Documentation of pollution status, ecological state and fishing activity in the Lakes of Bangalore

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Abstract

The documentation and investigative study is based on the pollution status, ecological state and fishing activity in surveyed Lakes of Bangalore. The 14 Lakes form different series of Bangalore were documented. The pollution status of these Lakes was categorized into 5 divisions like highly polluted, polluted, eutrophicated, restored and under restoration process. The physico-chemical parameters like BOD, COD, DO, pH, temperature and turbidity were analysed. Fishing activity signifies the socio-economic status of localities which is threatened due to heavy pollution. The avi- faunal diversity was also observed in lake area, which basically shows the ecological state of those. The anthropogenic activity aroused by urbanization and industrialization is the main cause of pollution and which ultimately causes the loss of biodiversity.

Keywords: Turbidity, Eutrophication, Physico-chemical parameter, Restoration, Seechi Disc

1. Introduction

The city Bangalore used to be known as city of Lakes. Several tanks and lakes were constructed to impound the run-off water for future better purpose. Lakes are highly valued for their recreational aesthetic and scenic qualities and the water they contain is one of the most treasured of natural resources. Lakes provide an important habitat and food resources for a diverse array of fish and other aquatic life. Due to rapid urbanization and industrialization, the sewage and industrial effluents enter into the lake, which causes the degradation of ecological status of lake. Studies revealed 35% decrease in number of water bodies during 1973-1996 (Deepa *et. al*. 1998) nearly 30% of lakes are used for irrigation fishing was being carried out in 25% of lakesand only 3% were observedfor drinking purpose (Krishna M.B. *et. al., 1996*). The quantity of physical, chemical and biological parameters serves as good index in providing complete and reliable picture of the condition prevailing in a water body (Mishra *et. al*, 1999). Looking at the present scenario it becomes important to monitor and document the status of the present lakes of Bangalore. During 1985, the Govt. of Karnataka constituted an expert committee headed by Sri N. Lakhsman Rau to examine all the aspects of preservation and restoration of existing tanks in Bangalore. The joint legislature committee set up under the chairmanship of Sri Ramaswamy to identify the encroachment of lake areas in Bangalore urban districts (2007). According to Moudgul and Chandra (2012) as many as 12 lakes were entrusted to the BDA. Apart from all the efforts, the current scenario of a no. of lakes is very poor which needs to be monitored.

2. Materials and methods

2.1 Water Sampling:

The water sample were collected from the different lakes in water sampling bottles and taken to the labs for the estimation of various physical and chemical parameters. The samples were collected between 9 - 10.30 am and the temp was noted down. The

Physical parameter such as pH and turbidity and chemical parameters such as COD, BOD and DO were estimated following the standard methods prescribed by APHA *et al.,* (1995).

2.2 Water Sampling Analysis:

Physical and Chemical parameters:
i. Temperature and pH
Temperature is accessed with a help of thermometer and pH by pH paper or pH meter.
ii. Turbidity
To access the water quality turbidity or transparency also an important factor, can be analysed with the help of Secchi disc. Secchi Disc used for turbidity: Secchi Disc is used by lowering it into the water with the help of a graduated rope. It is a method for measuring of light

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penetration in water. The two general groups for eg. Limit of visibility rate and light penetrate can be estimated. The lowering of disc into the water noting the depth when it disappear and then lifting the disc noting the depth at which it reappears and the average of these two reading is considered to be limit of visibility and calculated by the help of formula.

Formula: A+B /2= turbidity of water measured in NTU
Where A = Depth of water where the disc just disappear.
B = Depth of water where the disc just reappear.

iii. Chemical Oxygen Demand

50 ml of water sample was taken in a clean conical flask. 5ml of KMnO4 was added and heated in water bath (620 C) and cooled it for 10 mins. Later 5ml of KI solution was added, followed by 10 ml of 2M H2SO4. 35ml of this solution was taken and titrated against 0.1 M Sodium Thiosulphate until appearance of pale yellow colour. Few drops of starch solution were added and blue colour appeared. This was titrated until the disappearance of blue colour. The titrate reading was noted and COD was calculated with the help of following formula:

COD = [8× C (A – B) × 0.23]/S
Where C = conc. Of titrant
S = vol. of sample
A = titrant used for blank.
B = titrant used for sample.

iv. Biological Oxygen Demand

The water samples are brought to the lab, different dilution of the unfiltered water samples were prepared in BOD bottles (300ml capacity) by adding dilution water two sets for each dilution are prepared. Initial dissolved oxygen was determined in the first set of BOD bottles and the second set was kept for incubation in BOD incubator at 20^0 C for 5 days. After 5 days the bottle from the BOD incubator was removed and the dissolved oxygen from the incubated set of bottles were determine and the readings were noted.

v. Dissolved Oxygen

The DO content in water sample was estimated by using the light and dark bottle method. A bottle of known volume was taken and it was filled water sample. 1ml of Manganous sulphate and 1ml of alkaline iodide were added and content was mixed well. The bottle was transferred to the dark place. After 15 minutes the ppt was formed. Then 1ml of conc. Sulphuric acid was added to dissolve the precipitate. 25 ml of this water sample was taken in a conical flask and 1ml of starch solution was added. Blue color appeared. The blue coloured sample was titrated against sodium thiosulphate (0.025N) solution until the disappearance of blue color. The oxygen content was determined by using the following formula.

Oxygen=K*200*U*O.698/volume of sample) mg/L
K= vol. Of bottle/vol. Of bottle-vol. of reagent used
V=volume of water sample taken
U= vol. Of sodium thiosulphate used for titration

vi. Total Alkalinity

Total alkalinity was measured by phenolophthalein and methyl orange alkalinity.
OH- and ½ CO3 -were measured by the phenolphthalein

alkalinity. 100ml of water sample is taken in a flask and 5 to 6 drops of phenopthalein were added. Pink colour appeared and it was titrated with acid till pink colour disappears. The P was noted.

The remaining CO3 - and HCO3 -were measured by methyl orange alkalinity.5-6 drops methyl orange were added and titrated with acid till the colour change from yellow to orange (M). Total titrate value T = P+M. Formula is as follows:

P alkalinity
P=A× N× 50000/ml of sample
Total alkalinity=B× N× 50000/ml of sample, Where A=ml of P; B=ml of T; N=0.02

BIOLOGICAL PARAMETER

Plankton Analysis:

The plankton is a minute organism which remains suspended in aquatic bodies, which for the first time recognised in 1845 by John Miller. However it was Vector Henson in 1887, an oceanographic, who coined the term "plankton" for such organisms. The term plankton derived from Greek word wanderer i.e., drifting minute organisms in water, which have no directive movement of their own. They are pelagic floating organisms. They move by the marshy of water current, but can't move against current. Plankton"s are classified into two types: Phytoplankton and Zooplankton Planktons are collected with the help of plankton net. The water sample of 25 litres is poured in the net of Boltan silk cloth and the plankton is sieved and collected at the bottom of the net into a graduated test tube. The plankton along with the water sample is collected and taken for analysis. The qualitative analysis of plankton was done and the types and species of plankton were identified by the Stereozoom Zesis microscope. The quantitative analysis of plankton can be done with the help of Sedgewickrafter counting cell.

3. Results

3.1 Analysis of Water

The water sample were collected from 14 different lakes which belong to different lake series of Bangalore city and water parameters viz. temperature, pH, turbidity, COD, BOD, and DO were analyzed and the results were tabulated in Table A. The water quality analysis of the lakes gives the exact nature, cause and levels of the pollutants, if any. The physical parameters such as temperature and turbidity play an important role in lake productivity. The levels of chemical parameters including the pH, BOD, COD and nutrients decide the quality of lake water. The methods adopted for water quality analysis are listed in Table A. As per the water analysis conducted for the selected lakes the results showed that, the temperatures were in a range of 250 to 280 Celsius for all lakes. The physical parameters of water analysis of the lakes showed that the Chikkbanavara lake, Hoskere nallakadarenahalli and Chandapura lake are more turbid than the other lakes. Water samples analysis from other lakes such as Chikkabanavara lake, Hoskere Nallakadarenalli lake, Chandapura lake and Hebbagodi lake, showed a

significant increase in pH, which in turn indicates a high level of alkalinity. Whereas the water samples from Hulimavu lake, Puttenahalli lake and Sarakki lake showed a decrease in pH level indicating the water to be acidic. Table B showed that Chikkabanavara lake, Hoskere nallakadarenahalli, Hulimavu lake, Hebbagodi lake, Chandapura lakes are in eutrophic condition. A significant increase in level of COD, BOD and a marked decrease in DO level was recorded in the lakes which were reported to be polluted with industrial effluents and domestic sewage such as Hebbagodi, Chandapura, Rayasandra, Yelemallappa Chetty and Hulimavu lakes.

3.2 Present status of following lakes surveyed:
Lake system in Bangalore city:
The lakes in Bangalore form a chain of hydrological connection through them. The flow of water runs from North to South-East as well as South-West along the natural gradient of the land. During monsoons, the surplus water from the upstream lake flows down into the next lake in the chain and from there further down. The lakes thus form a chain of reservoirs in each of the three valley systems. Each valley at the ridge top gives birth to small streams. They were designed in cascades from higher to lower elevations; as a lake overflowed the excess water would flow into the next lake in the cascade. These cascade down to form major stream systems in three valleys namely Hebbal Valley, Koramangala & Challaghatta Valley and Vrishabhavati Valley (fig. 5). The lakes thus form a chain of reservoirs in each of the three valley systems. Each valley at the ridge top gives birth to small streams. These valleys are the repository of all the lakes in Bangalore and these lakes themselves are interlinked to each other through a series of chains of lakes giving a cascading effect to the whole system. The naturally undulating terrain of Bangalore city, with its hills and valleys, lends itself perfectly to the development of lakes that impound rainwater, store it for future use and ensure ground water recharge. Lakes are thus live ecological systems, and play a crucial role in the supporting life, including human. Lakes are critical to the city of Bangalore, as it does not have any perennial river (Cauvery River is about 140 km away). However, unplanned urban growth, encroachments, pollution and other human interventions have endangered these lakes. In the present study following lakes were surveyed for their pollution status and fishing activity. The lakes surveyed for the present study belong to the following series.
A) Madavara lake series,
B) Yellamallappa lake series,
C) Puttenahalli lake series and
D) Hulimavu lake series.
E) Lakes of Electron city area
MADAVARA LAKE SERIES
In Madavara lake series, Madavara lake, which connected nine lakes, was the main source of water to Hebbal valley. "Water flowing from two chain of lakes, namely Laxmipura lake, Chikkabanavara lake, Dasarahalli lake, Doddabidarakallu lake on one side and Herohalli lake, Andrahalli Lake, Narasappanakere, Hosakere, Nallakadarenahalli on other side, used to get

collected at Madavara Lake, which in turn, used to quench the thirst of Hebbal valley," was confirmed by environmentalist, Naveen (2011) and for the same reason, the lake had been a hot spot for fish rearing. Officials in the fisheries department had also reported that eight lakes, including Madavara Lake, were biologically dead in Bangalore North taluk and many will soon followsuit. Even though the Bangalore Development Auhority (BDA) started rejuvenation and overall development of these Lakes in October 2010, not much progress was made. The dying lakes are also affects the food chain.
The following lakes surveyed have been identified under this series:
    a) Chickkabanavara lake
    b) Hosakere nalakadaranahalli lake
    c) Herohalli lake

Chikkabanavara Lake:
The lake is identified under the Madavara lake series which is a part of Hebbal valley system and situated near Peenya in Bangalore North Taluk. It is a rural area within Bangalore city. The lake is surrounded by small buildings. Approximate area of this lake is 120 ha. It is a huge water body situated in north Bangalore region. It has a great diversity of flora and fauna. The lake has not been fenced and so it is open for encroachment as observed during the survey, building construction work were build abutting the lake bank. As public interaction says the depth of the lake varies all through with an average depth of 10 feet, but having average depth of 2 feet. It was also observed that inlet and outlet of this lake were blocked due to blockage of rajakaluve. Rainwater is the main source of water in the lake. It is seen that about 60% of the lake is covered with green vegetation and therefore the lake is in eutrophicated condition.

Flora and Fauna: Lake vegetation includes typha, tape-grass mosses, ferns, shrubs and small trees etc. and it supports many amphibians, reptiles, and birds for their habitat and foraging.
Aquatic Avi-fauna: The aquatic birds observed during the study were Purple Heron, Grey Heron, Indian pond Heron, Dab-Chicks, cranes and kingfisher etc.
Fishing Activity: A regular fishing activity takes place over the lake all round the year. A periodic introduction of the fish seeds and fingerlings is being done by the local fishermen. The lake seems to have a high yielding capacity since large number of fishes is being harvested every week and hence this provides a regular source of income to the fishermen. The fish species found in abundance include common carp, grass carp, catla, rohu and tilapia sp. etc**.** Most of these fishes have high fecundity and surviving capacity and also a few can tolerate adverse conditions. Eutrophication has proved to be one of the most wide spread and serious anthropogenic disturbance to the aquatic ecosystem, mainly due to the deposition of the compounds of N, K, P in the water. The sediment deposition and siltation are the main causes of water level depletion. Thus the lake has now turned shallow and may die its own death.

Table: A: Analysis of chemical aspects of water parameters viz. BOD, COD and DO in the following surveyed lakes.

SL no.	Name of the Lake	COD	BOD	DO
1	Chikkavanavara	14.6	14.3	3.5
2	Hoskere nallakarenalli	15.8	21.4	3.5
3	Herohalli	Dried		
4	Yellamallappa chetty	43.7	17.4	3.3
5	Madivala	15.3	11	4.9
6	Jakkur	11.3	10.4	5.4
7	Begur doddakere	14.6	20.5	3.3
8	Gottegere	12.6	21.3	4.3
9	Hulimavu	15.3	19.6	5.7
10	Puttenalli	14.5	27.4	3.6
11	Sarakki	13.5	20.3	4
12	Chandrapura	18	14.3	3.2
13	Hebbagodi	17.3	13.4	3.6
14	Rayasandra	6.4	9.8	5.6

Table: B: Analysis of physical aspects of water parameters viz. temperature, pH and turbidity in the following surveyed lakes.

Sl no	Name of the lake	Water Temp. (°C)	pH	Turbidity (NTU)
1	Chikkavanavara	26	8.5	31
2	Hoskere nallakadarenahalli	28	9.6	34
3	Herohalli	Dried		
4	Yellamallappa chetty	25	8.1	29
5	Madivala	27	7.5	25
6	Jakkur	26	7.0	22
7	Begur doddakere	26	7.3	21
8	Gottegere	25	7.9	17
9	Hulimavu	28	5.5	28
10	Puttenahalli	25	5.7	29
11	Sarakki	26	6.1	25
12	Chandrapura	27	10.11	34
13	Hebbagodi	28	11.8	35
14	Rayasandra	26	6.3	20

Source of Pollution: The Lake is polluted due to the high level of anthropogenic activity. Since its present in a rural locality and there is no chance of pollution by the industrial effluents. All types of garbage disposal, refuse dumping, washing of the clothes by the professional washermen are the responsible factors for negative effect on the lake. The activities such as immersion of the idols like Lord Ganesh and other deity into lake water in large numbers during festive seasons are some of the other causes of polluting the water (both metal and organic pollution) and its depletion. The lake water was analyzed for its DO, COD, BOD, pH, etc., parameters to assess the water quality. After analysis the COD and BOD were found at a significantly high level and DO showed a significant low level when compared to the other mildly polluted lake as analyzed during the study.

Impression: It's a highly eutrophicated lake.

Hosakera Nallakadarenahalli Lake:
The lake has been identified under the Madavara lake series which is a part of Hebbal valley system and situated

in Shivpura area. The lake is having an approximate area of 19.21 acres. It is situated in the industrial area, surrounded by many industries that include the Bata factory, agro-chemicals, acid factory and garment factory and commercial and residential buildings also. Lake has been fenced by the government which is present in various areas but it has been noted that the fencing has been destroyed by the local people for their illegal activities. It was accorded by the interaction with the local people that the depth of the lake had reduced due to siltation and sedimentation and was only about to be 7 feet in the centre and the edges were shallow. Therefore this lake can be counted as one of the highly polluted lakes in north Bangalore. It was observed during the survey that the boundary of the lake has been encroached and an unauthorized foot path which is being used as a short cut route passing near by the lake was observed. Rain water is the only source of water for the lake. The inlet of this lake could not be located but an outlet of the lake was found to be heading towards the Narasappana lake and Tigularapalya lake.

Flora and fauna: The lake was identified to be highly polluted. Large number of algal blooms and other toxic aquatic plants were noted. Variety of other flora was absent.

Aquatic Avi-Fauna: The avi-fauna observed in this lake are such as, Purple heron, Grey Heron, Indian pond Heron and Dab chicks**.** It was found by the primary data that large number of migratory birds would visit this lake but presently the number of these birds had significantly decreased due to increase in the level of pollution.

Fishing Activity: The presence of a large number of fishes in the lake a few years earlier was a flourishing livelihood of local people. But presently due to the discharge of domestic sewage and effluents the water has become unfit for the survival of fishes. It was found that fishing activity has been temporarily stopped. The seeds and fry of fishes such as Rohu and Catla are introduced for rearing but these fishes along with tilapia sp. and catfishes are not been harvested in large numbers.

Source of Pollution: At the first sight of the lake, the colour of water is blackish, which gives an idea about the level of pollution. It can be said that either due to direct or indirect discharge of sewage and industrial effluents, as seen at the site, (Photo showing the direct connection of the outlets of the industries into the lake the water is polluted and toxic for the flora and fauna.

Impression: Highly polluted.

Herohalli Lake:
This lake comes under the Madavara lake series which is a part of Hebbal valley situated near Peenya. The approximate area of the lake is 17 ha. This lake is surrounded by residential area and an unauthorized road was observed to be present near the bank of the lake. Restoration process was also seen to be taking place. Large number of bulldozers and Lorries were seen carrying silt and sediment out of the lake bed. It was noted by the primary data that during past few years it was one of the highly polluted and eutrophicated lake, bearing very less amount of water. Due to eutrophication and siltation the sediments were deposited in the bottom of the lake which was the main cause for decrease in water level and consequent filling of the lake which has resulted in its extinction. Most of the lake area is a dry land and it is being used as a play ground. Small parts of the lake look like rainwater filled pools.

Restoration process:
The lake is taken up on a war-footing for its survival by the government bodies as LDA and KSPCB. Now the water from the lake is being drained out and silt and sediment is being removed to the joy of the local population. This can be called as the process of restoration of the lake, its flora and fauna. Draining of water is an important process for cleaning of the lake bed. After which rain water would fill up and again the lake will have its flora and fauna. Shallow eutrophicated lakes can be restored by removal of sediments. This technique simultaneously removes large quantities of nutrients stored in sediments hence increasing the mean depth of the basin and removing toxic substance. De-siltation is another important process to remove the sediment from the lake to improve permeability, water holding capacity and ground water recharge.

Impression: This Lake is under restoration process.

YELLAMALLAPPA CHETTY LAKE SERIES:
The following lakes surveyed have been identified under this series:
    a) Yellamallappa Chetty lake
    b)Madivala lake
    c) Jakkur lake

Yellamallappa Chetty Lake:
The Yellamallappa Chetty lake is identified under the Yellamallappa Chetty series which is a part of Hebbal valley system. This lake is located near Krishnarajpuram-Hoskote taluk. It is huge water body located towards North east of Bangalore in outskirts of Bangalore. Cipla pharmaceutical industry is constructed almost 20 year ago and it has been discharging its treated and untreated effluents regularly in to the lake. The area of this lake is about 110 ha. The approximate depth of the lake is 10-12 feet. Rain water is the only source of water drained to this lake. The rajakaluves have been blocked due to encroachment and therefore inlet and outlet were not found or has dried. The water level of this lake was observed to be reducing every year. Excepting during rainy season sewage water from city enters to the lake along with pollutants from a storm water drain which is located although very far but enters the lake directly which helps in increase of level of the lake. Nearly 75% of the lake is covered with algal bloom which has resulted in eutrophicated condition of the lake. Lake vegetation includes mainly water hyacinth, mosses, ferns and small tress, which supports many amphibians, reptiles and birds to inhabit.

Aquatic avi-fauna: Birds like Indian pond heron, purple heron, cranes etc. were observed to be nesting and predating during the study.

Fishing activity: Regular fishing activity is observed in this lake. The population of catfish was reported to be more in this lake as it is a pollution resistant species. The other species of fishes like tilapia, catla and rohu which were present in large number in this lake and are not tolerant to pollutants are recorded to be dying.

Source Pollution- Discharge of sewage water from urban areas in to the lake is major cause of pollution. By the interaction with people it was recorded that there are many anthropogenic activities like garbage dumping and discharge of various types of effluents into the lake. The presence of pharmaceutical industry at the banks of this lake has been a cause of concern since long. The treated and overflow of the effluents and stored waste discharged into the water has caused high pollution. This has in turn resulted in death of fry and fingerlings of Catla and Rohu, reared in this lake by the fish farmers. Excepting catfishes and Tilapia sp. no other fish species have been netted in the near past, because of its high resistant to pollutants. Another source of pollution is immersion of painted and coloured idols of Lord Ganesha statues into the water during Lord Ganesha festival.

Impression: Lake is eutrophicated and polluted.

Madivala Lake:
Madiwala Lake is one of the biggest lakes in Bangalore. The area of the lake is 114.3 ha (0.441 sq m; 1.143 km2). The lake is situated in the BTM Layout at 12° 54' 28" North, 77° 37' 0" East. The lake has been under the administration of Karnataka State Forest Department which

carries out the routine maintenance of this lake. This lake is also a recreational area which includes a children's park and boating. Thus this lake is a home to many migratory birds. The main source of water is rainwater and therefore during rainy season water level was observed to be high. The lake contains water for the whole year so it's a perennial lake. The outlet of the lake is connected to yellamallappa Chetty lake of K.R puram.

Fauna and Flora: About 50% of the lake is covered with green vegetation, which is helpful to the birds for their nest building and habitat.

Aquatic avi-fauna: As per the reports many migratory birds visit the lake during Nov – Feb. Huge number of Spot-billed Pelican migratory birds are observed in winter (November–December). The main food for this bird is fish. Pelicans take small flight across the lake for fishing; Egrets can also be sighted along with these pelicans. Local people have great love towards these migratory birds. The lake has an island and many birds such as purple heron, grey heron, cranes, moorhens, pelicans and ducks etc., were observed to inhabit the trees present on the island.

Fishing Activity: Fishing activity is regularly done in this lake. The fishes like catla, rohu, and tilapia are mostly observed and netted in large numbers**.**

Source of Pollution: The sewage water from the residential area enters into the lake which is one of the sources of pollution. The local *dhobi* were observed to wash clothes near the outlet of the lake. This adds up to the pollution of the lake water of connecting lakes.

IMPRESSION: Lake is restored and maintained.

Jakkur Lake:
Jakkur Lake is one of the very few lakes existing towards the North-Eastern outskirts of Bangalore, about 15 kms from Bangalore city center. It is more than two hundred years old and is densely connected with the history of Bangalore. The area of the lake is 50ha. And the depth is approximately 8-10 feet. The lake comes under the Yellamallappa Chetty series which is a part of Hebbal valley system. The lake is recently restored and is fenced.

Fauna and Flora: Not much vegetation was observed in this lake since the lake was recently restored.

Aquatic avi fauna: An island is constructed for the benefit of nesting of migratory birds. At one point of time bird watching was perhaps the most engaging aspect of the local population that made thorough document of the birds in relation to this lake. This lake is a paradise for various types of birds. The common birds found in the lake are such as Coots, Herons, and Cormorants. The most heartening aspect of the lake is that yet the migratory birds seasonally come to this lake in October and takes off in April to European countries. The migratory and regional birds co-exist here. Some of the birds travel up to 8,000 kms at one stretch to arrive at Jakkur lake.

Fishing Activity: As the lake was recently restored, the fishing activity is not initiated.

Source of Pollution: Algae and other aquatic vegetation are seen at the periphery.
Dumping of garbage was observed beside the fenced area. During rainy season the refuse and other pollutants enter into the lake along with the runoff water.

Impression: Lake is restored.

PUTTENAHALLI LAKE SERIES:
The following lakes surveyed have been identified under this series:
    a) Puttenahalli lake
    b) Sarakki lake

Puttenahalli Lake:
This lake comes under Puttenahalli lake series which is a part of Vrishabavathi valley system. The area of the lake is 13 ha 25 guntas. This lake is situated in J P Nagar, between residential apartment as Enclave- Brigade millennium and L & T South city. The main source of water of the lake is rainwater. The inlet and outlet of the lake can be seen but it is dried. This is the main reason for the reduction in the depth of the lake. The water body has a perimeter of 1.1km. Very less amount of water was observed in the lake and there are all possibilities of it to dry in coming summer months since the inlet has been encroached although the lake has been completely fenced so as to avoid encroachment.

Flora and Fauna: The periphery of the lake is filled by large number of aquatic weeds and grasses such as tape grass, mosses, fern etc. The lake is home to several species of water and land birds, butterflies and many other insects.

Aquatic Avi-fauna: The avi-fauna observed in this lake are such as, Wagtail, Indian pond heron, Grey heron, purple heron, Dab-chick etc.

Fishing activity: Fishing activity is stopped temporarily though earlier it was done on regular basis.

Source of Pollution: Anthropogenic activities were carried out in the past in this lake is a main cause of the water to get polluted, but presently all the connection from sewage system is blocked and eutrophication is the main cause for pollution of lake water which is a result of illegal dumping of garbage and other construction material. Due to eutrophication (aquatic plants and weeds) and sedimentation, the water level is depleting and the lake is becoming shallow. To restore lake to its former glory the encroachments are cleared, sewage inflow stopped and tens of trees are planted around the lake. The sewage water used to flow into the lake from the apartment in the form of a storm water drain present beside the periphery of the lake has been blocked. This has created a different problem for this will cause the lake to dry.

IMPRESSION: Lake is eutrophicated.

Sarakki Lake:
This lake is identified under Puttenahalli lake series which is a part of Vrishabavathi valley system. The area of lake is approximately 60 acres.

Flora and fauna: The lake is completely eutrophicated. It was observed that 60 to 70 % of lake is covered with weeds. The lake is fenced strongly by the authority but it is destroyed by the public for easy dumping of garbage near the bank of the lake**.** It is also observed that the lake has become reservoir for untreated sewage and a dumping yard for the surrounding neighbourhoods. Due to the urbanization in and around the lake, approximately 10 lakh liters of sewage enter lake every single day, which resulting in a foul odour. Many tents and huts have recently come up on the embankment surrounding the lake. Because of encroachment the lake's total area has reduced and now the area of lake is approximately 40 acres. By

looking at the present situation of this lake, it is very difficult to believe that it is a water body. It needs quick action to be restored and rejuvenated.

Impression: Lake is highly eutrophicated.

HULIMAVU LAKE SERIES:

The following lakes surveyed have been identified under this series:

    a) Begur doddakere

    b) Gottegere lake

    c) Hulimavu lake

Begur doddakere:

This lake comes under Hulimavu lake series which is a part of Koramangala Challagatta valley. The area of this lake is 3.23 ha and depth is around 10-12 feet as per the primary data. Outlet and inlet are blocked due to the blockage of rajakaluves. So the main source of water in the lake is rainwater. This lake is fenced all around mainly near the road side. Many new apartment / complexes have been constructed around the lake due to which the amount of sewage and garbage disposal has shown an increase around the lake. The local people have been observed dumping waste and refuse in the lake and on its sides, which can make a landfill in the lake in due course as observed for many of the lakes in city. The lake is at the verge becoming eutrophicated due to gradual inflow of sewage**.**

Flora and Fauna: The lake is 40 to 45% covered with algal blooms and aquatic weeds. Very few aquatic birds were observed during the study.

Fishing activity: Large number of fishes which were present a year ago. Presently very few in number of fishes are being netted. This may be due to increase in vegetation and decrease in DO level of lake water. Therefore, fishing activity is rarely observed and has become restricted to once in a week.

Source of Pollution: Many anthropogenic activities are been carried out such as, washing of clothes with the help of detergents and other chemicals. Car and other vehicles are also being washed near the bank of the lake which is responsible for polluting the lake water. The road is present on the two opposite side of the lake and other two sides consist of buildings which are very close to the periphery of the lake. This encroachment of the lake area is a clear violation of government rules.

Impression: Lake is polluted.

Gottegere Lake:

This lake comes under Hulimavu lake series which is a part of Koramangala Challagatta valley. The area of the lake is around 14.83 ha, and depth is around 3 to 4 feet. The fencing of lake is done by the government. The lake is completely eutrophicated and very less amount of water is present in this lake.

Flora and Fauna: 80% of the lake is covered with green vegetation resulting into eutrophic condition. During study period many cattle and other animals were observed grazing on the weeds and grass.

Aquatic Avi- fauna: The avi-fauna observed in this lake are such as, Pond Heron, Purple Heron, crane etc.

Source of Pollution: Sewage and garbage waste was observed in the periphery of the lake. Lake was dying gradually with sewage inflow and weeds. The outlet of the lake is seen to be attached to the bridge which is present beside the lake. Eutrophication has proved to be one of the most wide spread and serious anthropogenic disturbance to the aquatic ecosystem, mainly due to the deposition of the compounds of N, K, P in the water. The sediment deposition and siltation are the main causes of water level depletion. Thus the lake has now turned shallow and may die its own death.

Impression: Lake is eutrophicated.

Hulimavu Lake:

This lake comes under Hulimavu lake series which intern is a part of Koramangala- Challgatta valley. This is a reasonably big lake in the Hulimavu village (now part of BBMP) in the south Bangalore off Bannerghatta Road. The area of the lake is around 9.84 ha. Outlet and inlet are blocked due to the blockage of rajakaluves. So the main source of water is rainwater. There is no inlet and outlet for this lake. The lake is fenced on road side only and there is no demarcation on any other side.

Flora and fauna: Lake is covered by floating weeds and is eutrophicated.

Aquatic Avi-fauna: The avi-fauna observed in this lake are such as, Pond heron, and Crane.

Fishing activity: Fishing is done on a regular basis. Fishes like rohu and catla are netted in the lake.

Source of pollution: The lake is polluted due to anthropogenic activites like dumping of garbage and sludge in the lake. Sand - cement machinery have been installed at the bank of the lake which is resulting into sedimentation. Mining and quarrying activities were also done in the past. Many buildings and apartments have been constructed in the vicinity of the lake which adds to the source of pollution**.** Since there is no industry present in this rural locality so there is little chance of pollution by the industrial effluents. The extent of pollution is not severe.

Impression: Lake is polluted.

LAKES SURVEYED IN ELECTRONIC CITY (Industrial area):

    a) Chandapura lake

    b) Hebbagodi lake

    c) Rayasandra lake

Chandapura Lake:

This lake is present in electronic city of Bangalore. The main source of this lake is rainwater. Many other lakes are connected to this lake which acts as other water sources for this lake. The outlet of the lake mixes with the sewage water and cement storages and other wastes which together go to the rice field which is next to the lake**.** This lake shows hydrological chain formation.

Flora and fauna: The Lake showed eutrophicated condition due to the presence of 40% of lake area being covered with water hyacinth seen floating on the surface of the lake. Eutrophication has proved to be one of the most wide spread and serious anthropogenic disturbance to the aquatic ecosystem, mainly due to the runoff water containing nitrates, phosphates and potassium in the water.

Aquatic avi-fauna: The avi-fauna observed in this lake are such as, Blue heron, Pond heron, and Cranes were found.

Fishing activity: Very less number of fishes is present, therefore fishing activity is rarely observed.

Sources of pollution: The lake water is highly polluted due to the tragedy which was held recently six to eight months ago when all the effluents from chemicals factory were released into the lake due which many aquatic lives were died in this incident. Other sources of pollution were like dumping of garbage at the periphery of the lake and inflow of drainage water from the city into the lake.

Impression: Lake is eutrophicated.

Hebbgodi Lake: The source of water comes from different lakes such as Gollahalli Lake, Veersandra Lake, which come through inlet of the lake. The outlet water goes to other lakes such as Kombgatta Lake which are in Electronic city area. One of the sides of the lake is almost dried and converted into wetland and road is constructed by the government within the lake. The lake area is encroached by constructing 30 to 35 houses, temple. In this way the lake area is eaten up by certain developers. A factory is also constructed beside the lake.

Flora and fauna: The floating vegetation is found in the lake; also weeds growth is seen at the periphery of the lake which is used by local people to feed the cattle. It was reported by the local people that certain skin diseases are caused for those who get into the lake periphery for cutting the weeds.

Fishing activity: The fishing activity in this lake was carried out 5 to 6 years back. Now also fishes are present in the lake but no fishing activity is observed in this lake.

Source of pollution: The water of this lake is heavily polluted due to the anthropogenic activities by the local people, even domestic sewage and pit water goes to the lake directly through a drain which pollutes the lake.

Impression: Lake is heavily polluted.

Rayasandra Lake:

This lake is present in Electronic city. The main source of the lake is rainwater. The lake was recently restored. The water was very clean and clear. The lake is present near the main road. Many buildings and apartments are present near the lake.

Fishing activity: Many gill nets were introduced into the lake which shows fishing activity is going on the lake.

Aquatic avi- fauna: The avi-fauna observed in this lake are such as, Blue heron and cranes were seen around the lake. Electric pole was observed at the one end of the lake.

Source of pollution: As this lake was recently restored so the water quality of the water was seen to be free from pollutant. The water quality of this lake was very good as compared to the other lakes.

Impression: Restored Lake

3.3 PRESENT STATUS AND FISHING ACTIVITY IN SURVEYED LAKES OF BANGALORE

The lakes were categorized on the basis of its pollution status and aquatic birds as shown in Table-C. According to the study conducted Yellamallappa Chetty, Hosakere nallakadarenalli and Hebbagodi lakes were observed to be highly polluted lakes, whereas lakes like Gottegere, Sarakki and Chandapura lake showed eutrophicated condition. Rayasandra lake and Jakkur lake are the restored lakes. Herohalli is dried lake. The Eutrophication is the major source of nutrients worldwide. This can be treated by establishment of sewage treatment plants. Moreover, fertilizer leachates of largely nitrogen and phosphorous

which are designed to boost plant productivity actually end up destroying the water quality and biodiversity of lake system. The general urban run-offs carrying detergents accelerate eutrophication and hence the death of a lake biodiversity. Urban monsoon floods increase the water levels in various waterways and drains. The flushing and scooping phenomenon of the storm water take with it highly enriched organic matter. By combining all the data, public interaction and thorough observation, the lakes can be divided into 5 categories namely,

      a) Highly Polluted,
      b) Polluted,
      c) Eutrophicated,
      d) Restored And
      e) Under Restoration process.

4. Discussion:

In the present investigation 14 lakes from the different series of Bangalore were documented according to their pollution status, fish diversity and bird diversity in our study it was found that out of 14 lakes most of the lakes are eutrophicated, some lakes are polluted by sewage inflow, some are highly polluted with industrial effluents, some are restored and some are under the process of restoration. In our present study lakes like Hosakere nallakadarenalli and Yellamallappa Chetty are highly polluted with industrial effluents whereas, Begur doddakere, Chandapura, Sarakki lakes are polluted by sewage inflow. Industrial effluents containing heavy metals are usually discharged into sewage canals of cities, thus polluting the water bodies and soil (Baddesha and Rao, 1986). The lakes like Chickkabanavara, Gottegere and Puttenahalli are eutrophicated, and those like Rayasandra and Jakkur are restored. Herohalli Lake is under the process of restoration. It indicates that the water quality of the lakes is on the verge of degradation. It was observed during the study and with other primary data that rapid urbanization of Bangalore is a key cause for the lake degradation in this city. Indiscriminate use of the lake area such as construction of apartments, factories at the vicinity of the lake is also affecting the lake. Inlet and outlet of the most of the lakes are encroached or blocked due to the interference of *rajakaluve'*. As a consequence the rain water is the main source of lake water. So except rainy season the lakes in Bangalore are seen to be dry throughout the year. Due to this people are heading towards the lake area for constructions which finally results in encroachment of lakes. Many lakes were recorded to be dried up and many of them intentionally used up to solve the land crises, this has put a permanent mark on the socio-economic as well as the environmental sectors of Bangalore. Due to the rapid urbanization, when the fresh and drinking water demand have gone up, at the same time, the lake as a water source is also rapidly being destroyed. This destruction of the lake environment is directly influencing the biodiversity of the lake and hence the environment. The temperature changes, rainfall and extinction of bird species are the major red lights those can be taken as the warning signals. Temperature is an important factor which regulates the biogeochemical activities in the aquatic environment. The maximum temperature is recorded during the summer season and the minimum during winter season. The cli-

matic change in Bangalore over the recent years is one of the problems that have been evolved, which are a consequence as well as the complementary to the lake destruction. All these issues together has resulted in decrease in the population and diversity of fish which is another major problem threatening the local economy. The local fishermen who used to be dependent on the lake are now helpless and have to switch up to other sectors for their livelihood. As a whole, the changes in lake water quality, level of pollution and low fecundity rate are the factors that are affecting the socio-economic status of fishing community in a negative way. The physio-chemical parameters such as temperature, pH, turbidity, COD, BOD, and DO are the basic parameters to determine whether a lake is polluted or non-polluted. In a eutrophicated or industrially polluted lake, the level of BOD, COD are significantly high and the DO level is remarkably less. This directly affects the aquatic organism which inhabits in the lake. Dissolved oxygen is of vital importance to living organisms in water. The effect of waste discharges in a water body is largely determined by the oxygen balance of the system. Turbidity of water is due to colloidal and extremely fine particle dispersed in water. Quality of an aquatic ecosystem is dependent on the physic-chemical qualities of waters as also on the biological diversity of the system. Carian and Dickson (1971) stated that analysis of biological materials along with chemical factors of water forms a valid method of water quality assessment. Higher COD values in the pollute lakes are due to the nutrient enrichment, high salinity and sulphate content. COD is an important parameter for industrial waste studies and for quality of waste treatment plants. The maximum turbidity in water was recorded during winter season whereas minimum during summer may be due to addition of large amount of sewage waste and pollutant from the surrounding slums area. Fishing activity was found to be negatively affected in most of the lakes in Bangalore. Though having the fishes in the lakes the fishermen are not willing to go into the water due the high level of pollution. Even if fishing is done the people are not ready to consume these fishes due to the degradation in the quality of water such as blackish colour of the water and foul smell emanating from these lakes. Mortality of fishes occurs due to the pathological lesions caused by pollutants. (Ayyappan, *et al.*, 1998). In most of the lakes the fish population mainly includes rohu, catla, silver carp, tilapia and catfish. In spite of high level of pollution the fishes like tilapia and catfish are surviving because these fishes can breed in these lakes, they are hardy fish, can tolerate high level of pollution and low level of oxygen. Whereas the fingerlings and seeds of the major carps have to be introduced since they do not breed in lakes and ponds and due to their less survival rate in present lake water status very few grow up to table size for commercial purpose. Being carnivorous in their food habit, tilapia and catfishes consume the fingerlings of carps. This has resulted in a decrease in the population of major carps in most of the lakes. Fish are one of the important organisms to establish and balance the aquatic ecosystem. Fish plays an important role and are at a higher trophic level in the food chain of the aquatic habitat. Several fish eating birds are found near the periphery of the lake. Besides the fish eating birds, other frugivo-rous, insectivorous birds are also found near the lake due to the good flora and fauna of the lake. But due to the degradation of lakes" habitat the few species of birds visit the lakes. Lakes are the lung spaces of a city and climate moderators adding to thermal ambience. The present investigation showed a very bad status of lakes in all aspects. The lakes are the only freshwater resource for Karnataka. Rivers like Cauvery, Arkavathi, Pinakini etc., are rain fed and origin from Western ghats. But the present denudation of forests in Western ghats areas has a direct effect on the rains resulting reduction of rains as on yearly basis. These rivers are the resource of potable water for Bangalore which is exhausting a very fast rate. Thus conservation of lakes, removal of encroachments from the rajakaluves becomes important and serious steps should be taken to construct new lakes in the areas of Bangalore were the pipeline of Cauvery or borewells are absent. It needs to be said that the sewerage system has to be reworked upon. Because the amount of water used finally goes into sewages which led to lakes in the form of dirty water.

5. *Summary:*

The selected lakes of different series of Bangalore were survey according to there fishing activity and pollution status. The morphometry *viz.* area in hector and depth in a feet of the lakes were recorded. From the recorded data it was concluded that the area of lakes have been encroached by the construction activity of the people at the vicinity of the lakes and depth of the lake are decreased and the lakes become shallower due to siltation and sediment deposition. The physico-chemical parameters such as pH, turbidity, temperature, COD, BOD and DO of the different lakes were analysed. Most of the lakes showed significantly higher level of the COD, BOD and turbidity which indicate the high eutrophication. A good diversity of flora and fauna are strongly necessary for an appropriate lake habitat but according to our survey the diversity of fish and bird species are decreased in number due to the high pollution level in the lake. In most of the lakes fishing activity is stopped due to the highly polluted water quality, fishermen are not willing to get into the water and fishes are not surviving. The main source of fresh water in Bangalore city is the lake water, people depend on lake for irrigation, bathing, washing clothes etc. but on the same while, due to the anthropogenic activity like, garbage dumping, washing of cloths by the use of detergent etc, thus the lake water is getting polluted. The fisherman and local people were asked questions about their problem related to the lake. The common complaint was water pollution because of discharge of domestic sewage and various types of effluent directly into the lake which inturn has lead to fish kill and the public around the lake faced health problems as skin irritation, fever and infection affecting their livelihood. An event as Walkthon was organised by Puttenahalli Neighbourhood Lake Improvement Trust (PNLIT) to help nature enthusiasts explore the rich flora and fauna at the 13-acre Puttenahalli Lake, located in JP Nagar 7th Phase. The walk, led by Deepa Mohan, a member of the Bird Watchers Field Club, drew more than 50 people, a record when compared with previous figures. "In the last two months, this is the third walk

we are undertaking and the number of participants has jumped from just a handful to over 50 today. This was possible owing to our persistent approach," said Usha Rajagoplan, writer and trustee of PNLIT. Various events and awareness programmes are being conducted by the general public and NGO"s but there seems to be no effect on the concerned authority and the lakes are dying daily in the hands of land sharks because of the lobby and their approach to the same authority for clearing the construction projects.

6. Conclusion:

Before we end up with a final concluding statement, the necessity to understand the significance of fresh water bodies, as lakes becomes important. The disappearance or degradation of lakes due to anthropogenic activity in a rapidly expanding city like Bangalore is a sign of anxiety. Lakes in Bangalore, clearly define their importance to the environment as well as their benefits to the public since they are the only source of groundwater, irrigation and potable-water. Throughout the study and visits to the lakes, it has been noticed that, knowingly or unknowingly, the lake and its biodiversity are being severely threatened, directly or indirectly by the people. Most of the lakes which seem to be in good condition or naturally healthy are becoming much polluted and the ones" which are heavily polluted are further deteriorating which may be gobbled by developers later. The steps undertaken by the authorities to restore such lakes have to be intensified. The functioning towards the lake restoration by the government or non-government might be half-hearted or not being executed well upto a satisfactory level or else the status of the lakes are not well known. During the present study it has been noted that the biodiversity of these lakes have been adversely affected due to its indiscriminate use. The statistical data reveals a decrease in number of lakes in Bangalore since last 4-5 decades which has the direct relation to urbanization and industrialization which is going at a immeasurable rate. Many reports from various organizations has shown and statistically evaluated the present status of lakes, the land grabbers are continuing construction unabatedly at the cost of lakes. This is not a good idea. We need to balance both the sides, and for that we need to really look keenly for our environment and lake conservation & restoration. The present scenario of the fishing status and the presence as well as the existence of the fish population in different lakes clearly demonstrates the status of lake, quality of lake water and its biodiversity. The pollution level of the lakes is to be considered attentively. Wherever a high level of pollution was detected, fish population as well as its diversity was found to be less. The diversity of birds, which are consumers of fish were also found to be less indicating a disturbance in the food chain. The altered pH level, DO and presence of other pollutants are directly affecting the fish population. Even though the lakes are present in the same geographical location, the existing fish population and their ratio of density, percentage, survival as well as the fecundity largely differs when the data was analyzed by comparing the different lakes" statistics. This is an indication of the anthropogenic activities and indiscriminate use of lakes that has resulted in the sad status of lakes in Bangalore, on this date.

8. REFERENCE:

1. Abbasi, S.A., Khan, F.J., Sentilevelan, K. and Shabuden, A. (1999): *Indian J. Env. Hlth.* **14** (3): 176-183.
2. Abel. P.D. (1989): "Water Pollution Biology" Ellis Howard Ltd .44-99.
3. Ahluwalia, A. A. (1999): Limnological Study of wetlands under Sardar Sarovar command area. *Int. J. Res. Chem. Environ.* **2** (1): 109.
4. Angadi S.B., Shiddamaliayya, N. and Patil, P.C. (2005): Limnological study of papnash pond, Bidar (Karnataka). *J. Env. Biol.,* **26:** 213-216.
5. Bagde, U.S. And Verma, A.K. (1985): Limnological studies on JNU Lake, New Delhi, India. *Bull. Bot. Soc. Sagar.* **32:** 16-23.
6. Billore, D.K. (1981): Ecological studies of Pichhola lake, Ph.D. Thesis, Univ. of Udaipur.
7. Bohra, O.P. and Bhargava, S.C. (1977): Abiotic factor, chlorophyll pigment and primary production in two lakes of Jodhpur. *Geobios* **4** (5): 215-216.
8. Chaudhary, S., Anuradha and Sastry, K.V. (2004): Pollution of River Yammuna at Faridabad Hariyana. *Poll Res,* **23** (4): 749-756.
9. Chaurasia, M. and Pandey, G.C. (2007): Study of physicochemical characteristic of some water pond of Ayodhya –Faizabad. *Indian J. of Environmental protection* **27** (11): 1019-1023.
10. Dagaonkar and Saksena, D.N. (1992): Physicochemical and biological characterization of a temple tank, Kaila Sagar, Gwalior, Madhya Pradesh. *J. Hydrobiol.* **8** (1): 11-19.
11. Diwakar, D. and Partha Sarathy, K.T. (1991): Study on the Trophic status of Yediyur Tank water in the Bangalore city UVCE, University of Bangalore.
12. Durrani, I.A. (1993): Oxidative Mineralization of Plankton with its Impact on eutrophication of Bhopal. Ph.D. Thesis, Barkatullah University, Bhopal.
13. Ganpati, S.V. (1977): Ecology of tropical water, *Proc. Symp. Algology*, ICAR New Delhi: 204-218.
14. Jamil, K.(1991): Changes in water quality due to the presence of certain aquatic plants: An environmental concentration. In: Current Trends in Limnology. Narendra Publishing House, New Delhi: 29-36.
15. Joshi, P.C. and Singh, A. (2001): Analysis of certain physicochemical parameters and plankton of freshwater hill stream at Nanda devi biosphere reserve. *Uttarpradesh j. Zool*. **21:** 177-179.
16. Kadiri, M.O. (2000): Seasonal trend in the chemical limnology of shallow Nigerian manmade lake. Acta. *Hydrobiol*, **421:** 29-40.
17. Kataria, H.C., Singh, A. and Pandey, S.C. (2006): Studies on water Quality of Dahod Dam, India. *Poll. Res.* **25** (3): 553-556.
18. Kaur, H., Dhillon, S.S., Bath. and Mander, G. (1996): Analysis of the Elements pollution river Gaggar in the region of Punjab. *Journal of Environment and Pollution.* **3** (2): 65–68.
19. Kiran, R. and Ramachandra, T.V. (1999): Status of wetlands in Bangalore and its conservation aspects ENVIS. *Journal of human Settlements*: 16-24
20. Lakshman Rao Committee report. (1984): Restoration and status of lakes of Bangalore submitted to The Govt of Karnataka.
21. Lakshman Rao, N., Issar, T.P., Parthasarathy, M.A., Patil, S.M., Vijaya Devi., Giri Gowda, P. and Shenoy, P.D. (1993): Report on the high power committee set up by the government of Karnataka on 'Beautification of Bangalore'. Pub. by Shivashankar Engineering Co. Pvt. Ltd., Bangalore for the Government of Karnataka:128.
22. Lavanya, S., Chandrappa, G.T. (2011): The fascinating history of Jakkur Lake. Lokeshwari, H. and Chandrappa, G.T. (2006): *Journal of environment science &engg.* **48** (3**)**:183-188.
23. Mason. C F. (1991): Biology of Fresh Water Fishes. Longman Scientific and Technical, New York, U.S.A: 351. Mariappan, P. and Vasudevan, T. (2002): Correlation of some physico-chemical parameters of drinking water ponds in Eastern Parts of Sivagangai district, Tamil Nadu. *Poll Res.,* **21**(4), 403 – 404.
24. Mathuthu, A.S., ZaranYika, F.M., Jannalagadde, S.B. (1993): Monitoring of water quality in upper Mukavisi river in Harare, Zimbabwe. *Environ . int.* **19** (1): 51-60.
25. Mohanta, B.K. and Patra, A.K. (2000): Studies on the Water Quality index of river Sanamachhakandana at Keonjhar Garh, Orrisa, *Poll. Res.* **19** (3): 377-385.
26. Murugesan, A., Ramu, A., and Kannan, N. (2006): Water quality assessment from Uthamapalayam municipality in Theni District, Tamil Nadu, India. *Poll Res.* **25** (1): 163–166.
27. Nair, A.S.K. and Thrivikramaji, K.P. (1996): Classfication of Kayals in the coastal Zone of Kerala, Proc .8th Kerala Science Congress.89-90.
28. Padma, S. and Periakali, P. (1999): Physico -chemical and geochemical studies in Pulikat lake, east coast of India. *Indian J. Mar. Sci* **28**:434-437.
29. Pant, M.C., Gupta, P.K., Pandey, J., Sharma, P.C. and Sharma, A.P. (1981): Aspect of water pollution in Lake
30. Praveen, M., Saurabh, A. and Mudita, N. (2008): Assessment of Physico –chemical characteristic and suggested restoration Measures for Pushkar Lake.
31. Raina, M., Mairer, Ian.L.Pepper and Charles,P.Gerba. (2000): Environment microbiology, Academic press ; Elsevier; New Delhi:**1**
32. Shankarnarayann, Y.N., Udayaverma, P., Pylee, A., Balachandran, K.K., and Joseph, T. (1986): Estuarine characteristics of the lower reaches of the river Periyar (Kerala). *Indian J. Mar. Sci.* **15 (3)**:166-170.
33. Sharma, M.R. and Gupta, A.B. (2004): Seasonal Variation of physico-chemical parameters of Hathli stream in outer Himalaya. *Poll Res.* **23** (2): 265-270.
34. Shastri, Y. and Pendse, D.C. (2001): Hydrobiological study of Dahikhura reservoir. *Journal of Environmental Biology*: **22** (1): 67-70.
35. Shobha C., Praveen J. and Chaturvedi, R. (1996): Evaluation ofdrinking water quality of Kolar dam water, near Bhopal Madhya Pradesh. *Poll. Res.* **15** (3): 241-243.

36. Shrestha, S. and Kazam, F. (2006): Assessment for surface water quality using multivariate stastical techniques: A case study of the fuzi river basin, Japan. Environmental modelling and software. **22**:464-475.

37. Singh, K.P., Malik, A., Mohan, D. and Sinha, S. (2004): Multivariate statistical techniques for the evaluation of Spatial and temporal variation in water quality of Gomti River (India): A case study. *Water Research.* **38**:3980-3992.

38. Singh, R.P. and Mathur, P. (2005): Investigation of variations in physicochemical characteristics of a fresh water reservoir of Ajmer city, Rajasthan. *Ind. J. Environ. Sci.* **9:** 57-61.

39. Singhal, R. N., Swaranjeet. and Davis, R. W. (1986): The physico-chemical environment and the plankton of managed ponds in Haryana, India, *Proc. Indian Acad. Sci.* (Sec B). **95:** 253-63.

40. Solanki, H. A. (2007): Ecological studies of phytoplankton of Mini Mahi River, Gujarat, India. *Vidya.* **2** (1): 47- 57.

41. Solanki, H.A. (2001): *Study on pollution of soils and water reservoirs near industrial areas of Baroda.* Ph.D Thesis submitted to Bhavnagar University, Bhavnagar.

42. Swarnalatha, N. and Narasingrao, A. (1998): Ecological studies of Banjara lake with reference to water pollution. *J. Environ. biol.* **19** (2): 179-186.

43. UdhayaKumar J., Natarajan D., Srinivasan K., Mohansundari, C. and Balasurami, M. (2006): Physicochemical and Bacteriological Analysis of water from Namakkal and Erode Districts, Tamilnadu, India. *Poll Res.* **25** (3): 495-498.

44. Venkatasubramani, R. and Meenambal, T. (2007): Study of subsurface water quality in Mattupalayam Taluk of Coimbatore district Tamil Nadu. *Nat. Environ. Poll. Tech.* **6:** 307-310.

45. Verma, P., Chandawat, D., Gupta, U. and Solanki, H. (2012): Water Quality Analysis of an Organically Polluted Lake by Investigating Different Physical and Chemical Parameters. *Int. J. Res. Chem. Environ.* **2** (1): 105 – 111.

46. Verma, S.R., Tyagi, A.K. and Delela, R.C. (1978): Physico- Chemical and Biological characteristics of Kadrabad in Uttar Pardesh, *Ind. J. Environ. Hlth.* **20:** 1-13.

47. Vijayan V.S. (1991): Keoladeo National Park Ecology Study. *Final report BNHS,* Bombay.

48. Vora, A.B., Ahluwalia, A.A., Gupta, R.Y. (1998): Study on water and soil, vegetation, zooplanktona and zoobenthos. In: Environmental Impact Assessment of Sardar Sarovar Project on Nalsarovar Bird Sanctuary, Gujarat Ecological Education and Research (GEER) Foundation, Gandhinagar.

49. Zafar, A.R. (1964): Ecology of algae in certain fish ponds of Hyderabad, India. III- The periodicity. *Hydrobiologia.* **30** (1): 96- 112.