A STUDY ON BIRD DIVERSITY AND WATER HEALTH OF SOME LAKES OF MYSORE CITY

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Abstract
It is widely accepted that the number of water birds using a wetland site is a good indicator of that sites's biological importance and water bird counts have been especially influential in the identification of important wetlands. Bird counts can also provide vital evidence for the protection of wetlands should they become threatened. The waterspread area of the five lakes have been studied. As a record of earlier, the quantity of land was comparatively larger than the present day. It is due to the growth and development of urbans/villages. In the meanwhile, the birds population and bird species have also been studied according to the data obtained and field survey carried out during the present study, the Egyptian vulture, Brown crake, Northern pintail, wooly necked stork etc, species were lost their presence in the lakes and new Asian paradise flycatcher, Indian pitta, Pheasant tailed jacana, stone curlew etc species of birds were identified in the present day. It indicates that, the lost bird species may have sensitive to pollution and remaining bird species may resist the pollution. Hence, this can be called as pollution indicators of the nature. In the whole, the study of lakes, water catchment area, water quality and bird diversity may indicates the nature of pollution level. The interlinkage/bonding of all these parameters promotes the positive correlation one to another. In these aspects the limnology study reveals that, any lakes nature/pollution level should be determine by the study of water quality along with the natural bio indicators called bird diversity. Hence, the study of bird diversity is also a one of the major tool to identify the pollution level of any water body/lakes.

INTRODUCTION

Water is one of the important natural resources of the planet earth essential for the survival of all forms of life and is one of the greatest looming commodities of the 21st century. It underpins all aspects of human society, from ecology to agriculture to industry and it has no known substitutes. An appreciable part of 1.7% gets lodged in snowcaps and natural lakes and is subsequently utilizable, in case of the former through snowmelt reaching a river system. A sizeable part is retained on the earth surface and used through evapo-transpiration for biomass generation. Some seep into the ground feeding natural aquifers. A major part appears in the river system downstream and is drained into seas. Water is recycled continuously through transpiration and evaporation from land, river systems and oceans, besides precipitation through condensation, rain and snow. Water on the earth is in motion through the hydrological cycle. The conflict between the growing human population and the unchanging supply of freshwater has already started and may get worse by the years to come.

According to the United Nation's World Water Development Report (2003), 70 per cent of the earth's surface is covered by water, but only 2.5 per cent of that water is fresh and a fraction of it i.e. 0.3 per cent of that water only is available for human use. Furthermore, pressures on this resource are growing. At the beginning of the 21st century, the Earth is facing a serious water crisis. This estimate reflects the impact of population growth alone. If per capita consumption of water resources continues to rise at its current rate, humankind could be using over 90 per cent of all available freshwater within 25 years, leaving just 10 per cent for all other organisms (UN/WWAP, 2003).

About 2 billion people in the developing countries of the world are not able to access safe drinking water today (Olson, 1999). Most of the indicators suggest that it is worsening and will continue to do so, unless corrective action is taken. According to WHO (2003) one billion people worldwide still lack adequate supply of clean

Drinking water and nearly two billion people do not get water for proper sanitation. In addition, the problem of water scarcity is not only its quality but also the quantity. For instance, pathogen contamination of aquatic ecosystems is known to occur from a range of sources including municipal wastewater effluents, agricultural wastes, and wildlife (Environment Canada, 2001) on hand and ever increasing demand for water from various competing sectors such as urban settlements, industry, irrigation, etc.

Wetlands

Wetlands are abundant in the region and support a rich array of waterbirds as well as providing habitats for breeding resident species. These include major staging and wintering grounds for waterbirds breeding in central and northern Asia. The region possesses a wide range of wetland types, distributed almost throughout, including mountain glacial lakes, freshwater and brakish marshes, large water-storage reservoirs, village tanks, saline flats and coastal mangroves and mudflats. A total of 23 of the subcontinent's wetland bird species are globally threatened.

Healthy lakes and their shores not only provide us with a number of environmental benefits but they influence our quality of life. Proper lake function can ease the impact of floods and droughts by storing large amounts of water and releasing it during shortages. Lakes also work to replenish groundwater, positively influence water quality of downstream watercourses, and preserve the biodiversity and habitat of the area. When the ecological puzzle pieces of a lake come together and the lake is able to work as it should, the big picture is clear, we all stand to benefit from this important resource.

MATERIALS AND METHODS

Study stations

Mysore is a city in the Indian state of Karnataka, and the administrative seat of Mysore District, one of the largest districts in Karnataka. Mysore was the former capital of the Kingdom of Mysore. Mysore is located at 770 m above sea level at 12.18° N 76.42° E and is 135 km from Bangalore, the state capital.

Mysore being one of the growing cities of Karnataka and it is so largely due to the presence of industrial resources and a well developed communication network. In recent decades industrialization has become main cause of city's growth. A large number of small medium and large scale industries exists in and around the Mysore city, including engineering, chemical, pharmaceutical, food, brewery, distillery, textile, steel and metal smelting. Mysore over the past decade has transformed itself into a destination for modern industries in the manufacturing service and Information and Technology sector.

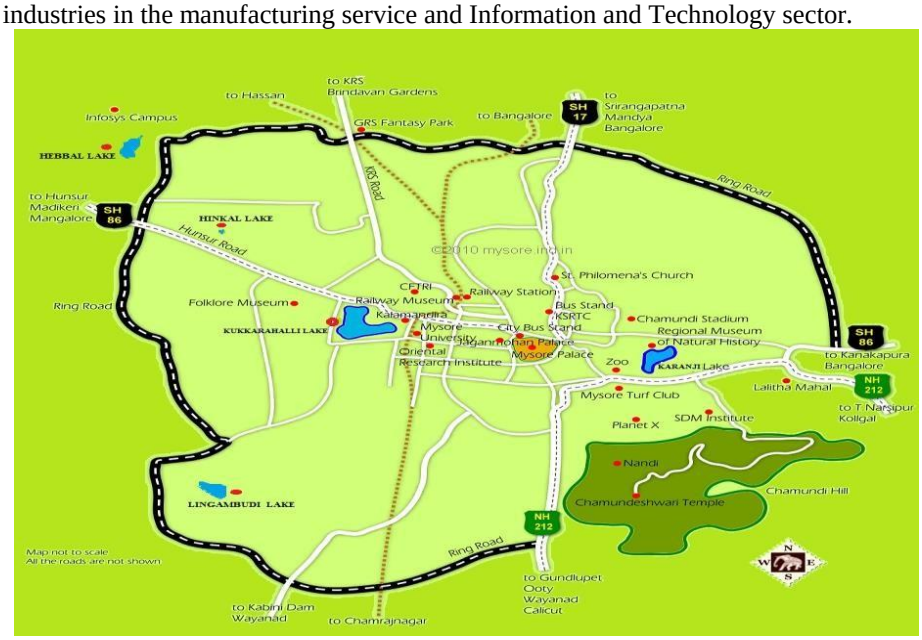

Figure 1: Location of selected lakes in Mysuru city

- **Station No 01: Kukkarali lake, Kukkaralli, Mysuru.**

  $12^0\ 18^1\ 27.9^1$ N

  $76^0\ 38^1\ 7.1^{11}$ E

- **Station No 02: Karanji lake, Sidhartha layout, Mysuru.**
  12^0 17^1 55.7^1 N
  76^0 40^1 9.8^{11} E
- **Station No 03: Hebbal lake, Hebbal, Mysuru.**
  12^0 21^1 30.9^1 N
  76^0 36^1 47.3^{11} E
- **Station No 04: Lingabuddi lake, Lingabudhi playa, Mysuru.**
  12^0 16^1 5.7^1 N
  76^0 36^1 46.1^{11} E
- **Station No 03: Hinkal lake, Hinkal, Mysuru.**
  12^0 19^1 53.5^1 N
  76^0 36^1 24.7^1 E

Water Sample Collection from Lakes

Water samples from each location of the sampling stations were collected during two seasons (Monsoon and Post-Monsoon) of 2014 in five litres capacity polyethylene cans. All the samples were transported to laboratory and stored at 4° C.

RESULTS AND DISCUSSIONS

In this section it deals with physic-chemical characteristics, lake structure study and bird diversity in the Kukkarahalli lake, Karanji lake, Lingambudi lake, Hebbal lake and Hinkle lake of Mysuru city.

Physico-chemical and Biological characteristics of lake water

All the techniques used were based on our goals in the sampling, techniques utilizing and the questions that we wants to have answered by the scientific and statistical analysis. The results of lake water characteristics are summarized and shown in Tables, All parameters are based on changeable water quality, like anthropogenic activities and natural phenomena. All the water quality is given separately as physico-chemical and biological parameters.

Table: 01. Physico-chemical characteristics of Kukkarahalli lake water sample

Sl.No	Parameters	Kukkarahalli			
		November	January	March	May
1	Colour	SG	SG	SG	SG
2	Temperature	27.5	25.5	26.4	26.1
3	pH	9.3	8.9	8.7	9.0
4	EC	1225	1110	640	610
5	Turbidity	106.3	84.6	90.0	92.1
6	TDS	785	682	426	395
7	TSS	175.2	150.2	162.1	132.1
8	DO	3.8	3.2	4.7	4.2
9	BOD	12	15	9.2	9.9
10	COD	49	32	68	55
11	Nitrate	0.49	0.22	0.48	0.46
12	Total nitrogen	2.96	3.48	3.84	2.86
13	Total phosphate	5.21	5.02	5.82	6.71
14	Sulphate	5.25	4.68	3.47	5.62

15	**Calcium**	92.18	68.14	96.19	88.70
16	**Magnesium**	220.36	300.18	118.3	129.7
17	**Total hardness**	760.60	986.02	778.6	750.6
18	**Sodium**	15.5	8.8	10.4	16.1
19	**Potassium**	21.5	12.6	13.0	21.0
20	**Chloride**	62.05	31.90	54.86	49.63

Table: 02. Physico-chemical characteristics of Karanji lake water sample

Sl.No.	**Parameters**	**Karanji**			
		November	**January**	**March**	**May**
1	**Colour**	PB	PB	PB	PB
2	**Temperature**	27.3	26.3	28.0	26.5
3	**pH**	9.1	8.7	7.7	9.2
4	**EC**	804	840	520	480
5	**Turbidity**	95.6	67.4	86.1	87.3
6	**TDS**	515	438	270	308
7	**TSS**	92.5	87.4	92.4	90.6
8	**DO**	8.2	8.2	8.4	8.1
9	**BOD**	6.1	2.3	2.4	2.0
10	**COD**	36	45	45	35
11	**Nitrate**	0.3	0.2	0.2	0.3
12	**Total nitrogen**	2.95	1.93	1.86	2.8
13	**Total phosphate**	6.55	3.58	4.23	5.23
14	**Sulphate**	4.85	5.18	3.18	4.66
15	**Calcium**	224.44	186.2	216.4	216.4
16	**Magnesium**	66.07	53.07	76.3	66.0
17	**Total hardness**	830.66	608.2	836.1	810.6
18	**Sodium**	7.0	3.3	4.6	5.6
19	**Potassium**	11.2	7.6	8.3	10.2

20	**Chloride**	51.40	60.26	138.25	44.31

Table: 03. Physico-chemical characteristics of Lingambudi lake water sample

Sl.No.	Parameters	Lingambudi			
		November	January	March	May
1	Colour	SB	SB	SB	SB
2	Temperature	24.0	27.4	26.4	22.1
3	pH	7.8	7.8	8.2	8.4
4	EC	956	990	820	585
5	Turbidity	61.2	52.1	49.6	53.1
6	TDS	612	562	365	375
7	TSS	**51.5**	55.4	47.3	50.6
8	DO	8.4	8.0	7.4	8.5
9	BOD	3.1	4.2	2.8	3.4
10	COD	54	38	51	53
11	Nitrate	0.60	0.46	0.7	0.66
12	Total nitrogen	2.96	1.96	2.8	2.86
13	Total phosphate	5.75	4.44	4.51	5.55
14	Sulphate	4.65	3.27	2.87	2.66
15	Calcium	300.6	250.6	218.1	292.5
16	Magnesium	95.71	85.4	167	56.3
17	Total hardness	980.78	881.46	583.2	960.7
18	Sodium	8.8	5.8	8.6	6.1

19	**Potassium**	12.8	10.7	13.2	11.0
20	**Chloride**	49.63	134.71	38.99	46.08

Table: 04. Physico-chemical characteristics of Hebbal lake water sample

Sl no	**Parameters**	**Hebbal**			
		November	**January**	**March**	**May**
1	**Colour**	**SB**	**CL**	**SB**	**SB**
2	**Temperature**	32.1	24.2	24.3	28.7
3	**pH**	8.5	8.2	7.5	8.6
4	**EC**	2305	880	1110	1920
5	**Turbidity**	85.5	60.1	74.1	89.0
6	**TDS**	1475	876	985	1230
7	**TSS**	45.1	30.4	111.4	40.0
8	**DO**	6.6	4.4	3.7	7.2
9	**BOD**	4.5	2.0	2.0	5.6
10	**COD**	74	50	68	71
11	**Nitrate**	0.68	0.70	0.56	0.66
12	**Total nitrogen**	3.50	2.28	3.48	3.80
13	**Total phosphate**	5.45	4.12	5.15	4.51
14	**Sulphate**	4.65	3.23	2.76	3.66
15	**Calcium**	248.29	187.1	96.19	256.5
16	**Magnesium**	116.52	86.4	52.3	63.6
17	**Total hardness**	999.72	631.7	938.6	900.7

18	**Sodium**	18.5	10.4	16.3	17.1
19	**Potassium**	23.5	18.6	18.0	25.0
20	**Chloride**	154.07	31.90	28.36	155.98

Table: 05. Physico-chemical characteristics of Hinkal lake water sample

Sl no	**Parameters**	**Hinkal**			
		November	**January**	**March**	**May**
1	**Colour**	**SB**	**SB**	**NA**	**SB**
2	**Temperature**	30.0	29.7	NA	26.7
3	**pH**	8.3	8.2	NA	8.6
4	**EC**	1025	1920	NA	590
5	**Turbidity**	45.1	22.3	NA	38.9
6	**TDS**	657	295	NA	378
7	**TSS**	135.5	45.6	NA	111.7
8	**DO**	7.1	8.3	NA	6.5
9	**BOD**	7.1	2.5	NA	3.2
10	**COD**	63	42	NA	62
11	**Nitrate**	0.6	0.8	NA	0.6
12	**Total nitrogen**	3.9	128	NA	3.80
13	**Total phosphate**	4.51	3.12	NA	4.51
14	**Sulphate**	3.56	4.02	NA	3.16
15	**Calcium**	468.93	163.2	NA	464.9
16	**Magnesium**	553.49	41.3	NA	303.5

17	**Total hardness**	2502.0	683.1	NA	2401.0
18	**Sodium**	9.1	14.0	NA	8.1
19	**Potassium**	13.1	23.0	NA	14.6
20	**Chloride**	74.45	56.72	NA	70.09

Results of Physico-chemical analysis

After collection of samples as per standard methods that mentioned earlier and raw results of water quality in during two seasons of November, January, March and May are presented in Table 01-05.

Temperature

The water temperature of a lake is very important, as many of the physical, biological, and chemical characteristics of lakes are directly affected by temperature. Most waterborne animal and plant life survives within a certain range of water temperatures, and few of them can tolerate extreme changes in this parameter. The water temperature is checked with a Digital thermometer at the sample site.

In the present study the temperature was recorded from a range of minimum of 22.1^0celcius and maximum of 30.0^0celcius.

pH

pH, an indicator of acidity is measure of water's ability to neutralize base and formulate a close relationship among carbonates and bicarbonates, calcium and free carbon dioxide. The hydrogen and hydroxide ions control variables in aqueous systems as they influence both physico-chemical and biological processes in the ecosystem.

In the present study pH ranged from minimum of 7.7 at Karanji lake during March, maximum of 9.3 at Kukkarahalli lake during November in the randomized lake sample.

Electrical conductivity

Electrical conductivity **(**EC**)** is used as a basic index to select the suitability of water for agricultural purposes. During the study period EC ranged from minimum of 480 at Karanji Lake in the month of May, maximum of 2305 at Hebbal lake in the month of November.

Turbidity

Turbidity is caused due to presence of suspended matter, clay silt, colloidal organic particles, plankton and other microscopic organisms. If water becomes too turbid, it loses the ability to support a wide variety of plants and other aquatic organisms. It is an expression of certain light scattering and light absorbing properties of water. It has significant effect on microbiological quality of drinking water and irrigation water.

The turbidity in the lake water sample ranged from minimum of 22.3NTU at Hinkal lake in January, maximum of 106.0NTU at Kukkarahalli lake in the November in all respected months in Mysuru city.

TDS

TDS is a measure of the solid materials dissolved in the water. This include salts, some organic materials, and a wide range of other materials from nutrients to toxic materials.

The water sample has TDS with minimum of 270 at Karanji lakein the month of March, maximum of 1475 at Hebbal lake in the month of November.

TSS

The Total Suspended Solids indicates the amount of solid suspended in water. High concentration of particulate matter can cause increased sedimentation and siltation in a stream.

During the study period, TSS ranged from minimum of 30.4mg/l at Hebbal lake in the month of January, maximum of 175.2mg/l at Kukkarahalli in the month of November.

DO

Dissolved oxygen is essential for the self-purification process in natural water systems. The dissolved oxygen level may indicate the effects of oxidisable wastes on receiving waters. It also indicates

the capacity of the natural body of water maintaining aquatic life. The oxygen dissolved in water may be derived from the atmosphere or from the photosynthetic activity of aquatic plants. Many times, the concentration of dissolved oxygen is depleted due to the pollution load and this renders the water usage table for consumption by living beings.

The DO ranged from minimum of 3.2mg/l at Kukkarahalli in January, maximum of 8.5mg/l at the Lingambudhi Lake in May.

BOD

The Biological oxygen demand is an empirical test used to determine the relative oxygen requirement of water and wastewater. BOD provides an estimate of how much biodegradable waste is present in the water. The biodegradable matter is usually composed of organic wastes, including leaves, manure and pollutants.

The collected water sample showed the BOD which ranged from minimum of 2.0mg/l at Karanji in the month of May, maximum of 15mg/l at Kukkarahalli in January in the analyzed water samples.

COD

In the environmental chemistry, the Chemical Oxygen Demand test is commonly used to indirectly measure the amount of organic compound in water. Most of the application of COD determine the amount of organic pollutants from surface water (lakes), making COD a useful measure of water quality.

During the study period COD ranged from minimum of 32mg/l at Kukkarahalli in the Month of January, maximum of 74mg/l at Hebbal in November.

Nitrite

The forms of nitrogen found in surface water are nitrates, nitrites, and ammonia. Ammonia is usually rapidly converted to nitrate in aerobic waters, as is true in soils (nitrate is a stable form of nitrogen, while ammonia is unstable). Ammonia is associated with municipal treatment discharges, and the stressing effects of ammonia on aquatic organisms, increase at low dissolved oxygen levels and at increased pH.

In the present study Nitrite is not observed in Hinkal lake only in the season of March, maximum of 0.8mg/l at Hinkal lake in January

Total Nitrogen

The total Nitrogen varied from minimum of 1.28mg/l at Hinkal lake in January, maximum of 3.90mg/l in November at Hinkal lake.

Total Phosphate

The Total Phosphate in the lake water sample ranged from minimum of 3.12mg/l at Hinkal Lake in the month of January, maximum of 6.71mg/l at Kukkarahalli lake in the month of may.

Sulphate

Sulphate is one of the major anions, which appear to be dominant in the aquatic system. The sulphate content in natural water is an important consideration in determining the quality of water. Sulphates in natural water system may find its origin both from natural such as leaching from rocks with deposition of gypsum, oxidation of organic materials from household origin as well as industrial sources.

The concentration of Sulphate was varied from minimum of 2.66mg/l at Lingambudi lake in may, maximum of 5.62mg/l at Kukkarahalli lake in may.

Calcium

During the study period the concentration of Calcium showed a range from minimum of 68.14mg/l at Kukkarahalli lake in the month of January, maximum of 468.93mg/l at Hinkal in the month of November.

Magnesium

Magnesium is one of two major constituents of hardness in water, which is found in minerals such as, magnetite and dolomite groups.

In the present study Magnesium ranged from minimum of 52.3mg/l at Hebbal lake in the month of march, maximum of 553.49mg/l at Hinkal lake in the month of November.

Total Hardness

Total hardness is one of the important constituents considered in accessing the potability of water. The hardness of water may be temporary or permanent. Temporary hardness is mainly due to the presence of bicarbonates of calcium and magnesium.

The Total Hardness was estimated and ranged from minimum of 583.02mg/l at Lingambudi lake in the month of march, maximum of 2502.02mg/l at Hinkal lake in November.

Sodium

The present investigation of quality of lake water showed the concentration of Sodium ranged from minimum of 3.3ppm at Karanji lake in January, maximum of 18.5ppm at Hebbal lake in the month of November.

Potassium

Potassium occurs in far lesser concentration in natural waters than calcium, magnesium and sodium. It behaves in the water as does sodium and is found in small amounts. It plays a vital role in the metabolism of fresh water environment and considered being an important macronutrient.

The quality of water is also depending on the concentration of potassium present in the sample. In the present investigation the Potassium ranged from minimum of 7.6 mg/L at Karanji lake in January, maximum of 25.0 mg/L at May.

Chloride

Chloride ion is generally present in natural waterand its presence can be attributed to the dissolution of salt deposits, discharges, irrigation drainage and contamination from refuge leachates. The salty taste produced bu chloride ion depends on chemical composition of the water (Kumara, 2002***)***

During the study period the Chloride ranged from minimum of 31.90mg/l at Kukkarahalli lake in January, maximum of 155.98mg/l at Hebbal lake in the month of may in all respective Seasons of 2014-15.

Variation in bird diversity and watershed areas

As a record of earlier, the quantity of land was comparatively larger than the present day. It is due to the growth and development of urbans/villages. In the meanwhile the birds population and bird species have also been studied according to the data obtained and field survey carried out during the present study, the **Egyptian vulture, Brown crake, Northern pintail, wooly necked stork** etc, species were lost their presence in the lakes and new **Asian paradise flycatcher, Indian pitta, Pheasant tailed jacana, stone curlew** etc species of birds were identified in the present day. It indicates that, the lost bird species may have sensitive to pollution and remaining bird species may resist the pollution. Hence, this can be called as pollution indicators of the nature.

Table: 06. New bird species sited in kukkarahalli lakes

Sl no	Bird species	Scientific name
1.	Alpine swift	*Apus melba*
2.	Ashy drongo	*Dicrurus leucophaeus*
3.	Asian brown flycatcher	*Muscicapa dauurace*
4.	Asian open bill stork	*Anastomus oscitans*
5.	Black headed oriole	*Oriolus xanthornus*
6.	Black naped oriole	*Oriolus chinensis*
7.	Black shouldered wood pecker	*Chrysocolaptes festivus*
8.	Blue capped rock thrush	*Monticola cinclorhynchus*
9.	Blue throat	*Luscinia svecica*
10	Brainfever bird	*Hierococcyx varius*
11	Brown hawk owl	*Ninox scutulata*
12	Common lesser white throat	*Sylvia curruca*
13	Common woodshrike	*Tephrodornis pondicerianus*
14	Crested serpent eagle	*Spilornis cheela*
15	Eurasian collared dove	*Streptopelia decaocto*
16	Eurasian eagle owl	*Bubo bubo*
17	Grey headed starling	*Sturnia malabarica*
18	Indian planative cuckoo	*Cacomantis merulinus*
19	Jerdon's bush lark	*Mirafra affinis*

20	Jerdon's chloropsis	*Chloropsis cochinchinensis*
21	Jungle bush quail	*Perdicula asiatica*
22	Lesser grey babbler	*Turdiobes malcolmi*
23	Lesser pied kingfisher	*Ceryle rudis*
24	Mottled wood owl	*Strix ocellata*
25	Oriental honey buzzard	*Pernis ptilorynchus*
26	Paddy field warbler	*Acrocephalus agricola*
27	Plain prinia	*Prinia inornata*
28	Rufous bellied babbler	*Dumetia hyperythra*
29	Small green billed malkoha	*Phaenicophaeus tristis*
30	Verditer flycathcher	*Eumyias thalassinus*
31	White browed bul bul	*Pyoluscnonotus luteolus*
32	White eyed buzzard	*Butastur teesa*
33	Wire tailed swallow	*Hirundo smithii*
34	Yellow wagtail	*Motacilla flava*
35	Yellow eyed babbler	*Chrysomma sinenses*
36	Yellow legged green pigeon	*Treron phoenicoptera*

Table: 07. Dissapered bird species of Kukkarahalli lake

Sl no	Bird species	Scientific name
1	Black backed yellow headed wagtail	*Motacilla flava*
2	Barn owl	*Tyto alba*
3	Black bellied tern	*Sterna acuticauda*
4	Brown flycatcher	*Muscicapa latirostris*
5	Chestnut bittern	*Ixobrychus cinnamomeus*
6	Chestnut headed bee eater	*Merops leschenaulti*
7	Chiff chaff	*Phylloscopus collybita*
8	Comb duck	*Sarkidiornis melanotos*
9	Common pochard	*Aythya ferina*
10	Common quail	*Coturnix coturnix*
11	Common red shank	*Tringa totanus*
12	Common snipe	*Gallinago gallinago*
13	Green shank	*Tringa nebularia*
14	Grey shrike	*Lanius excubitor*
15	Indian cuckoo	*Cuculus micropterus*
16	Indian little nightjar	*Caprimulgus asiaticus*
17	Indian robin	*Saxicoloides fulicatus*
18	Indian white backed vulture	*Gyps bengalensis*
19	Indian yellow legged button quail	*Turnix tanki*
20	Jack snipe	*Lymnocryptes minimus*
21	Kentish plover	*Charadrius alexandrinus*
22	Large cuckoo shrike	*Coracina macei*
23	Lesser adjutant stork	*Leptoptilos javanicus*
24	Little stint	*Calidris minuta*
25	Painted snipe	*Rostratula benghalensis*
26	Pied kingfisher	*Ceryle rudis*
27	Pintail duck	*Anas acuta*
28	Pintail snipe	*Gallinago stenura*
29	Red winged bush lark	*Mirafra erythroptera*
30	Shoveller	*Anas clypeata*
31	Stone curlew	*Burhinus grallarius*

32	Tawny eagle	*Aquila rapax*
33	Tawny pipit	*Anthus campestris*
34	Watercock	*Gallicrex cinerea*
35	White rumped munia	*Lonchura striata*
36	Wood shrike	*Tephrodornis pondicerianus*
37	Yellow bittern	*Ixobrychus sinensis*

Table: 08. New bird species sited in Karanji lake

Sl no	Bird species	Scientific name
1	Alpine swift	*Apus melba*
2	Asian paradise flycatcher	*Terpsiphone paradise*
3	Black-headed cuckoo shrike	*Coracina melanoptera*
4	Black-shouldered wood pecker	*Chrysocolaptes festivus*
5	Black-winged stilt	*Himantopus himantopus*
6	Booted warbler	*Hippolais caligata*
7	Brainfever bird	*Hierococcyx varius*
8	Brown headed gull	*Chroicocephalus brunnicephalus*
9	Brown shrike	*Anius cristatus*
10	Common greenshank	*Tringa guttiger*
11	Common lesser white throat	*Sylvia curruca*
12	Common teal	*Anas crecca*
13	Greater painted snipe	*Rostratula benghalensis*
14	Green sandpiper	*Tringa ochropus*
15	Greenish leaf warbler	*Phylloscopus trochiloides*
16	Grey headed starling	*Sturnia malabarica*
17	Indian great reed warbler	*Acrocephalus sterntoreus*
18	Indian pitta	*Pitta brachyuran*
19	Jerdon's bushlark	*Mirafra affinis*
20	Jerdon's chloropsis	*Chloropsis cochinchinensis*
21	Lesser golden backed woodpecker	*Dinopum benghalense*
22	Little brown dove	*Streptopelia senegalensis*
23	Little stint	*Calidris minuta*
24	Northern pintail	*Anas acuta*
25	Northern shoveller	*Anas clypeata*
26	Pheasant tailed jacana	*Hydrophasianus chirugus*
27	Pintail snipe	*Gallinago stenura*
28	River tern	*Sterna aurantia*
29	Rosy starling	*Sturnus roseus*
30	Ruddy breasted crake	*Porzna fusca*
31	Small green billed malkoha	*Phaenicophaeus tristis*
32	Stone curlew	*Burhinidae esacus*
33	Streaked fantail	*Rhipidura verreauxi*
34	Streaked weaver	*Ploceus manyar*
35	Western marsh harrier	*Circus aeruginosus*
36	Western reef egret	*Egretta gularis*
37	Whiskered tern	*Chlidonias hybridus*
38	White wagtail	*Motacilla alba*
39	Yellow legged green pigeon	*Treron phoenicoptera*

Table: 09. Dissapered bird species of Lingambudi Lake

Sl no	Bird species	Scientific name

1.	Black bellied tern	*Sterna acuticauda*
2.	Black tern	*Chlidonias niger*
3.	Black tailed godwit	*Limosa limosa*
4.	Booted eagle	*Hieraaetus pennatus*
5.	Brown crake	*Amaurornis akool*
6.	Brown headed gull	*Chroicocephalus brunnicephalus*
7.	Cinnamon bittern	*Ixobrychus cinnamomeus*
8.	Citrine wagtail	*Motacilla citreola*
9.	Common greenshank	*Tringa guttiger*
10	Common redshank	*Tringa tetanus*
11	Common stonechat	*Saxicola rubicola*
12	Egyptian vulture	*Neophron percnopterus*
13	Eurasian curlew	*Numenius arquata*
14	Eurasian wigeon	*Anas Penelope*
15	Green sandpiper	*Tringa ochropus*
16	Greenish leaf warbler	*Phylloscopus trochiloides*
17	Grey headed starling	*Sturnia malabarica*
18	Jerdon's bushlark	*Mirafra affinis*
19	Little brown dove	*Streptopelia senegalensis*
20	Mottled wood owl	*Strix ocellata*
21	Northern pintail	*Anas acuta*
22	Pied avocet	*Recurvirostra avosetta*
23	Oriental honey buzzard	*Pernis ptilorhynchus*
24	Pintail snipe	*Gallinago stenura*
25	River tern	*Sterna aurantia*
26	Ruddy breasted crake	*Porzna fusca*
27	Short toed snake eagle	*Circaetus gallicus*
28	Small pratincole	*Glareola lacteal*
29	Southern grey shrike	*Lanius meridionalis*
30	Streaked fantail	*Rhipidura verreauxi*
31	Tawny bellied babbler	*Dumetia hyperythra*
32	Tickell's leaf warbler	*Phylloscopus affinis*
33	Whiskered tern	*Chlidonias hybridus*
34	White eyed buzzard	*Butastur teesa*
35	Wooly necked stork	*Ciconia episcopus*
36	Yellow bittern	*Ixobrychus sinensis*
37	Yellow fronted pied woodpecker	*Dendrocopos mahrattensis*
38	Yellow throated sparrow	*Petronia xanthocollis*

Table: 10. New bird species sighted at Hebbal lake

Sl no	Bird species	Scientific name
1.	Blue faced malkoha	*Phaenicophaeus viridirostris*
2.	Common iora	*Aegithina tiphia*
3.	Grey wagtail	*Motacilla cinerea*
4.	Indian bush lark	*Mirafra erythroptera*
5.	Indian cormorant	*Phalacrocorax fuscicollis*
6.	Indian cuckoo	*Cuculus kundoo*
7.	Little stint	*Calidris minuta*
8.	Oriental skylark	*Alauda gulgula*
9.	Pale billed flowerpecker	*Dicaeum erythrorhynchos*

10.	Spot breasted fantail	*Rhipidura albogularis*
11.	Tricoloured munia	*Lonchura Malacca*
12.	White wagtail	*Motacilla alba*
13.	White browed fantail	*Rhipidura aureola*
14.	White browed wagtail	*Motacilla maderaspatensis*
15.	Wire tailed swallow	*Hirundo smithii*

Table:11. Disaapered bird species of Hebbal lake

Sl no	Bird species	Scientific name
1.	Asian brown flycatcher	*Muscicapa dauurace*
2.	Asian paradise flycatcher	*Terpsiphone paradise*
3.	Baillon's crake	*Porzana pusilla*
4.	Black headed munia	*Lonchura Malacca*
5.	Booted eagle	*Hieraaetus pennatus*
6.	Brahminy starling	*Sturnus pagodarum*
7.	Brainfever bird	*Hierococcyx varius*
8.	Brown shrike	*Anius cristatus*
9.	Cinerous tit	*Patus cinereus*
10	Common iora	*Aegithina tiphia*
11	Common greenshank	*Tringa guttiger*
12	Common kestrel	*Falco tinnunculus*
13	Common lesser white throat	*Sylvia curruca*
14	Common swallow	*Hirundo rustica*
15	Cotton teal	*Nettapus coromandelianus*
16	Greenish leaf bird	*Phylloscopus trochiloides*
17	Indian great reed warbler	*Acrocephalus sterntoreus*
18	Indian roller	*Coracias benghalensis*
19	Indian shag	*Phalacrocorax fuscicollis*
20	Indian spotted eagle	*Clanga hastate*
21	Large grey babbler	*Turdiobes melcolmi*
22	Large pied wagtail	*Motacilla maderaspatensis*
23	Lesser golden backed woodpecker	*Dinopum benghalense*
24	Pied crested cuckoo	*Clamator jacobinos*
25	Red munia	*Amandava amandava*
26	Ruddy breasted crake	*Porzna fusca*
27	Rufous backed shrike	*Lanius schach*
28	Short toed snake eagle	*Circaetus gallicus*
29	Spotted owlet	*Athene brama*
30	Streaked weaver	*Ploceus manyar*
31	Tickell's flowerpecker	*Dicaeum erythrorhynchos*
32	Western marsh harrier	*Circus aeruginosus*
33	White necked stork	*Ciconia episcopus*
34	White rumped munia	*Lonchura striata*
35	White throated fantail flycatcher	*Rhipidura albicollis*
36	White throated munia	White-throated Munia
37	Yellow eyed babbler	*Chrysomma sinenses*
38	Yellow wattled lapwing	*Vanellius malabaricus*

Water spread Area

Table: 12. Changes in the area of lakes water spread areas

Sl no	Name of the lake	Water spread area in 2001-02 (ha)	Independent catchment area in 2001-02 (Sq km)	Water spread area in 2001-02 (ha)	Independent catchment area in 2014-15 (Sq km)
1	**kukkarahalli**	183.58	30.08	173.18	29.27
2	**karanji**	161.43	22.34	154.09	18.48
3	**Hebbal**	132.76	18.26	124.38	15.17
4	**Lingambudi**	92.40	12.41	78.32	9.86
5	**Hinkal**	12.32	4.87	4.18	3.826

Source: Minor irrigation department

Conclusion

Healthy lakes and their shores not only provide us with a number of environmental benefits but they influence our quality of life. Proper lake function can ease the impact of floods and droughts by storing large amounts of water and releasing it during shortages. Lakes also work to replenish groundwater, positively influence water quality of downstream watercourses, and preserve the biodiversity and habitat of the area. When the ecological puzzle pieces of a lake come together and the lake is able to work as it should, the big picture is clear, we all stand to benefit from this important resource.

It is widely accepted that the number of water birds using a wetland site is a good indicator of that sites's biological importance and water bird counts have been especially influential in the identification of important wetlands. Bird counts can also provide vital evidence for the protection of wetlands should they become threatened. The waterspread area of the five lakes have been studied. As a record of earlier, the quantity of land was comparatively larger than the present day. It is due to the growth and development of urbans/villages. In the meanwhile the birds population and bird species have also been studied according to the data obtained and field survey carried out during the present study, the **Egyptian vulture, Brown crake, Northern pintail, wooly necked stork** etc, species were lost their presence in the lakes and new **Asian paradise flycatcher, Indian pitta, Pheasant tailed jacana, stone curlew** etc species of birds were identified in the present day. It indicates that, the lost bird species may have sensitive to pollution and remaining bird species may resist the pollution. Hence, this can be called as pollution indicators of the nature.

In the whole, the study of lakes, water catchment area, water quality and bird diversity may indicates the nature of pollution level. The interlinkage/bonding of all these parameters promotes the positive correlation one to another. In these aspects the limnology study reveals that, any lakes nature/pollution level should be determine by the study of water quality along with the natural bio indicators called bird diversity. Hence, the study of bird diversity is also a one of the major tool to identify the pollution level of any water body/lakes.

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