IMPACT OF URBANISATION ON LAKES – A CASE STUDY

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ABSTRACT

This paper describes the studies conducted on the impact of urban development of lakes in Bangalore City. The study investigates the impact of urbanisation on the bird life, aquatic life, reduction of green cover, shrinkage of the water bodied due to encroachments and the study is supported by the limnological characteristics of lakes . For the studies three lakes in Bangalore City namely Puttenahalli Lake in southern Bangalore with a water spread of 13 acres, Yediyur Lake in central Bangalore with a water spread of 15acresand Sankey Lake in northern Bangalore with a water spread of 15 acres. There was a marked reduction in the bird life over the years .The aquatic life in all the lakes was tapering over the years. The satellite imagery of the lakes supported by ground truth checking indicated marked reduction in the water spread. A survey of the existing industries and their nuisance value has been recorded. Water quality analysis indicated marked increasein the sulphate content in all the lake samples,high pH values indicating excess alkalinity in Yediyur Lake and Sankey Tank and excess levels of turbidity reported from all the three lakes under study. High levels of heavy metals like Chromium and Nickel reported from the lakes beyond the permissible levels.All the lakes had high level of pathogenic organisms as demonstrated by the biological analysis. Suitable remedial measures and methods to control pollution has been recommended.

Keywords-Distress, Impact, Limnology, Urban Development, Water Quality

I. INTRODUCTION

Bangalore, capital of the State of Karnataka (South India), is situated on the Deccan Plateau at an altitude of 920m. Traditionally known as the "city of lakes", Bangalore used to enjoy, till recently, a pleasant and salubrious climate with pure air, due not only to its altitude but also to its numerous green spaces and famous lakes.Water bodies in Bangalore are either natural lakes, man- made lakes or tanks which have been built from the 16th century to meet the water requirements of the population. These lakes are still used by poor sections of the population for both domestic needs (bath and cloth washing) and livelihood activities like agriculture (irrigation), livestock, fishing or commercial washing (dhobi).The lakes help reducing temperature, reducing pollution , prevents flooding , raises the level of groundwater , provides an habitat for aquatic life, supplies drinking water, provides long space and is a source of recreation.

The disappearance of Bangalore's lakes started in the 80s but has sped up with rapid urbanisation. While in 1961 there were 262 lakes, official statistics today mention 117 lakes, but only 33 lakes are still more or less visible on satellite imagery.The current status of the lakes in Bangakore is that 13lakes have been dried up and leased by the government, 60 lakes are in the advance stage of detoriation,, 28 lakes have been breached by the

Bangalore Development Authority (BDA) for forming extensions and creating public utilities and house sites for the general public, 7 lakes are recognizable as small pools of water and 4 lakes have been fully encroached..

Over the last decades, lakes have been rented to private constructors. The authorities themselves have built their own infrastructures on lakebeds whereas other areas have been illegally encroached upon. Previous lakes have thus been transformed into residential and commercial areas, universities, bus stands, stadium or golf course. Some lakes are now used as rubbish dump for domestic and industrial wastes or open sewage. Fourteen percent of them are surrounded by slums.

The rapid growth of human population, proliferation of buildings ,roads and vehicular traffic congestion has taken a heavy toll on Bangalore's lakes. Further encroachment, illegal waste disposal activities and bad management have threatened the very existence of many of the valuable and productive lakes in the city.

II. STUDY AREA

Fig1: Map Of Bangalore Showing The Three Lakes Under Study

PuttenahalliLake is located in South Bangalore having the co-ordinates 12°53'N and 77°35'E. The total area of the lake is 13 acres 25 guntas.The total lake periphery of the lake is 1000m. The catchment area of the lake is 0.23sq.km. The primary inflow into the lake include runoff from urbanised parts mixed with little domestic sewage. The maximum depth of water in the lake was found to be 6.2m.

YediyurLake has co-ordinates 12° 53'N and 77° 34'E. The total area of the lake is 15 acres 23 guntas. The primary inflow into the lake include storm water and runoff from urbanised parts mixed with domestic sewage. The maximum depth of water in the lake was found to be 7.8m.

Sankey Lake is located innorthern Bangalore having coordinates 13°01'N and 77°57'E . The lake type is fresh water. The total catchment area of the lake is 1.254km and surface area is 15 hectres. The primary inflow into the lake is from the rainfall and city drainage. The maximum depth of water in the lake is 9.26m, shore length is 1.7km and paved walkway 1.42km. The volume of the waterbodyis estimated to be 1015680MLD at maximum depth.

III. ANALYSIS

With regard to pH, 57% of the samples in PuttenahalliLake were in the range of 6 to 6.5 and 43% of the samples had pH ranging from 6.5 to 7.86. 42 % of the samples had a pH less than the permissible limits and 58% of the samples were within the permissible limits.

With regard to pH,77% of the samples in YediyurLake were in the range of 7.4 to 7.8 and 23% of the samples were in the range of 7.9 to 8.36. All the samples had pH within the permissible limits.

With regard to pH,71% of samples in SankeyTank were in the range of 7.8-8 and 29% of the samples were in the range of 8.1 to 8.23.All the samples had pH within the permissible limits

With regard to Turbidity, 42% of the samples in PuttenahalliLake were in the range of 5 to 7 NTU and 58% of the samples had turbidity ranging from 8 to 11NTU. 11% of the samples had Turbidity equal to the permissible limit and 89% of the samples had turbidity greater than the permissible limits.

With regard to Turbidity, 55% of the samples in YediyurLake were in the range of 16 to 20 NTU and 45% of the samples had turbidity ranging from 21 to 27 NTU. The turbidity of all the samples was above the permissible limits.

With regard to Turbidity, 57% of the samples in SankeyTank were in the range of 28 to 32 NTU and 43% of the samples had turbidity ranging from 33 to 38 NTU. The turbidity of all the samples was above the permissible limits.

With regard to Alkalinity, 71% of the samples in PuttenahalliLake were in the range of 600 to 640 mg/l and29% of the samples had alkalinity ranging from 641 to772 mg/l. The alkalinity of all the samples was above the permissible limits.

With regard to Alkalinity, 44% of the samples in YediyurLake were in the range of 320 to 350 mg/l and 46% of the samples had alkalinity ranging from 351 to 400 mg/l. The alkalinity of all the samples was above the permissible limits.

With regard to Alkalinity, 57% of the samples in SankeyTank were in the range of 400 to 425 mg/l and 43% of the samples had alkalinity ranging from 430 to 452 mg/l The alkalinity of all the samples was above the permissible limits.

With regard to total hardness, 86% of the samples in PuttenahalliLake were in the range of 180 to 200 mg/l and14% of the samples had total hardness ranging from 201 to 272 mg/l. The total hardness of all the samples were within the permissible limits.

With regard to total hardness,44% of the samples in YediyurLake were in the range of 90 to 110 mg/l and 56% of the samples had total hardness ranging from 120 to 132 mg/l. The total hardness of all the samples was found to be within the permissible limits.

With regard to total hardness,57% of the samples in SankeyTank were in the range of 90 to 110 mg/l and 43% of the samples had total hardness ranging from 120 to 164 mg/l. The total hardness of all the samples was found to be within the permissible limits.

With regard to calcium hardness, 71% of the samples in PuttenahalliLake were in the range of 150 to 160 mg/l and 29% of the samples had total hardness ranging from 175 to 196 mg/l. The total hardness of all the samples was above the permissible limits.

With regard to calcium hardness, 45% of the samples in YediyurLake were in the range of 65 to 75 mg/l and 55% of the samples had total hardness ranging from 80 to 90mg/l.45% of the samples have calcium hardness within the permissible limits and 55% of the samples have calcium hardness above the permissible limits.

With regard to calcium hardness, 71% of the samples in SankeyTank were in the range of 85 to and 100 mg/l and 29% of the samples had total hardness ranging from 101 to 104 mg/l. The calcium hardness of all the samples was above the permissible limits.

With regard to chlorides, 85% of the samples in PuttenahalliLake were in the range of 100 to120 mg/l and 15% of the samples had chlorides ranging from 120 to 130 mg/l. The chloride content of all the samples was found to be within permissible limits.

With regard to chlorides, 33% of the samples inYediyurLake were in the range of 65 to 75 mg/l and 67% of the samples had chlorides ranging from 84 to 92 mg/l. The chloride content of all the samples was found to be within permissible limits.

With regard to chlorides, 28% of the samples inSankeyTank were in the range of 55 to 60 mg/l and 72% of the samples had chlorides ranging from 61 to 69.88 mg/l. The chloride content of all the samples was found to be within permissible limits.

With regard to DO, 57% of the samples in PuttenahalliLake were in the range of 3.9 to 5 mg/l and 43% of the samples had DO ranging from 5.8 to 6.3 mg/l. 14% of the samples have DO less than the permissible limit, 14% of the samples have DO equal to the permissible limits and 72% of the samples had DO greater than the permissible limits.

With regard to DO,55% of the samples inYediyurLake were in the range of 6.5 to 7 mg/l and 45% of the samples had DO ranging from 7.1 to 7.4 mg/l. The DO content of all the samples was found to be above the permissible limits.

With regard to DO,71% of the samples in SankeyTank were in the range of 6.5 to 7 mg/l and 29% of the samples had DO ranging from 7.1 to 7.3 mg/l. The DO content of all the samples was found to be above the permissible limits.

With regard to nitrates, 43% of the samples in PuttenahalliLake were in the range of 10 to 14 mg/l and 57% of the samples had nitrates ranging from 14.1 to 19.4 mg/l. The nitrate content of all the samples was found to be within permissible limits.

With regard to nitrates, 44% of the samples in YediyurLake were in the range of 5 to 8 mg/l and 56% of the samples had nitrates ranging from 8.1 to 10.4mg/l. The nitrate content of all the samples was found to be within permissible limits.

With regard to nitrates, 71% of the samples in SankeyTank were in the range of 8.5 to 8.9 mg/l and 29% of the samples had nitrates ranging from 9 to 9.96mg/l. The nitrate content of all the samples was found to be within permissible limits.

With regard to sulphates, 71% of the samples in PuttenahalliLake were in the range of 185 to 200 mg/l and 29% of the samples had nitrates ranging from 201 to 215.05 mg/l. The sulphate content of 71% of the samples was found to be within permissible limits and 29% samples had sulphate content greater than the permissible limits.

With regard to sulphates, 44% of the samples in YediyurLake were in the range of 180 to 200 mg/l and 56% of the samples had nitrates ranging from 210 to 236.05 mg/l. The sulphate content of 44% of the samples was found to be within permissible limits and 56% samples had sulphate content greater than the permissible limits.

With regard to sulphates, 43% of the samples in SankeyTank were in the range of 176 to 190 mg/l and 57% of the samples had sulphates ranging from 210 to 275 mg/l. The sulphate content of 43% of the samples was found to be within permissible limits and 57% samples had sulphate content greater than the permissible limits.

With regard to iron, 85% of the samples in PuttenahalliLake were in the range of 0.1 to 0.15 mg/l and 15% of the samples had chlorides ranging from 0.16 to 0.18 mg/l. The iron content of all the samples was found to be within permissible limits.

With regard to iron, 66% of the samples in YediyurLake were in the range of 0.1 to 0.13 mg/l and 34% of the samples had chlorides ranging from 0.14 to 0.16 mg/l. The iron content of all the samples was found to be within permissible limits.

With regard to iron, 43% of the samples in SankeyTank were in the range of 0.11 to 0.15 mg/l and 57% of the samples had chlorides ranging from 0.16 to 0.21 mg/l. The iron content of all the samples was found to be within permissible limits.

With regard to copper, 85% of the samples in PuttenahalliLake were in the range of 0.02 to 0.05 mg/l and 15% of the samples had chlorides ranging from 0.05 to 0.06 mg/l. The copper content of 85% of the samples was found to be within permissible limits and 15% samples had sulphate content greater than the permissible limits.

With regard to copper, 89% of the samples in YediyurLake were in the range of 0.01 to 0.05 mg/l and 15% of the samples had chlorides ranging from 0.05 to 0.07 mg/l. The copper content of 88% of the samples was found to be within permissible limits and 12% samples had sulphate content greater than the permissible limits.

With regard to copper, 57% of the samples in SankeyTank were in the range of 0.03 to 0.04 mg/l and 43% of the samples had chlorides ranging from 0.04 to 0.05 mg/l. The copper content of all the samples was found to be within permissible limits.

With regard to nickel,71% of the samples in PuttenahalliLake were in the range of 0.02 to 0.03 mg/l and 29% of the samples had nickel ranging from 0.03 to 0.04 mg/l. The nickel content of 14% of the samples was found to be within the permissible limits and 86% of samples had nickel content greater than the permissible limits.

With regard to nickel, 78% of the samples in YediyurLake were in the range of 0.04 to 0.05 mg/l and 22% of the samples had nickel ranging from 0.05 to 0.06 mg/l. The nickel content of all the samples was found to be above the permissible limits.

With regard to nickel,43% of the samples in SankeyTank were in the range of 0.01 to 0.02 mg/l and 57% of the samples had nickel ranging from 0.03 to 0.04 mg/l. The nickel content of 43% of the samples was found to be within the permissible limits and 57% of the samples had nickel content above the permissible limits.

With regard to chromium, 86% of the samples in PuttenahalliLake were in the range of 0.02 to 0.04 mg/l and 14% of the samples had chromium ranging from 0.0 4to 0.05 mg/l. The chromium content of all the samples was found to be within the permissible limits.

With regard to chromium, 89% of the samples in YediyurLake were in the range of 0.03 to 0.04 mg/l and 11% of the samples had chromium ranging from 0.04to 0.05 mg/l. The chromium content of all the samples was found to be within the permissible limits.

With regard to chromium, 29% of the samples in SankeyTank were in the range of 0.03 to 0.04 mg/l and 11% of the samples had chromium ranging from 0.05 to 0.06 mg/l. The chromium content of 86% of the samples were found to be within the permissible limits and 14% of the samples had chromium content above the permissible limits.

With regard to MPN,43% of the samples in PuttenahalliLake were in the range of 10 to12 per 100 ml and the remaining 57% of the samples had MPN ranging from 14 to 18 per 100 ml. The MPN of 14% of the samples were found to be within the permissible limits and the remaining 86% of the samples had MPN above the permissible limits.

IV. DISCUSSION

With regard to MPN,33% of the samples in YediyurLake were in the range of 9 to12 per 100 ml and the remaining 67% of the samples had MPN ranging from 13 to 15 per 100 ml. The MPN of 22% of the samples were found to be within the permissible limits and the remaining 78% of the samples had MPN above the permissible limits.

With regard to MPN,57% of the samples in SankeyTank were in the range of 9 to14 per 100 ml and the remaining 43% of the samples had MPN ranging from 14 to 17 per 100 ml. The MPN of 14% of the samples were found to be within the permissible limits and the remaining 86% of the samples had MPN above the permissible limits.

According to LakmanRau report (1981), PuttenahalliLake has a water spread of 13 acres,Government records (1994) show the actual water spread as 11.76 acres and from satellite images (1997) we see that 9.5% of the water spread has been encroached.

According to LakmanRau report (1981) , YediyurLake has a water spread of 6 acres,Government records (1994) show the actual water spread as 5.8 acres and from satellite images (1997) we see that 3.2% of the water spread has been encroached.

According to LakmanRau report (1981) , SankeyTank has a water spread of 15 acres,Government records (1994) show the actual water spread as13.77 acres and from satellite images (1997) we see that 8.2% of the water spread has been encroached.

The existing bird life in PuttenahalliLake include Painted Storks, Asian Openbill Storks, Purple Herons, Black-crowned Night Herons, Pond Herons, Darters, Cattle Egret, Little Egret, Eurasian Spoonbills, Little Grebe, Spot billed Pelican, Spot-billed Ducks, Little Cormorant, Common Sandpiper, Purple Moorhen.

Over the last few years , a lot of bird species have disappeared from PuttenahlliLake .These birds include - Common Coot, Pintail Snipe Common Snipe Wood Sandpiper Greater Painted Snipe Pheasant-tailed Jacana . Bronze-winged Jacana . Little Grebe .

The existing bird life in YediyurLake includeSpot billed Pelican, Spot-billed Ducks, Little Cormorant, Common Sandpiper, Purple Moorhen.

The bird species which have disappeared from YediyurLake over the years include Common Coot . Pintail Snipe Common Snipe ,Wood Sandpiper Greater Painted Snipe , Pheasant-tailed Jacana Bronze-winged Jacana , Little Grebe.

The existing bird life in SankeyTank includeNight Herons, Pond Herons, Darters, Cattle Egret, Little Egret, Eurasian Spoonbills, Little Grebe.

The bird species which have disappeared from SankeyTank over the years include White-throated Kingfisher . White-breasted Waterhen Brown Crake Baillon's Crake Ruddy-breasted Crake Slaty-breasted Rail.

The aquatic life in PuttenahalliLake include White-throated Kingfisher . White-breasted Waterhen Brown Crake Baillon's Crake Ruddy-breasted Crake Slaty-breasted Rail.

The aquatic life which has disappeared from PuttenahlliLake include Murrels (Channamarulius), Catfishes (Heteropneustesfossilis), small palaemonid prawns.

The aquatic life in YediyurLake includeCommon carp, Grass carp, Katla, Rohu.

The aquatic life which has disappeared fromYediyurLake include Govankar,Rahu,MurgalKamankar/Labeorohita.

The aquatic life in SankeyTank include Etroplussuratensis, Murrels (Channamarulius), Catfishes (Heteropneustesfossilis), small palaemonid prawns.

The disappeared aquatic life in Sankey Tank includeEutroplussuratensis, Chandaranga, Puntius sp., Nandusnandus and Amblypharyngodonmola.

The sediment analysis of Puttenahalli Lake showedthat pH was 6.90, normal conductivity was 0.09 milli mhos/cm, low available phosphorus (2.068 kg/acre) , low available potassium (19.5 kg/acre), lead quantity was 0.67 ppm, soil lead content was 0.58 ppm and cadmium was 0.08 ppm.

The sediment analysis of Yediyur Lake showed that pH was 7.90,normal conductivity was 0.04 milli mhos/cm, low available phosphorus (1.068 kg/acre), low available potassium (17.5 kg/acre), lead quantity was 0.47 ppm, soil lead content was 0.63 ppm and cadmium content was 0.03 ppm.

The sediment analysis of Sankey Tank showed that pH was 5.90, normal conductivity was 0.07 milli mhos/cm, low available phosphorus (3.068 kg/acre), low available potassium (17.5 kg/acre), lead quantity was 0.47 ppm, soil lead content was 0.55 ppm and cadmium content was 0.05 ppm.

The limnological study of Puttenahalli Lake showed that water temperature was 28°C, water transparency was 29 cm, free carbon di-oxide (FCO2) generally absent, water ph was 6.683 (avg: average) and 0.500 (Sd: standard deviation), water conductivity was 0.597 (avg) and 0.09 (Sd) milli mhos/cm. dissolved oxygen (DO) 1.6 mg/land an average of 2.025 (Sd:0.076) mg/lit during the period of fish-kill, nitrite and nitrate revealed 0.329 (avg) and 0.044 (Sd) and 1.074 (avg) and 0.387 (Sd) mg/lit; Phosphorous was 5.155 (avg) and 3.825 (Sd) mg/lit.

The limnological study of Yediyur Lakeshowed that water temperature was 28°C, water transparency was 27 cm, free carbon di-oxide (FCO2) generally absent, water ph was 6.533 (avg: average) and 0.600 (Sd: standard deviation), water conductivity 0.497 (avg) and 0..06 (Sd) milli mhos/cm. dissolved oxygen (DO)2.1mg/land an average of 2.056 (Sd:0.086) mg/lit during the period of fish-kill, nitrite and nitrate revealed 0.429 (avg) and 0.064 (Sd) and 1.056 (avg) and 0.265 (Sd) mg/lit; Phosphorous was 4.355 (avg) and 4.625 (Sd) mg/lit.

The limnological study of Sankey Tank showed that water temperature was 28°C, water transparency was 31 cm, free carbon di-oxide (FCO2) generally absent, water ph was 7.683 (avg: average) and 0.570 (Sd: standard deviation), water conductivity was 0.397 (avg) and 0.07 (Sd) milli mhos/cm ,dissolved oxygen (DO) was 2.6 mg/land an average of 3.025 (Sd:0.076) mg/lit during the period of fish-kill, nitrite and nitrate revealed was 0.229 (avg) and 0.054 (Sd) and 1.374 (avg) and 0.477 (Sd) mg/lit; Phosphorous was 7.055 (avg) and 2.925 (Sd) mg/lit.

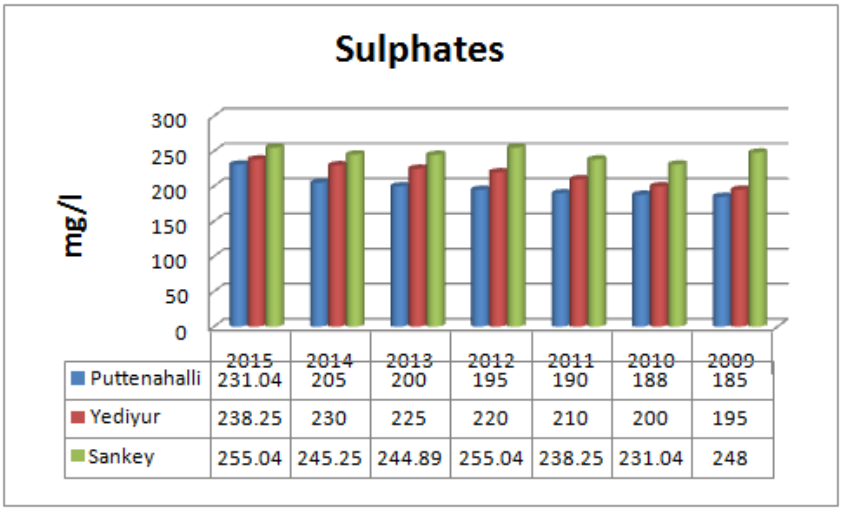
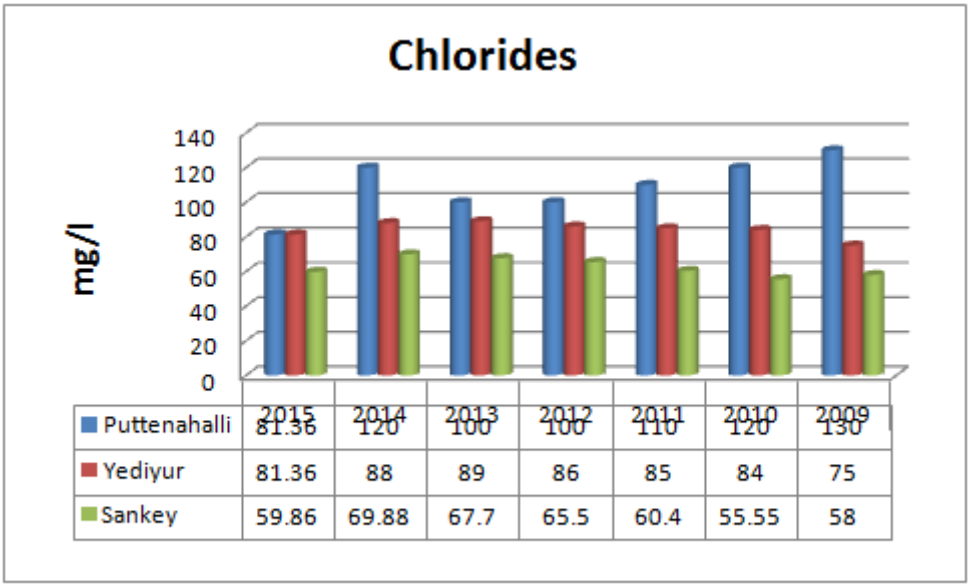
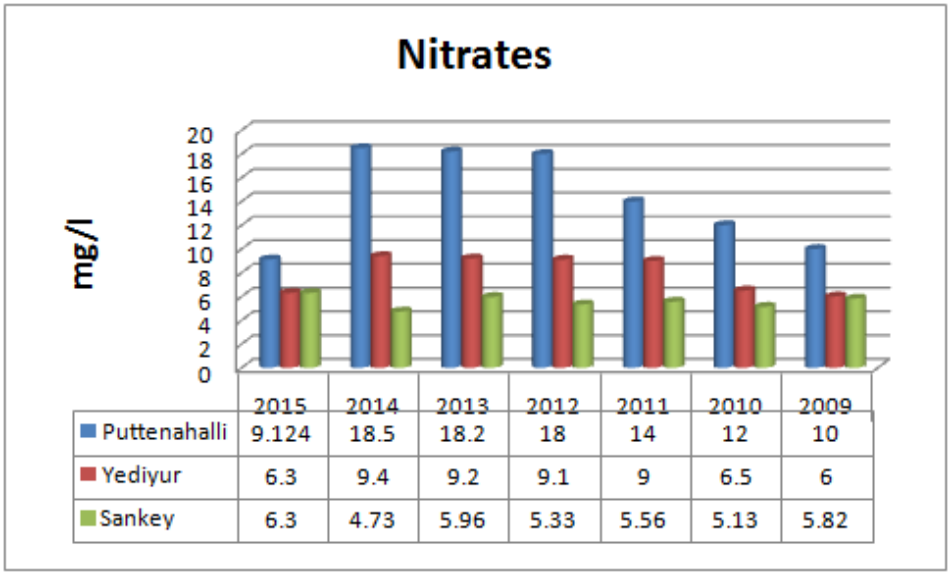


Fig2: The Graph Shows the Variation of Sulphates in All 3 Lakes



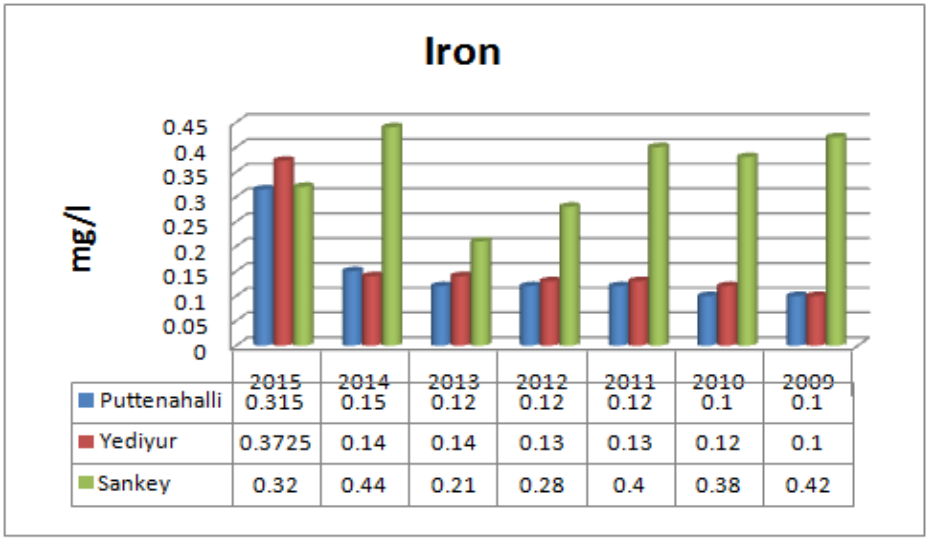
	2015	2014	2013	2012	2011	2010	2009
Puttenahalli	81.36	120	100	100	110	120	130
Yediyur	81.36	88	89	86	85	84	75
Sankey	59.86	69.88	67.7	65.5	60.4	55.55	58

Fig3: The Graph Shows the Variation of Chlorides in All 3 Lakes



	2015	2014	2013	2012	2011	2010	2009
Puttenahalli	9.124	18.5	18.2	18	14	12	10
Yediyur	6.3	9.4	9.2	9.1	9	6.5	6
Sankey	6.3	4.73	5.96	5.33	5.56	5.13	5.82

Fig4: The Graph Shows the Variation of Nitrates in All 3 Lakes



	2015	2014	2013	2012	2011	2010	2009
Puttenahalli	0.315	0.15	0.12	0.12	0.12	0.1	0.1
Yediyur	0.3725	0.14	0.14	0.13	0.13	0.12	0.1
Sankey	0.32	0.44	0.21	0.28	0.4	0.38	0.42

Fig5: The Graph Shows the Variation of Iron in All 3 Lakes

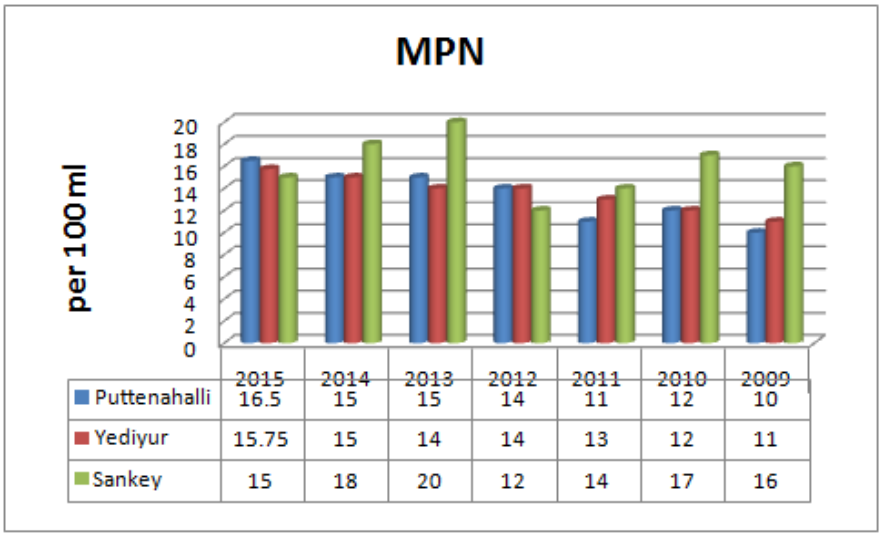


Fig6: The Graph Shows the Variation of MPN in All 3 Lakes

V. CONCLUSIONS

All the three lakes have detoriated in water quality and limnological parameters. All the lakes have suffered disappearance of bird species and extinction of aquatic life. Lake preservation has to be integral to layout development by the concerned authorities. Lake areas should not be diverted for any other purpose. Lake areas to be surveyed and encroachments to be removed. Core operations like survey, fencing, watch and ward, clearing of blocked and encroached main drains and lateral drains. Desilting of lakes to the extent absolutely required to be taken. Desilting should also be minimized to remove only sludge portion with minimum depth near fore shore area reaching maximum at the bund. The entry of untreated sewage into the lakes should be restricted. The present norm of 30m buffer surrounding the legal boundary of lakes is a must to preserve lakes. The effective lake area should not be reduced by converting lake areas intoparks, children's playground, etc.Lake restoration is to be taken up based on lake series/ subseries and not in isolation to have betterresults and impacts. Lakes may bepreserved with minimum disturbance in the area and may be notified under Wetland (Conservation and Management) Rules 2010.Selected lakes to be developed for augmenting water supply to the city.Lake Management Committees should be constituted.

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