which ultimately disturbs the ecological balance of the lake and finally leads to eutrophication in water bodies. In the present work, the Kukkarahalli Lake, Karanji Lake, Dalvoy Lake situated in different locations in Mysuru, Karnataka, India has been selected as case study and its physico-chemical water quality parameters have been analysed. The results show fluctuation of the values. This study reveals the current status of the all the above mentioned three Lakes in terms of water quality and thereby suggestions are listed to improve the quality by eco remediation measures.

Keywords: Kukkarahalli Lake, Karanji Lake, Dalvoy Lake, Mysuru city, Physico-chemical variables, water quality.

1. INTRODUCTION:

Water is indispensable and one of the most abundant resources of nature and prime necessity for the survival of life. So the availability of water both in terms of quality and quantity is essential for the existence of living world. The rapid industrialization, urbanization and modern civilization (increased population) have lead to the increasing demand for water in domestic, agricultural and industrial sectors. Surface water comprises of flowing fresh water system (lotic), such as, river, streams, canals etc. and static fresh water system (lentic), like ponds, lakes, and reservoirs etc. Rivers attracted more attention by providing water for large scale activities and are defined as a relatively large volume of water moving within a visible channel, including sub surface water moving in the same direction and the associated flood plain and riparian vegetation. Both streams and rivers as ecological systems are highly variable over space and time, and exhibit high degrees of connectivity between systems longitudinally, laterally and vertically. (N. Athira.et.al 2014).

The lakes comprise the one of the most productive ecosystem. Lake environments are comprised of physical, chemical and organic properties contained inside these water bodies. Numerous living beings rely upon freshwater for endurance and humans commonly depends upon lakes for a considerable number of 'goods and services', for example, drinking water, waste removal, fisheries, agricultural irrigation, industrial activity and recreation. Hence lakes represent imperative biological communities. The study of water variables of a lake ecosystem plays an important role to determine the biological production. The changes in these variables of aquatic ecosystem also showed considerable impact on the biological diversity. Therefore an accurate evolution of the physico-chemical variables in Lake Ecosystem is significant for controlling pollution. (Rama Kumari.et.al 2018). Lakes serves as an important life support system by helping in recharging of aquifers and regulating hydrological regimes. Restoration and recharge of water table is possible due to lakes, so the lakes play an important role in human life. (K C Khare.et.al 2008)

Lakes are dynamic ecosystem that reflects their specific lake basin characteristics, variations in climate and biological components. The size of the lake basin, its depth and volume, quantity and quality of water that enters the lake are important considerations. Lake management activities are implemented on the basis of this information, including surface use regulations, aeration, and native and exotic aquatic plant management. Important water quality issues include the biological productivity of a lake (trophic state), water chemistry profiles, regional water quality comparisons, nutrient concentrations, water transparency, specific

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pollutants and historical trends. Lake management issues, related to the physical characteristics of the lake will require data on the surface area, shape, depth and volume of the lake. The inlet and outlet characteristics and bottom types are also important. (Parul Baranwal.et.al.)The quality and quantity of these resources is an indicator of sustainable development of a country. Water bodies like lakes and rivers located in urban cities provide market and non-market benefits like boating, recreation, nature viewing, climate amelioration, water flow regulation, carbon sequestration etc. (P. Chaudhry.et.al 2013).
Water contamination is becoming the most serious threat to human health. It has been estimated that about 80% of all the diseases in mankind are due to one or the other unhealthy aspects of water. Contamination of lakes and other reservoirs is seen as one of the commonly occurring phenomenon in almost all developing nation, especially urban ones, due to demographic expansion coupled with lack of civic amenities results in hitting these natural water reservoirs very hard. Majority of the urban and rural lakes have vanished due to this human neglect and the others which could sustain this pressure, present non-potable water or are not able to meet human requirements. (Ravinder Kumar.et.al 2018).
The aim of this research is to determine Physico-chemical and biological parameters of water pollution in Kukkarahalli Lake, Karanji Lake, Dalvoy Lake of Mysuru city with a view to reveal information about its water quality, the impact of water pollution on the aquatic ecosystem and public health of the Kukkarahalli Lake, Karanji Lake, Dalvoy Lake of Mysore city. It will also help in conservation, effective utilization, and sustainable exploitation of the vast aquatic resources that abound in the lake along with aquatic life.

1.1 DESCRIPTION OF STUDY AREA:

Mysore city is geographically located between 12° 18' 26" North Latitude and 76° 38' 59" East Longitude. It is located at an altitude of 2,427 feet. It encompasses an area of 6,268 sq. km., the temperature varying between 14ºC and 35ºC. The weather of Mysuru is pleasant throughout the year. Mysore city is located in the southern part of the Deccan Plateau. Location map of Mysuru city is as shown in Fig 1. It is a beautiful land, bordered by luxuriant forests. Mysuru is located 140 km from the city of gardens, Bengaluru (Hanieh Farzaneh.et.al 2016). Mysuru has several large and small water bodies. Some of the major lakes are Kukkarahalli Lake, Lingambudi Lake, Devanoor Lake, Dalvoy Lake and Karanji Lake. Though Mysuru, a heritage city, has developed into a modern city, is still moving at a gentle, unhurried and leisurely pace. The city has a good green cover and has a few lakes that add to the beauty and calmness of the city. These lakes are popular picnic spots and are frequented by nature lovers as they attract a number of migratory birds (T. S. Mamatha.et.al 2013).

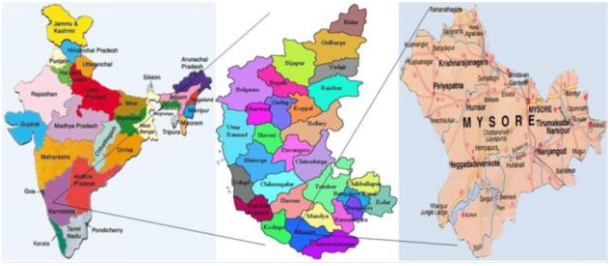

Fig. 1 Location of Mysore city-India

1.2 PHYSICAL CHARACTERISTICS OF THE LAKES:

Kukkarahalli Lake located in the heart of the Mysuru city, adjoins the Manasagangotri (University of Mysore), the Kalamandir (Rangyana) and the Central Food Technological Research Institute (CFTRI) campus (separated by the Hunsur Road). It provides lung-space to the city. Mummadi Krishnaraja Wodeyar, (1794–1868) of the Mysore Dynasty (Kingdom of Mysore) was responsible for getting the lake created, in the year 1864, to provide water for irrigation to about 4000 ha (10,000 acres) of land outside the city. The Lake also used to be a source of water supply to the city of Mysore but over the years, sewage and excessive land encroachments (mostly illegal) and blockage of water flow sources almost led to the eutrophication of the lake. The University of Mysore and the citizen forums of Mysore continue to make efforts to preserve the lake by implementing several remedial measures. The Lake drains a catchment area of more than 414 square kms (160 sq. mi) and the water body spreads over 62 hectares (150 acres). Dewan Poornaiah feeder canal, 27 km (17 mi) long, which passes through Hinkal, Bogadi, Kudremala and Manasagangotri outfalls into the Lake. The Lake is ‘J’ shaped. The maximum depth of lake is reported to be 5 m (16 ft.). The east-west bund holds water on one side. Sandy loams to clay loam form the dominant geological condition of the Lake. On the northern side another temporary bund hold back the direct flow of waste water into the lake. The highest flood level in the lake is 755.73 m (2,479.4 ft.).(Hanieh Farzaneh.et.al 2016).
Karanji Lake, located in the heart of the Mysuru city in the state of Karnataka, India. It was constructed by Maharaja of Mysore. It is one of the biggest lakes in Karnataka and spreads over an area of 90 acres with a water spread area of about 55 hectares. This lake is the site for largest walk through aviary in India. It is an abode for more than 90 species of native and migratory birds, butterflies and mammals. The lake is surrounded by a beautiful nature park (Butterfly Park). Regional museum of natural history is also located on the banks of the lake. Being a percolation lake, it started getting polluted when sewage water made its way into the lake. This if not controlled and checked properly will lead to the destruction of a wonderful tourist attraction and nature’s gift to the mankind. (Anima Upadhyay.et.al 2016).
The Lake is shallow with a maximum depth of 2.2m and minimum depth of 0.2m. In the past, Karanji Lake was fed with the storm water a drain surrounding the lake in the catchment area. The lake is now managed by Mysore Zoological Garden. The Karanji Lake is facing serious problem of inflow of huge quantity of drainage water from the UGD running from the adjoining residential areas (Siddhartha Layout) and dairy industry. (T. S. Mamatha.et.al 2013).

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Dalvoy Lake was constructed during the period of Maharaja's of Mysuru (19th century) to fulfil the needs like water supply for drinking, irrigation, industries and other related works. This lake is located 5km south of Mysuru city. The total catchment area of the lake is 2615 acres covering dalvoy series, shettykere, marshy pickup and gudumadanahally pickup. The main source of water to take is rainfall, urban runoff from the elevated areas through storm water drains, sewage water from Mysuru city (Mahesha.et.al 2010).

1.2.1 SAMPLING AND ANALYSES:

The sampling sites were selected by keeping in mind the locations of inflow and outflow. The location map of Kukkarahalli Lake, Dalvoy Lake and Karanji Lake is as shown in Figs 2, 3, and 4 respectively. Water samples were collected from the surface and few meters below water level to find out the varying characteristics, if any, of surface and bottom waters, by using specially designed airtight sampler, using clean and sterile polythene bottles.

Fig 2: *Location map of kukkarahalli Lake*

Fig 3: Location map of Dalvoy Lake

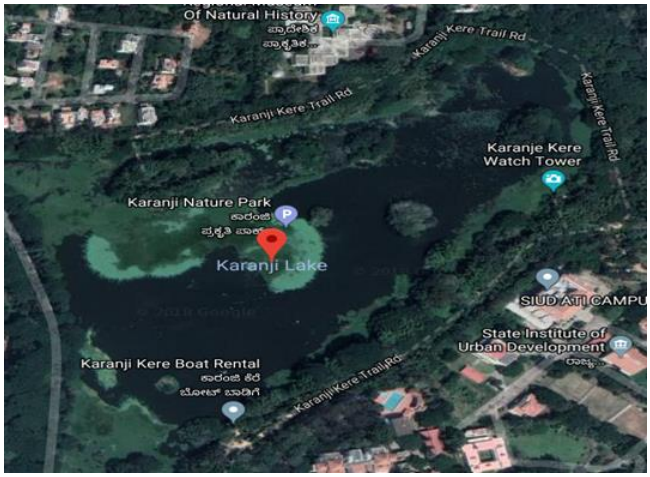

Fig 4: *Location map of Karanji Lake*

1.3 EXPERIMENTAL FINDINGS AND DISCUSSION:

The results of the physico-chemical and biological parameters of the lake water are tabulated in Table 1. The trends of some of the main parameters like pH, DO, BOD, COD, Faecal and total coliforms in different months is also represented in Fig 5, 6 and 7 respectively. The physical condition of water strongly influences the chemical and biological process that take place in the water body (N. Athira.et.al 2014). The depth of the sampling stations can influence the other parameters of the water. The mean depth of Kukkarahalli Lake, Dalvoy Lake and Karanji Lake was recorded as 0.5 m, 0.5 m and 0.4 m respectively during the analyses. The temperature, also have effect on hydrochemistry and biological reactions in the organisms in both surface and ground waters. Temperature of the water body varied from 22^0C to 32^0C during the study period.

The pH of the surface waters mainly contributes the atmospheric precipitation and the presence of several compounds. pH is considered as an ecological factor and is the result of interaction of various substances in solution, in water and also influences numerous biological phenomenon. The pH values were found to be 8.6 to 9.3 in Kukkarahalli Lake, 7.2 to 8.6 in Karanji Lake and Dalvoy Lake.

The electrical conductivity (E: C) is an index to represent total concentration of salts. High level of electrical conductivity indicates the pollution status as well as tropic level of aquatic body. The E: C values varied from 747 to 890µs in Kukkarahalli Lake, 683 to 975 µs in Karanji Lake and 1044 to 1175µs in Dalvoy Lake. The value of conductivity is directly related to total solids. Higher the value of dissolved solids, greater will be the amount of ions in water. The turbidity of the Kukkarahalli Lake ranges from 19.1 NTU to 24 NTU, 5 NTU to 18.3 NTU in Karanji Lake and 6.8 NTU to 13.1 NTU in Dalvoy lake.

In the present study, the alkalinity values show gradual changes 168 to 240 mg/L as $CaCO_3$ in Kukkarahalli Lake, 200 to 20 mg/L as $CaCO_3$ in Karanji Lake, and 256 to 302 mg/L as $CaCO_3$ in Dalvoy lake, which is high, compared to standards due to the salts present in lake water. The total dissolved solids (TDS) and total suspended solids (TSS) were found as high in the all three lakes which varied from 40 to 50 mg/L and 580 to 650 mg/L in Kukkarahalli Lake, 30 to 50

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mg/L and 500 to 750 mg/L in Karanji Lake, 30 to 60 mg/L and 740 to 820 mg/L in Dalvoy lake respectively.

The oxygen dissolved in water can influence the biological process of the aquatic ecosystem. The major sources of oxygen in water include diffusion from the air and photosynthetic activity within water. The dissolved oxygen level varies from 6.2 to 7.5 mg/L in Kukkarahalli Lake, 5.8 to 6.8 mg/L in Karanji Lake and minimum amount of dissolved oxygen that is 1.8 to 2.8 mg/L in Dalvoy Lake was found which is due to the increase in temperature or adding of some organic matter in sediments and dissolved ammonia can contribute oxygen depletion due to nitrification.

In the present study, the calcium, magnesium and total hardness values showed an increasing tendency, the concentration of total hardness, calcium and magnesium varied between208to 265 mg/L as $CaCO_3$, 100 to 104 mg/L as $CaCO_3$, and 104 to 170mg/L as $CaCO_3$, in Kukkarahalli Lake, 148 to 260 mg/L as CaCO3, 76 to 115mg/L as $CaCO_3$,and 72 to 155mg/L as $CaCO_3$ in Karanji Lake, 264 to 300mg/L as $CaCO_3$, 120 to 144 mg/L as $CaCO_3$ and 144 to 156 mg/L as $CaCO_3$ in Dalvoy Lake respectively, the lake water gets evaporated rapidly devoid of the dissolved cations and anions in the water, and contributes to hardness.

The concentration of sodium ranged from 57 mg/L to 83.2 mg/L in Kukkarahalli Lake, 68.3 to 84.4 mg/L in Karanji Lake, 76.3 to 87 mg/L in Dalvoy Lake respectively. The sodium occurs generally in lower concentrations than calcium and magnesium in lake waters and makes its way in water through rock weathering. The potassium concentration ranged from 13 mg/L to 20.5 mg/L in Kukkarahalli Lake, 6.8 to 10.7 mg/L in Karanji Lake, 7 to 9.9 mg/L in Dalvoy Lake respectively.

The sulphate content varied from 12 mg/L to 18 mg/L in Kukkarahalli Lake, 5.9 to 27 mg/L in Karanji Lake, 14 to 17.1 mg/L in Dalvoy Lake respectively. Domestic sewage and industrial effluents, besides biological oxidation of reduced sulphur species, may add to sulphate content of water. The phosphate concentration varied from 0.29 mg/L to 0.40 mg/L in Kukkarahalli Lake, 0.08 to 0.6 mg/L in Karanji Lake, 0.2 to 0.8 mg/L in Dalvoy Lake respectively. The dumping of domestic waste, agricultural runoff and use of fertilizers contributes high phosphate concentration in the lakes. The presence of phosphates in large quantities in lake water indicates the pollution through sewage and industrial waste.

The nitrate concentration varied from 0.3 mg/L to 0.5 mg/L in Kukkarahalli Lake, 0.4 to 0.55 mg/L in Karanji Lake, 0.16 to 1.35 mg/L in Dalvoy Lake respectively. The nitrites and nitrates are the oxidized form of nitrogen and in water. It's most important source is biological oxidation of nitrogenous organic matter, fertilizers, animal waste, municipal sewage and decaying plant debris. Water naturally contains less than 1 mg/L, higher levels indicate that the water has been contaminated.

The fluoride concentration varied from 0.2 mg/L to 0.3 mg/L in Kukkarahalli Lake, 0.48 to 0.6 mg/L in Karanji Lake, 0.5 to 1.1 mg/L in Dalvoy Lake respectively. The fluoride has been considered as an acute pollutant to natural environment because of the ability of plants and aquatic organisms to accumulate it and have detrimental effect on the aquatic biota.

In the present study the changes in bacteriological parameters in lake water was analysed the total coliforms ranged from 5800 MPN in 100 ml to 6300 MPN in100 ml and fecal coliforms ranged from 1300 MPN in 100 ml to 1800 MPN in 100 ml in Kukkarahalli Lake, total coliforms ranged from 4000 MPN in 100 ml 5475 MPN in 100 ml and fecal coliforms ranged from 930 MPN in 100 ml to 1460 MPN in 100 ml in Karanji Lake, total coliforms ranged from 7000 MPN in 100 ml 8000 MPN in 100 ml and fecal coliforms ranged from 1700 MPN in 100 ml to 2800 MPN in 100 ml in Dalvoy Lake respectively. The coliform bacteria are discharged from the human intestine and their presence indicates the possibility of the presence of pathogenic organisms. The coliform bacteria include the genera Escherichia, Citrobacter, Enterobacter and Klebsilla etc. This result reveals that the lake water is bacteriologically contaminated and is not suitable for bathing and other recreational activities.

Table 1: Physico-Chemical and Biological Quality of Kukkarahalli Lake, Karanji Lake and Dalvoy Lake Water

Name of the Water body →		Kukkarahalli Lake				Karanji Lake				Dalvoy Lake			
PARTICULARS	Units	Jan 2017	Feb 2017	Mar 2017	April 2017	Jan 2017	Feb 2017	Mar 2017	April 2017	Jan 2017	Feb 2017	Mar 2017	April 2017
pH	--	9.3	9.3	8.8	8.6	8.6	8.0	7.4	7.2	8.6	7.8	7.4	7.2
Dissolved Oxygen	mg/l	7.5	7.5	7.0	6.5	6.8	6.0	6	5.8	2.9	2.5	2	1.8
BOD	mg/l	4.8	4.8	5.0	5.8	5.2	5.4	5.4	5..6	10.4	17.4	19.8	20.1
Conductivity	µs/cm	747	747	778	861	778	683	959	975	1044	1056	1130	1175
Nitrate As N	mg/l	0.3	0.3	0.4	0.48	0.4	0.4	0.5	0.55	0.16	0.2	1.25	1.35
Ammonia As N	mg/l	6.72	6.72	8.0	7.5	6	5.4	7.6	7.9	6.2	8.8	8.2	8.0
Feacal Coliform	MPN/100ml	1400	1400	1300	1700	930	1100	1400	1460	1700	2200	2700	2800
Total Coliform	MPN/100ml	6300	6300	5800	5800	4000	4700	5400	5475	7000	7900	7900	8000
COD	mg/l	118	118	149	185	74.4	100	144	163	144	134	151	163
Turbidity	NTU	19.1	19.1	23	23.1	18.3	14.7	5.1	5.0	8.2	6.8	12.2	13.1
Hardness as $CaCO_3$	mg/l	216	216	208	256	200	148	248	260	300	280	264	272

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Calcium as $CaCO_3$	mg/l	104	104	104	100	96	76	108	115	144	128	120	131
Magnesium as $CaCO_3$	mg/l	112	112	104	156	104	72	140	155	156	152	144	152
Chlorides	mg/l	112	112	148	136	144	128	132	140	144	164	160	162
Sodium	mg/l	57	57	83.2	76.3	68.3	71.6	81.2	84.4	76.3	78.5	84	87
Potassium	mg/l	13	13	20.5	18.1	8.3	10.7	6.8	7.1	9.7	9.9	7.0	8.0
Sulphate	mg/l	18	18	12	16	27	26	6.8	5.9	14	14	16.4	17.1
Phenolpthelene Alkalinity as $CaCO_3$	mg/l	28	28	32	16	24	Nil	Nil	Nil	20	24	Nil	Nil
Total Alkalinity as $CaCO_3$	mg/l	236	236	240	168	200	320	272	283	256	272	292	302
Total Kjeldahl Nitrogen as N	mg/l	14	14	14.6	15.2	13.8	9.8	13.4	13.6	12.32	15.4	15.4	15.6
Total Suspended Solids	mg/l	40	40	50	40	50	30	40	45	30	30	50	60
Total Dissolved Solids	mg/l	580	580	600	640	580	500	700	750	780	740	800	820
Total Fixed Solids	mg/l	460	460	500	500	480	420	580	610	620	580	640	665
Phosphate	mg/l	0.40	0.40	0.34	0.29	0.3	0.6	0.08	0.1	0.2	0.3	0.72	0.8
Fluoride	mg/l	0.3	0.3	0.2	0.24	0.6	0.5	0.48	0.5	0.5	1.1	0.43	1.0
Boron	mg/l	0.1	0.1	0.12	0.14	0.09	0.06	0.15	0.2	0.23	0.2	0.23	0.3

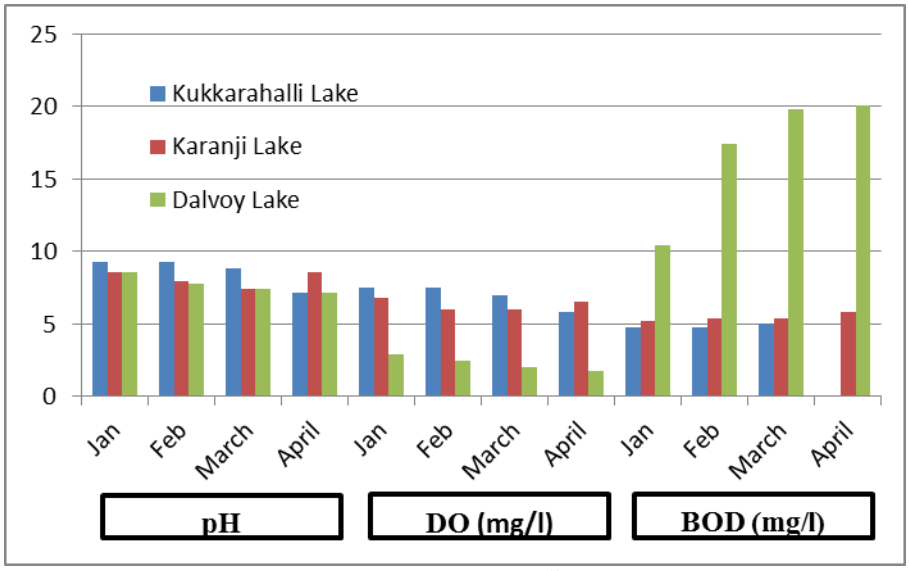

Fig 5: pH, DO& BOD Trends in Different Months

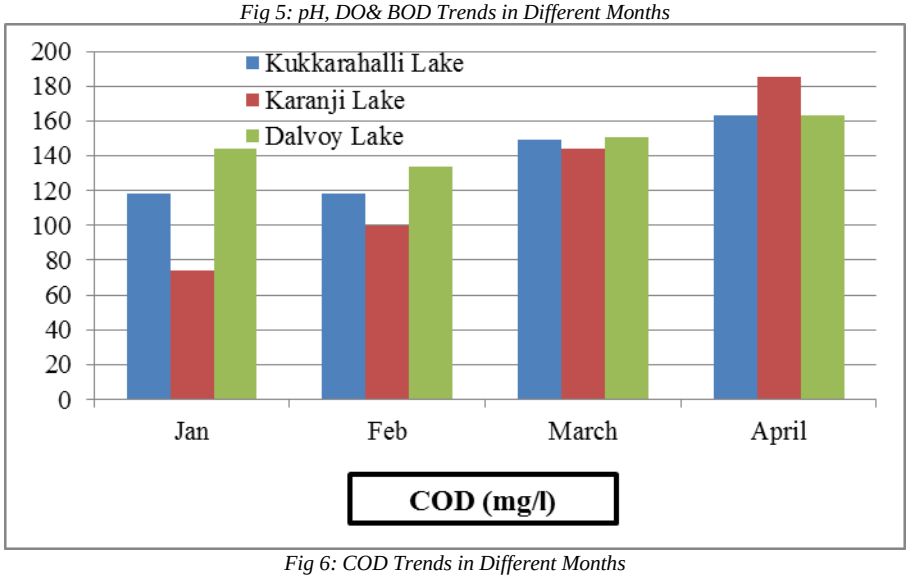

Fig 6: COD Trends in Different Months

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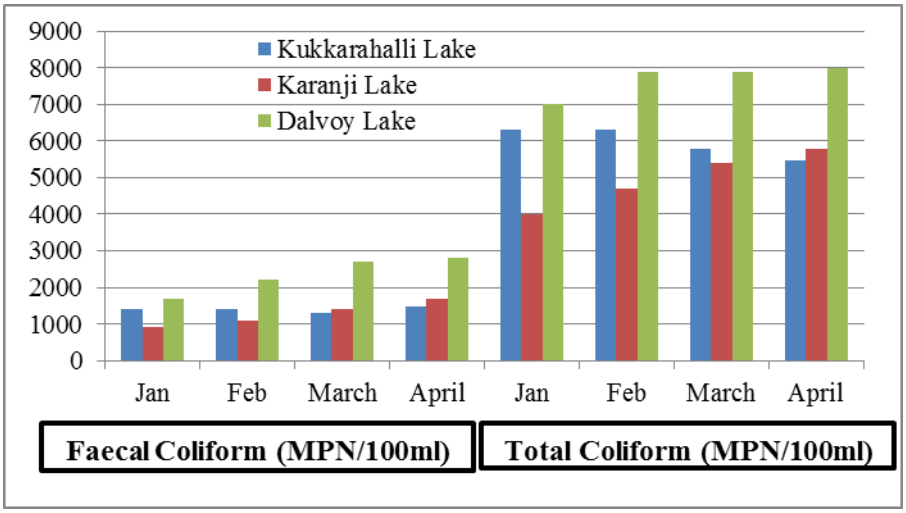

Fig 7: Faecal and Total Coliform trends in Different Months

1.4 CONCLUSIONS:

Based on the analysis of the experimental results obtained, the following conclusions have been drawn.

- The concentration of nitrate-and phosphate shows that the lake is eutrophic.
- The water quality parameters like pH, COD and BOD are in the range which supports the aquatic growth in the lake (the trends of different months is as shown in fig 5 and 6).
- The aquatic plants like water hyacinth and lavancha are seen abundant in the lake which helps in absorbing nutrients thereby reducing the pollutant concentration and aiding in Lake Self-purification.
- The DO level at lakes is found to be minimum, it can be concluded that the lakes are not fit for aquaculture.
- Based on adequacy of nutrients, it can be concluded that the lake water is most suited for agricultural purpose.
- The weeds can be used as domestic feed as they are rich in nutrients.

Thus from overall analysis, the above study can be used as predictive tool in lake/water management programme.

PREVENTIVE MEASURES

- Periodic removal and disposal of weeds from the lake.
- De-silting of the lake in the selected areas in regular intervals.
- Construction of silt traps and constructed wetlands at the entry of incoming drains and sewage.
- Strengthening/ formation of bund.
- Providing chain link fencing for protection of lake.
- Prevention of pollution from point sources by intercepting, diverting and treating the pollution loads entering the lake.
- Catchment area treatment and lake front Eco-development which may include bunding, fencing, and shore line development, creation of facilities for public recreation and entertainment (Children Park, boating etc.) and public area.
- Public awareness and public participation through formation of committees with local people.
- Other activities depending upon location specific conditions including the interface with human population.

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