

## **A Study on Water Quality Status of Major Lakes in Tamil Nadu**

**R.Rajamanickam**

Tamil Nadu Pollution Control Board  
Chennai, Tamilnadu, India  
rajmak20@yahoo.co.in

**S.Nagan**

Department of Civil Engineering,  
Thiagarajar College of Engineering  
Madurai, Tamilnadu, India

---

**Abstract:** *Lakes are considered to be one of the most productive and biologically rich inland surface water eco systems. In Tamil Nadu State, under Monitoring of Indian National Aquatic Resources (MINARS) programme funded by Central Pollution Control Board (CPCB), the water quality of 8 major lakes (i.e) at Ooty, Kodaikanal, Yercaud, Pulicat, Poondi, Red Hills, Veeranam and Porur are monitored by Tamil Nadu Pollution Control Board (TNPCB) on monthly basis by collecting water samples. The lakes in hill stations (i.e) at Ooty, Kodaikanal and Yercaud are monitored since 1988. The other lakes are monitored since December 2010. The monitoring report reveals that the lakes are generally meeting criteria for Class-C Drinking water source with conventional treatment prescribed by CPCB. However the level of Total Coliform, Fecal Coliform and Biochemical Oxygen Demand were found high in Ooty lake. BOD was found to be more than the criteria level in Kodaikanal, Yercaud and Porur lakes. This is mainly due to mixing of sewage and contaminated surface-runoff into lakes.*

**Keywords:** *Tamil Nadu, Lakes, Water Quality Status*

---

### **1. INTRODUCTION**

Lakes are an important feature of the Earth's landscape. They are extremely valuable ecosystems and provide a range of goods and services to humankind. They are not only a significant source of precious water, but extend valuable habitats to plants and animals, moderate the hydrological extreme events (drought and floods), influence microclimate, enhance the aesthetic beauty of the landscape and offer many recreational opportunities [1].

However, anthropogenic pressures on lakes have increased rapidly in recent decades. Major changes have occurred in the land use in their catchments where natural vegetation is cleared, and agricultural, urban and industrial activities are intensified. These anthropogenic activities (deforestation, agriculture, urban settlements and industries) have accelerated the aging process as increased amounts of sediments, nutrients and toxic substances enter lakes with the runoff [2]. Most lakes are in different stages of degradation in various ways - through eutrophication, toxic pollution or habitat loss. In addition the catchment based activities have been accompanied by encroachment on lake-shores by reclaiming shallow lake margins, sewage disposal, water abstraction, and diversification of in-lake recreational activities. All these activities directly cause rapid degradation of lakes.

Most important and common form of lake degradation is that of deterioration of water quality due to organic pollution from disposal of domestic wastewater and other solid wastes. Eutrophication, (i.e) enrichment with nutrients, is another major and most wide spread problem in almost all lakes. Enrichment occurs due to nutrients entering with the runoff from the catchments. Storm water runoff from urbanized catchments brings a variety of toxic substances besides nutrients and particulate matter. Siltation due to high sediment load in the runoff caused by erosion is also a serious problem in all reservoirs and lakes.

Large reservoirs are affected by silt carried by the rivers from their large catchments whereas in rural lakes much of siltation occurs due to human activities such as agriculture and over grazing in their close vicinity. Invasive aquatic weeds, particularly exotic species such as water hyacinth, are among other factors responsible for rapid degradation of lakes. Finally, equally important contribution to the degradation of lakes are human alteration in hydrology (excessive water abstraction), shoreline modification through landfill or beautification measure that remove natural vegetation and in-lake activities (bathing, washing, idol immersion and disposal of religious offerings).

The Central Pollution Control Board (CPCB) is an apex body in the field of water quality management in India. It classified surface water into five classes based on the requirements to satisfy ‘designated best use’ as per the IS: 2296 – 1982 tolerance limits for inland surface waters subject to pollution. According to CPCB, if a water body or its part is used for multipurpose, then the use which demands highest quality of water is designated as ‘designated best use’. The designated best use classification of surface water and the primary water quality criteria for each class of water body as prescribed by CPCB is given in Table. 1 [3].

**Table1.** Designated best use classification of surface water

Designated best use	Quality Class	Primary water quality criteria
Drinking water source without conventional treatment but with chlorination	A	<ul style="list-style-type: none"> <li>• Total coliform organisms (MPN/100ml) shall be 50 or less</li> <li>• pH between 6.5 and 8.5</li> <li>• Dissolved Oxygen 6 mg/L or more, and</li> <li>• Biochemical Oxygen Demand 2mg/L or less</li> </ul>
Outdoor bathing (organized)	B	<ul style="list-style-type: none"> <li>• Total coliform organisms (MPN/100ml) shall be 500 or less</li> <li>• pH between 6.5 and 8.5</li> <li>• Dissolved Oxygen 5 mg/L or more, and</li> <li>• Biological Oxygen Demand 3 mg/L or less</li> </ul>
Drinking water source with conventional treatment	C	<ul style="list-style-type: none"> <li>• Total coliform organisms (MPN/100ml) shall be 5000 or less</li> <li>• pH between 6.0 and 9.0</li> <li>• Dissolved Oxygen 4mg/L or more, and</li> <li>• Biological Oxygen Demand 3 mg/L or less</li> </ul>
Propagation of wildlife and fisheries	D	<ul style="list-style-type: none"> <li>• pH between 6.5 and 8.5</li> <li>• Dissolved Oxygen 4mg/L or more, and</li> <li>• Free ammonia (as N) 1.2 mg/L or less</li> </ul>
Irrigation, industrial cooling, and controlled disposal	E	<ul style="list-style-type: none"> <li>• pH between 6.0 and 8.5</li> <li>• Electrical conductivity less than 2250 micro mhos/cm</li> <li>• Sodium Absorption Ratio less than 26, and Boron less than 2 mg/L</li> </ul>

Source: CPCB: MINARS/27/2007-08

CPCB in collaboration with concerned State Pollution Control Boards (SPCBs)/Pollution Control Committees (PCCs) established a nationwide network of water quality monitoring comprising 2500 stations in 28 States and 6 Union Territories under the programme i.e. Global Environmental Monitoring System (GEMS), Monitoring of Indian National Aquatic Resources System (MINARS) and Yamuna Action Plan (YAP). The monitoring is done on monthly or quarterly basis in surface waters and on half yearly basis in case of ground water. The monitoring network covers 445 Rivers, 154 Lakes, 12 Tanks, 78 Ponds, 41 Creeks/Seawater, 25 Canals, 45 Drains, 10 Water Treatment Plant (Raw Water) and 807 Wells. Among the 2500 stations, 1275 are on rivers, 190 on lakes, 45 on drains, 41 on canals, 12 on tanks, 41 on creeks/seawater, 79 on ponds, 10 Water Treatment Plant (Raw Water) and 807 are groundwater stations [4], [5]. In Tamil Nadu there are 55 stations, among these, 47 stations are on rivers (Cauvery and its tributaries 33, Tamirabarani 12, Palar 1, Vaigai 1) and 8 stations are on lakes. (one station in each lake i.e. Ooty, Kodaikanal, Yercaud, Pulicat, Poondi, Red Hills, Veeranam, Porur) [6].

## 2. STUDY AREA

Tamilnadu is endowed with 39,202 lakes. These lakes are under the control of Public Works Department, local bodies, like Corporations, Municipalities, Panchayat Unions, and other departments. Lake around Chennai namely Red hills, Poondi, Chembarambakkam are used as main drinking water sources for Chennai metropolis [7]. Lakes at Ooty, Kodaikanal and Yercaud are main attraction to the tourists. Lakes at Vedanthangal, Pulicat and others are breeding sites for migration birds.

### 2.1. Ooty Lake

Ooty is in Nilgiris district of Tamilnadu situated at an altitude of 2240 metres. Ootacamund is called Ooty and also as 'Queen of Hill stations'. Ooty lake is the main attraction of this hill station to the tourists. Ooty lake has been formed during 1823-24 by the then Collector of Coimbatore district Mr John Sullivan. The original area of the lake was 65 hectares in the year 1823 and it is shrunken to the present status of 23 hectares [8], [16]. The main reason for the shrinkage of the lake is the encroachment and the silt deposition. The maximum depth of the lake is 12 metres and average depth of 6 metres.

### 2.2. Kodaikanal Lake

Kodaikanal is in Dindigul district of Tamilnadu situated at an elevation of 2285 metres, Kodaikanal town is one of the best hill stations of Tamilnadu and Kodaikanal lake is the main attraction of tourists. Kodaikanal lake has been formed during 1863 by the then collector of Madurai district Sir Venci Henry Levin [8]. The water spread area of the lake is 26.30 hectares. Its maximum depth is 11.50 metres and average depth is 3 metres.

### 2.3. Yercaud Lake

Yercaud village is a small hill station located on the Servarayan Hills at an altitude of 1320-1400 metres above sea level. The area of the Yercaud town is 6 km<sup>2</sup> (600 hectares), and the present populations is 11,582 (2011 censuses). The area is sloping from South to North, and Yercaud lake is located in the North-West end of the village (i.e) in the lower end of the village at an altitude of 1350 metres above sea level. The lake has a water spread area of 11.5 hectares. The lake has an average depth of 4 m and about 10 metre deep at the Eastern end. The outlet of the lake is a small river which runs dry during the dry season [9].

### 2.4. Pulicat Lake

Pulicat Lake is the second largest brackish – water lake or lagoon in India, after Chilika Lake. It straddles the border of Andhra Pradesh and Tamil Nadu states on the Coromandal Coast in South India and it is about 60 km of north from Chennai. The lake encompasses the Pulicat Lake Bird Sanctuary. The barrier island of Sriharikota separates the lake from the Bay of Bengal. The area of the lake is 250–450 km<sup>2</sup> (from low tide to high tide) and the average depth is 1 metre and the maximum depth is 10 metres.

### 2.5. Poondi Reservoir

Poondi Reservoir (later named as Sathyamoorthy Sagar) was constructed in 1944 across the Kosasthalaiyar River or Koratralaiyar River in Thiruvallur district with a capacity of 91 million cubic metre and placed in service for intercepting and storing Kosasthalaiyar River water. Surplus water flows down the river which is again intercepted at Tamaraiykkam Anicut and diverted to Sholavaram Lake and Puzhal lake. A lined canal known as Poondi Canal was later constructed in 1972 to convey water from Poondi Reservoir to Sholavaram Lake.

### 2.6. Red Hills Lake

Puzhal lake also known as the Red Hills Lake is located in Ponneri Taluk of Thiruvallur district, Tamil Nadu. It is one of the rain-fed lakes from where water is drawn for supply to Chennai City, the others being the Chembarambakkam Lake and Porur Lake. The full capacity of the lake is 93 million m<sup>3</sup>.

### 2.7. Veeranam Lake

Veeranam Lake is located 14 km SSW of Chidambaram in Cuddalore district. The lake located 235 km from Chennai, is one of the water reservoirs from where water is supplied to Chennai. Veeranam Lake was made during the regime of the Chola dynasty. It was built from 1011 to 1037 AD during the tenth century. Veeranam Lake receives water from Kollidam via Vadavar River. The full capacity of the lake is 41.23 million m<sup>3</sup>.

### 2.8. Porur Lake

Porur Lake is located on the fringes of the suburb of Porur in south-west Chennai and is a primary water resource for people residing in Chennai. It is actually a temporary catchment area connected with Chembarambakkam Lake. It is spread over 200 acres with a capacity of 1.3 million m<sup>3</sup>.

### 3. MATERIALS AND METHODS

Under the CPCB's MINARS monitoring programme, the water samples are collected on monthly basis by the Tamil Nadu Pollution Control Board (TNPCB) and got analyzed in its laboratories. Ooty, Kodaikanal and Yercaud lakes are monitored since 1988 and Pulicat, Poondi, Red Hills, Veeranam, and Porur lakes are monitored since December 2010 [6]. The water samples are analyzed for the parameters including Dissolved Oxygen, pH, Conductivity, Biochemical Oxygen Demand, Nitrate, Fecal coliform, Total coliform, Turbidity, Phenolphthalein alkalinity, Total alkalinity, Chlorides, Chemical Oxygen Demand, Total Kjeldahl Nitrogen, Ammonical Nitrogen, Hardness, Calcium, Magnesium, Sulphate, Sodium, Total Dissolved Solids, Total Fixed Solids, Total Suspended Solids, Phosphate, Boron, Potassium, and Fluoride. The monitoring data is published in the TNPCB's Annual Report every year [6]. From the TNPCB's Annual reports, the water quality of the lakes is compiled and given in Table 2-6. The data given in the Tables are annual average of the parameters analyzed every month. Data from 2001 to 2015 is given in Tables. The columns left as blank meant that monitoring was not done for that particular year and particular parameter.

**Table2.** Water Quality of Ooty Lake

S.No.	Parameters	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	pH	6.6-7.3	6.8-7.6	6.9-7.8	7.1-8.7	5.7-8.2	6.8-8.1	6.49-7.38	6.88-7.22	6.98	7.26	7.57	7.46	7.27	8.11	7.4
2	Dissolved Oxygen (mg/L)	4.2	2.9	3	5	4.2	5.2	4.9	3.46	4.63	4.68	5.5	4.63	4.8	6.44	5
3	BOD (mg/L)	8.8	5	11.5	18	10.2	9.3	14	16	8	13	8.3	11	16	6.89	8.03
4	Fecal Coliform (MPN/100mL)	155240	11556	530675	15980	2579	1396	2481	44893	39778	111443	25178	5353	7889	15726	10532370
5	Total Coliform (MPN/100mL)	381778	34367	1489833	28050	11085	3822	5750	58433	57443	150545	44975	10322	13689	29892	59570963
6	TDS (mg/L)		256	300									244	276	225	285.04
7	Chlorides (mg/L)	60	45	50	59	73	48	44	63	30			48	52	41.55	47.7
8	Sulphates (mg/L)	10	4	32	4	14	14	5.6	13	18			14	5	5.61	14.76
9	Nitrates (mg/L)	0.09	0.12	0.77	0.9	0.44	0.83	1.9	0.73	0.99	2.48	1	11	0.32	0.37	0.34
10	Nitrites (mg/L)										4.82	0.25				
11	Total Hardness (mg/L)	125	107	220	112	120	97	131	190	89			113	123	98.92	111.52
12	Conductivity ( $\mu$ mhos/cm)												407	454	353.95	456
13	COD (mg/L)												46	67	54.55	70.43
14	TSS (mg/L)												14	24	6.18	30.81
15	Turbidity (NTU)												12	13	10.94	32.56
16	Phenopthaline Alkalinity (mg/L)												0	<1	<1	1.37
17	Total Alkalinity (mg/L)												102	125	101.21	127.70
18	Total Kjeldahl Nitrogen (mg/L)												5	8	3.45	8.06
19	Ammonical Nitrogen (mg/L)												1.2	1	0.65	2.5
20	Calcium as Ca <sup>++</sup> (mg/L)												33	35	30.07	32.47
21	Magnesium as Mg <sup>++</sup> (mg/L)												7	9	5.69	7.48
22	Sodium (mg/L)												36	37	30.06	33.82
23	Total Fixed Solids (mg/L)												228	257	193.41	251.85

## A Study on Water Quality Status of Major Lakes in Tamil Nadu

24	Phosphates (mg/L)																	0.02	<0.005	<1	0.04	
25	Boron (mg/L)																		<0.002	<1	0.00	
26	Potassium (mg/L)																		12	13	11.51	13.67
27	Fluoride (mg/L)																		0.29	0.19	0.18	0.37

Source: TNPCB

**Table3.** Water Quality of Kodaikanal Lake

S.No.	Parameters	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	pH	6.3-7.8	6.8-8.5	7.3-8.7	6.1-7.5	6.1-8.0	6.4-7.9	6.19-7.28	7.05-7.52	6.81	6.51	6.66	6.51	7.01	7.88	7.1
2	Dissolved Oxygen (mg/L)	6.7	6.6	6.1	7	5.5	6.4	6.53	6.2	6.6	6.06	5.85	6.36	5.7	5.03	4
3	BOD (mg/L)	10.8	5.7	6.9	7	7.9	2.7	2.01	4.9	4.7	7	7.27	9	6	4.83	5
4	Fecal Coliform (MPN/100mL)	123	110	86	85	56	9	12	14	7	12	10	6	46	8.88	9
5	Total Coliform (MPN/100mL)	158	165	135	128	101	25	40	27	21	29	22	12	92	12.67	13
6	TDS (mg/L)		77	48									61	179	69.33	66.78
7	Chlorides (mg/L)	20	25	15	15	21	19	17.3	13	37			22	38	14.84	15.15
8	Sulphates (mg/L)	5	10	6	8	4	4.4	5.6	10	16			10	14	9.06	5.19
9	Nitrates (mg/L)	0.18	0.17	0.21	0.1	0.09	0.04	0.06	0.21	0.09	0.23	0	0.2	0.87	0.37	0.92
10	Nitrites (mg/L)										0.04	0.01				
11	Total Hardness (mg/L)	35	23	21	28	22	37	25.3	18	10			27	81	32.24	30.78
12	Conductivity ( $\mu$ mhos/cm)												102	272	103.14	104
13	COD (mg/L)												55	37	47.52	55.36
14	TSS (mg/L)												27	18	11.11	10.17
15	Turbidity (NTU)												7	17	3.85	3.39
16	Phenopthaline Alkalinity (mg/L)												0	9	<1	1.08
17	Total Alkalinity (mg/L)												29	86	22.78	28.82
18	Total Kjeldahl Nitrogen (mg/L)												5	16	1.31	0.34
19	Ammonical Nitrogen (mg/L)												0.1	<0.56	2.05	2.2
20	Calcium as Ca <sup>++</sup> (mg/L)												6	18	9.33	8.88
21	Magnesium as Mg <sup>++</sup> (mg/L)												3	10	2.81	1.82
22	Sodium (mg/L)												8	28	11.73	6.63
23	Total Fixed Solids (mg/L)												27	150	58.45	62.39
24	Phosphates (mg/L)												0.01	<0.005	0.59	0.15

25	Boron (mg/L)													0	<0.002	<1	0.43
26	Potassium (mg/L)													3	5	4.43	2.12
27	Fluoride (mg/L)													0.18	0.59	0.34	0.31

Source: TNPCB

Table 4. Water Quality of Yercaud Lake

S.No	Parameters	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	pH	7.4-8.6	7.2-8.9	6.5-8.2	7.6-8.9	6.4-7.9	6.8-8.5	6.64-7.87	7.0-7.26	7	7.63	7.8	7.9	7.58	8	7.7
2	Dissolved Oxygen (mg/L)	6.7	8.9	7.2	6.9	7	7.6	6.5	7.6	6	6.63	6.2	6.42	6.3	5.74	6
3	BOD (mg/L)	1.3	1.9	8.6	2.7	2.1	3.1	4.1	1.7	1	3	2.2	3	3	5.86	3.54
4	Fecal Coliform (MPN/100mL)	1078	292	476	453	126	538	173	558	2259	436	13308	439	369	7867.4	59164
5	Total Coliform (MPN/100mL)	2431	1056	2169	3327	604	1500	422	790	3039	743	31618	733	638	14952.29	133705
6	TDS (mg/L)		232										182	199	147.37	256.11
7	Chlorides (mg/L)	37	30		53	53	35	37	40	41			37	41	28.19	54.56
8	Sulphates (mg/L)	2	10		39	4.5	4	6.3	6	2.3			6	3	7.34	7.08
9	Nitrates (mg/L)	0.08	0.08	0.2	0.2	0.11	0.13	0.1	0.3	1	0.15	1	0.3	0.48	0.37	0.27
10	Nitrites (mg/L)										0.02	0.13				
11	Total Hardness (mg/L)	98	69		117	81	87	73	150	63			88	105	65.58	99.64
12	Conductivity (µ mhos/cm)												265	305	228.68	371
13	COD (mg/L)												27	26	51.03	63.36
14	TSS (mg/L)												127	43	8.65	35.69
15	Turbidity (NTU)												32	18	7.39	19.19
16	Phenolphthaleine Alkalinity (mg/L)												2	4	<1	4.45
17	Total Alkalinity (mg/L)												89	140	62	116.33
18	Total Kjeldahl Nitrogen (mg/L)												3	5	2.38	5.50
19	Ammonical Nitrogen (mg/L)												1	1	1.35	1.9
20	Calcium as Ca <sup>++</sup> (mg/L)												25	30	19.70	26.21
21	Magnesium as Mg <sup>++</sup> (mg/L)												6	8	4.25	8.93
22	Sodium (mg/L)												27	28	20.90	37.26
23	Total Fixed Solids (mg/L)												171	189	125.93	232.33
24	Phosphates (mg/L)												0.01	<0.005	0.59	0.05
25	Boron (mg/L)												0	<0.002	<1	0
26	Potassium (mg/L)												8	8	7.97	11.08
27	Fluoride (mg/L)												2.59	0.20	0.26	0.42

Source: TNPCB

## A Study on Water Quality Status of Major Lakes in Tamil Nadu

**Table5.** Water Quality of Pulicat, Poondi and Red Hills Lakes

S.No.	Parameters	Pulicat Lake				Poondi Lake				Red Hills Lake			
		2012	2013	2014	2015	2012	2013	2014	2015	2012	2013	2014	2015
1	pH	8.07	7.79	7.75	7.6	8.22	8.29	7.9	7.5	8.14	8.08	7.91	7.6
2	Dissolved Oxygen (mg/L)	5.71	6.3	5.93	6	6.03	6.7	6.46	6	6.16	7.3	6.85	8
3	BOD (mg/L)	3	9	2.45	2.08	2	3	2.08	2.47	2	2	1.92	2
4	Fecal Coliform (MPN/100mL)	173	321	263.33	373	997	1041	1000	715	1709	2074	1158.33	957
5	Total Coliform (MPN/100mL)	585	726	548.33	804	2424	3005	2465.83	1785	4744	4196	3140.83	2230
6	TDS (mg/L)	26911	33986	33705.55	37159.58	341	419	518.17	454.18	322	482	400.5	370.33
7	Chlorides (mg/L)	14670	17018	15883.18	17943.25	68	74	100.92	104.09	65	82	98.67	85
8	Sulphates (mg/L)	1948	2273	2645.09	2385	37	43	63.58	54.82	33	41	58.67	52.67
9	Nitrate (mg/L)	0.7	0.08	0.74	0.6	0.1	0.15	0.69	0.76	0.2	0.3	0.7	0.57
10	Total Hardness (mg/L)	4006	5289	5578.18	7208.33	95	87	134.83	152.36	91	92	144.08	125
11	Conductivity ( $\mu$ mhos/cm)	39873	46874	-	47405	501	609	739.58	674	498	689	583	562
12	COD (mg/L)	40	-	-	-	11	21	8	8	9	21	8	8
13	TSS (mg/L)	54	502	642.09	685.33	4	15	7.67	18.91	4	18	7.5	21.33
14	Turbidity (mg/L)	4	3	5.67	23	2	6	4	10.25	2	6	6.25	7.33
15	Phenophthaline Alkalinity (mg/L)	9	13	15	8.92	5	10	8.6	9.45	2	5	8.75	8.5
16	Total Alkalinity (mg/L)	111	112	126.82	128.42	148	135	145.42	134.55	119	126	131.92	122.33
17	Total Kjeldahl Nitrogen (mg/L)	29	13	10.82	12.67	41	10	11.42	13.82	23	13	12.43	14.58
18	Ammonical Nitrogen (mg/L)	5	3	3.48	3	6	3	4.08	3.2	4	3	4.05	3.6
19	Calcium as Ca <sup>++</sup> (mg/L)	340	516	782.91	1158.67	23	20	31.75	36.36	25	19	27.17	25.92
20	Magnesium as Mg <sup>++</sup> (mg/L)	740	914	884.45	1078.83	9	9	13.42	15	7	11	18.5	14.33
21	Sodium (mg/L)	7318	9347	10895.45	8333.75	70	93	114.67	68.09	58	82	104.08	53.67
22	Total Fixed Solids (mg/L)	24784	27975	29085.09	31141.92	309	332	395.92	373.64	283	336	309.08	293.92
23	Phosphate (mg/L)	0.11	0.5	0.22	2.83	0.07	0.04	0.12	2.89	0.05	0.1	0.58	3.06
24	Boron (mg/L)	0	0.2	0.29	0.71	0	0.1	0.23	0.26	0	0	0.29	0.39
25	Potassium (mg/L)	236	398	321.78	177.5	6	10	7.83	4.64	5	8	7.5	3.75
26	Fluorides (mg/L)	0.58	0.67	1.33	1.26	0.33	0.58	0.57	0.37	0.25	0.54	0.4	0.36

Source: TNPCB

**Table6.** Water Quality of Veeranam, and Porur Lakes

S.No.	Parameters	Veeranam Lake				Porur Lake			
		2012	2013	2014	2015	2012	2013	2014	2015
1	pH	7.87	8.49	8.43	8.3	8.36	8.44	8.04	8.2
2	Dissolved Oxygen (mg/L)	7.13	6.8	8.14	8	6.3	7.1	6.44	6
3	BOD (mg/L)	2	1	2.23	2.94	3	4	3.97	2.08

4	Fecal Coliform (MPN/100mL)	131	148	887.28	28964	1495	2399	4441.47	888
5	Total Coliform (MPN/100mL)	270	286	1512.22	49009	3725	4180	8662.63	2400
6	TDS (mg/L)	328	452	393.83	328.89	306	397	292.44	470.33
7	Chlorides (mg/L)	65	124	89.92	59.78	84	89	62.35	141.42
8	Sulphates (mg/L)	22	26	36.28	27	18	28	30.09	49.67
9	Nitrate (mg/L)	0.2	0.51	0.25	0.3	0.2	0.09	0.46	0.66
10	Total Hardness (mg/L)	145	156	147.53	131.06	83	82	103.86	132.17
11	Conductivity ( $\mu$ mhos/cm)	500	736	630	473	472	606	439.92	710
12	COD (mg/L)	16	21	43.2	52.67	16	27	35.38	8
13	TSS (mg/L)	5	7	10.78	17.11	7	14	8.65	29.33
14	Turbidity (mg/L)	6	4	7.68	2.58	3	8	6.69	5
15	Phenophthaline Alkalinity (mg/L)	7	8	14.96	12	4	6	10.77	4.83
16	Total Alkalinity (mg/L)	148	151	155.22	146.01	112	111	103.09	121.67
17	Total Kjeldahl Nitrogen (mg/L)	3	3	10.31	3.72	23	12	6.88	14.08
18	Ammonical Nitrogen (mg/L)	1	1	0.63	1.4	4	4	2.14	3.3
19	Calcium as Ca <sup>++</sup> (mg/L)	24	22	29.78	23.7	21	22	24.63	36.67
20	Magnesium as Mg <sup>++</sup> (mg/L)	20	24	19.56	17.97	10	6	10.7	9.83
21	Sodium (mg/L)	61	112	72.44	58.72	57	68	58.98	60.33
22	Total Fixed Solids (mg/L)	303	438	360.83	306.89	277	307	240.61	361.83
23	Phosphate (mg/L)	0.06	<0.005	<1	0.05	0.03	0.2	0.47	2.1
24	Boron (mg/L)	0	<0.002	<1	0.45	0	0.1	0.26	0.38
25	Potassium (mg/L)	5	5	5.86	6.98	9	12	7.51	5.92
26	Fluorides (mg/L)	0.26	0.22	0.21	0.34	0.43	0.11	0.33	0.39

Source: TNPCB

#### 4. RESULTS AND DISCUSSION

The lakes located in the hills (i.e), Ooty, Kodaikanal and Yercaud are grouped together and the lakes located in plains (i.e) Pulicat, Poondi, Red Hills, Veeranum, and Porur are grouped together and their water quality is presented in Figure 1-9.

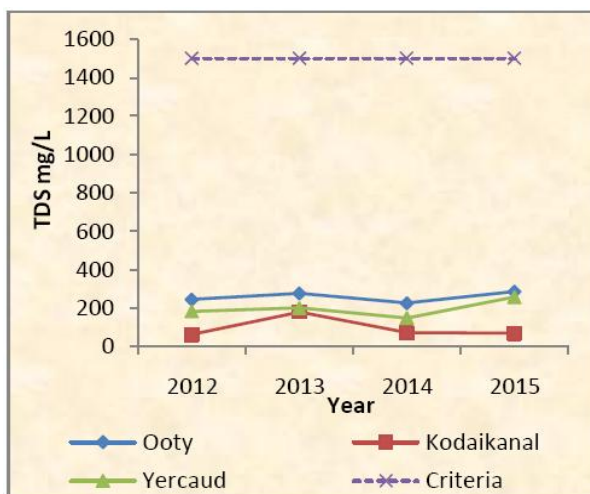


Figure 1(a) TDS level in lakes

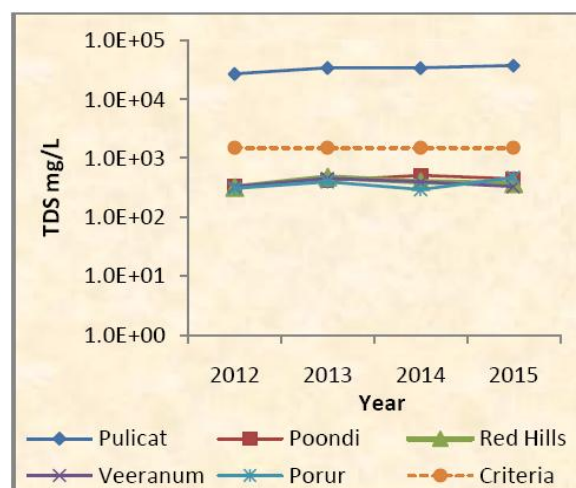


Figure 1(b) TDS level in lakes



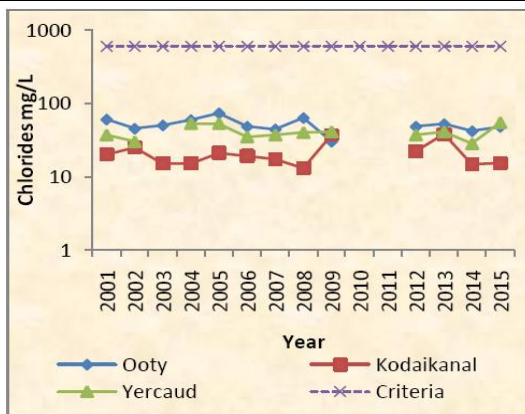


Figure 2(a) Chlorides level in lakes

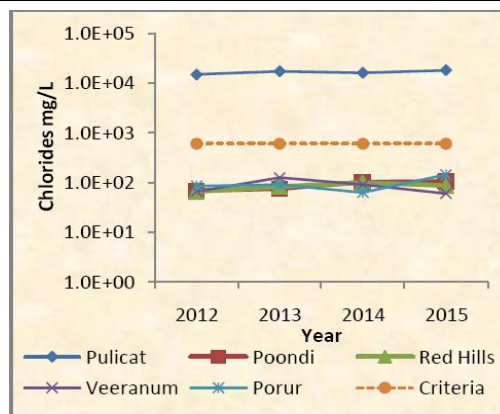


Figure 2(b) Chlorides level in lakes

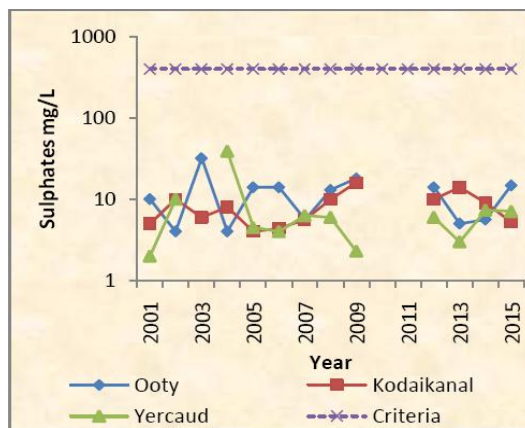


Figure 3(a) Sulphates level in lakes

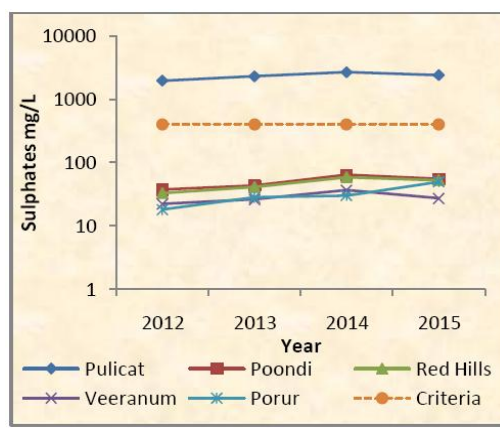


Figure 3(b) Sulphates level in lakes

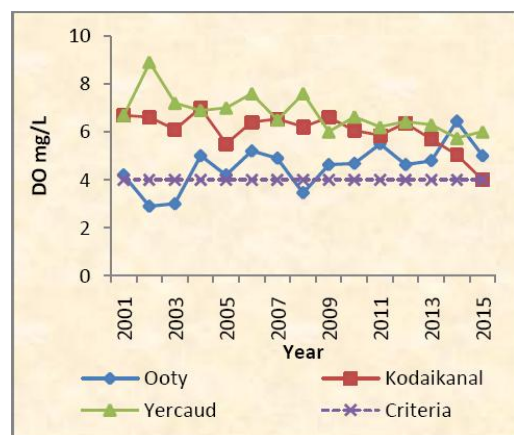


Figure 4(a) DO level in lakes

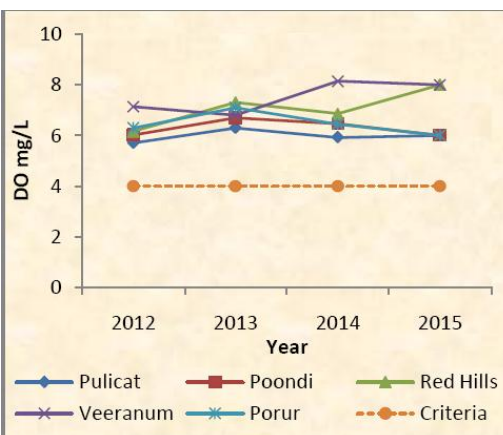


Figure 4(b) DO level in lakes

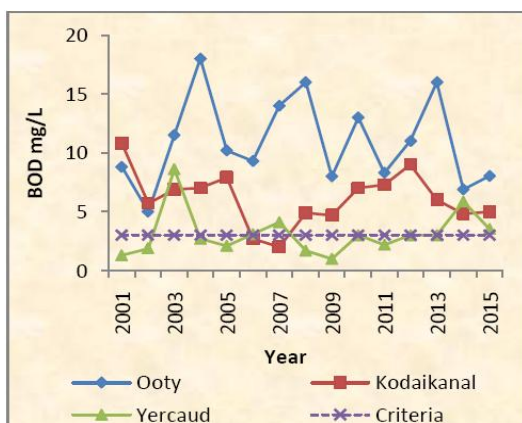


Figure 5(a) BOD level in lakes

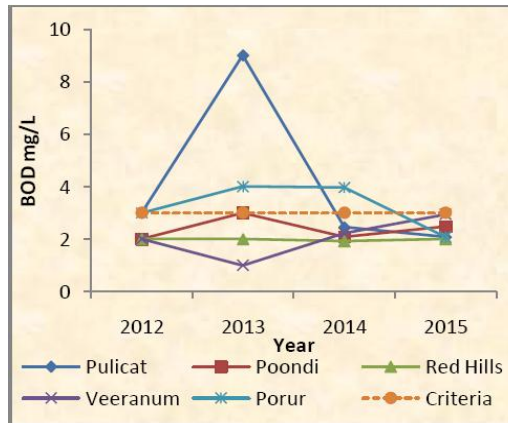


Figure 5(b) BOD level in lakes

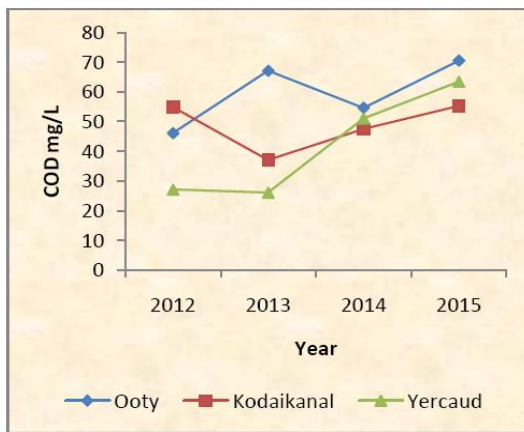


Figure 6(a) COD level in lakes

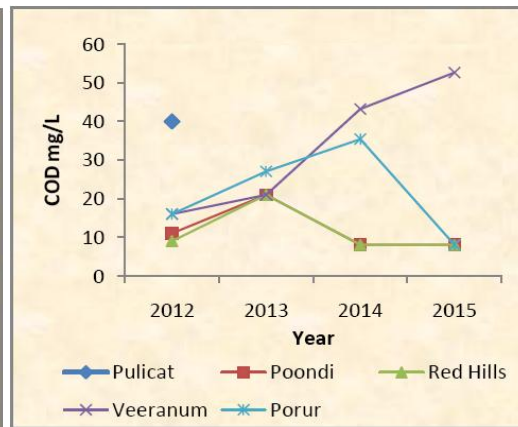


Figure 6(b) COD level in lakes

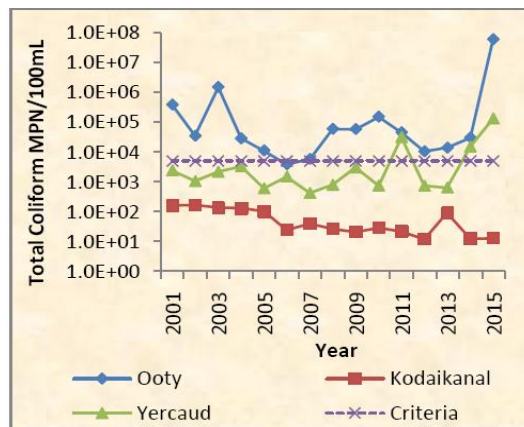


Figure 7(a) Total Coliform level in lakes

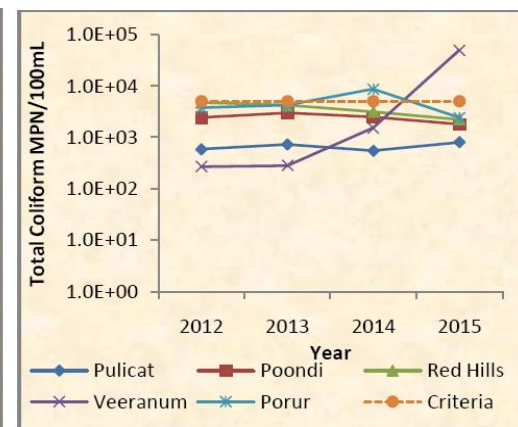


Figure 7(b) Total Coliform level in lakes

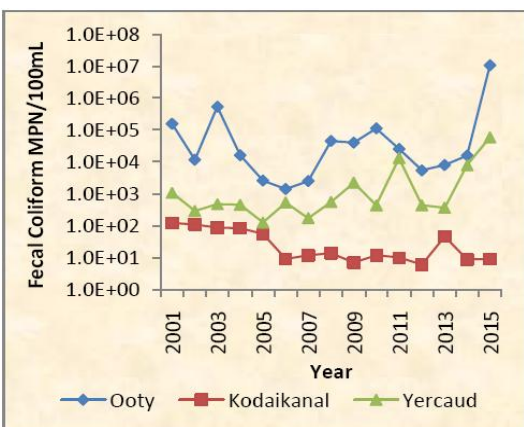


Figure 8(a) Fecal Coliform level in lakes

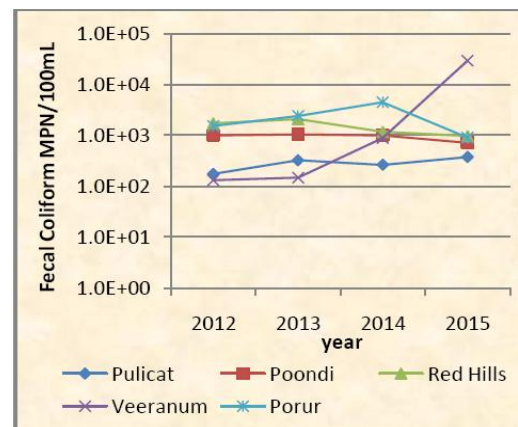


Figure 8(b) Fecal Coliform level in lakes

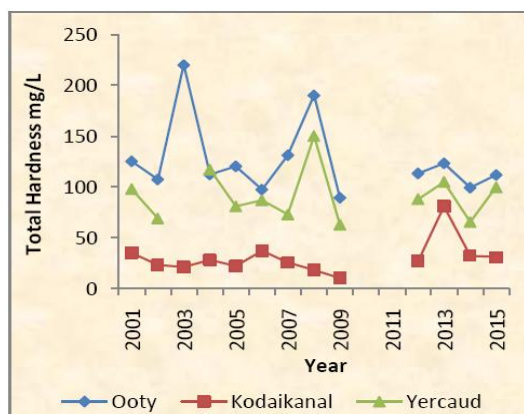


Figure 9(a) Total Hardness level in lakes

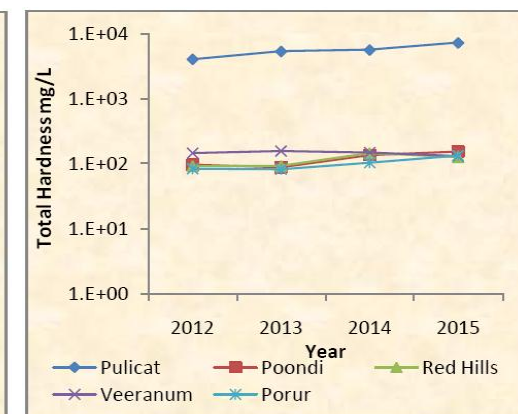


Figure 9(b) Total Hardness level in lakes

### 4.1. pH

The pH is largely depends on  $\text{CO}_2$ ,  $\text{CO}_3$  and  $\text{HCO}_3$  [10]. As per CPCB criteria, the pH level in the lake should be between 6.5 and 8.5. The study reveals that the pH in Ooty lake 5.7 – 8.7, Kodaikanal lake 6.1 – 8.0, Yercaud lake 6.4 – 8.9, Pulicat lake 7.6 – 8.07, Poondi reservoir 7.5 – 8.29, Red Hills lake 7.6 – 8.14, Veeranam lake 7.87 – 8.49, Porur lake 8.04 – 8.44. The pH is meeting the desired criteria in all the lakes.

### 4.2. Total Suspended Solids

Total Suspended Solids (TSS) indicate the visual level of pollution that a lake may have been exposed to. The study shows the TSS in Ooty lake 6 – 30 mg/L, Kodaikanal lake 10 – 27 mg/L, Yercaud lake 9 - 127 mg/L, Pulicat lake 54 - 68 mg/L, Poondi reservoir 4 – 19 mg/L, Red Hills lake 4 - 21 mg/L, Veeranam lake 5 - 17 mg/L, Porur lake 7 - 29 mg/L.

### 4.3. Electrical Conductivity

The Electrical conductivity, which is indicative of the total concentration of dissolved ions, is a valuable tool in assessing water quality. The recommended value of EC as per CPCB is < 2250 micro mhos/cm. The EC values of the samples in Ooty lake 225 – 285 micro mhos/cm, Kodaikanal lake 102 – 272 micro mhos/cm, Yercaud lake 228 – 371 micro mhos/cm, Pulicat lake 39873 – 47405 micro mhos/cm, Poondi reservoir 501 – 739 micro mhos/cm, Red Hills lake 498 – 689 micro mhos/cm, Veeranam lake 473 – 736 micro mhos/cm, and Porur lake 439 – 710 micro mhos/cm. All the lakes were meeting the criteria except Pulicat lake which is a brackish water lake.

### 4.4. Total Dissolved Solids

Total dissolved solids (TDS) refer to solid matter dissolved in water. TDS is a measure of all constituents dissolved in water. The inorganic anions dissolved in water include carbonates, chlorides, sulphates and nitrates. The inorganic cations include sodium, potassium, calcium and magnesium [10], [14]. High solids may adversely affect water quality. Water with high solids tend to be less palatable, and may cause transient gastrointestinal distress in non-acclimatized consumers. High mineral content in water may also limit its use in many industries. IS 2296: 1982 Tolerance limit of chloride for Class C surface water is 1500 mg/L. The study shows TDS levels in all the lakes were well below the tolerance level except Pulicat lake which is brackish water, where the TDS level was in the range of 26911 – 37159 mg/L.

### 4.5. Chlorides

Chloride is one of the major anions commonly found in water. Chlorides may get into surface water from several sources including: wastewater from industries and municipalities; wastewater from water softening; agricultural runoff. IS 2296: 1982 Tolerance limit of chloride for Class C surface water is 600 mg/L. The study shows chloride level in all the lakes were well below the tolerance level except Pulicat lake which is a brackish water where the chlorides level was in the range of 14670 - 17943 mg/L.

### 4.6. Sulphates

Sulphates are a constituent of TDS and may form salts with sodium, potassium, magnesium and other cations. Sulphates are widely distributed in nature and may be present in natural waters at concentrations ranging from a few to several hundred milligrams per litre. IS 2296: 1982 Tolerance limit of Sulphates for Class C surface water is 400 mg/L. The study shows sulphate level in all the lakes were well below the tolerance limit except Pulicat lake where the sulphates level was in the range of 1948 - 2645 mg/L.

### 4.7. Nitrates

Nitrogen fertilizer is the nutrient applied in large quantities for crop production. In addition to fertilizer, nitrogen occurs naturally in the soil in organic forms from decaying plant and animal residues. In the soil, bacteria convert various forms of nitrogen to nitrate. This is desirable as the majority of the nitrogen used by plants is absorbed in the nitrate form. However, nitrate is highly leachable and readily moves with water through the soil profile. If there is excessive rainfall or over-irrigation, nitrate will be leached below the plant's root zone and may eventually reach groundwater. IS 2296: 1982 Tolerance limit of Nitrate for Class C surface water is 50 mg/L. The study shows nitrate level in all the lakes were well below the tolerance limit.



#### 4.8. Dissolved Oxygen, Biochemical Oxygen Demand, and Chemical Oxygen Demand

Dissolved oxygen (DO) is the fundamental fuel of life in water. DO in water is of great importance to all aquatic organisms and is considered to be the factor that reflects the biological activity taking place in a water body and determines the biological changes that are brought out by the aquatic organisms [11], [12], [13]. The Biochemical Oxygen Demand (BOD) is directly linked with decomposition of dead organic matter present in the lake and hence the higher values of BOD can be directly correlated with pollution status and inverse relation with DO concentration.

As per CPCB criteria for Class C, the DO level in the lake should be more than 4mg/L. DO level in Ooty lake was in the range of 2.9 – 6.44mg/L, Kodaikanal lake 4 - 7mg/L, Yercaud lake 5.74 - 8.9 mg/L, Pulicat lake 5.71 – 6.3mg/L, Poondi reservoir 6 – 6.7 mg/L, Red Hills lake 6.16 – 8 mg/L, Veeranam lake 6.8 – 8.14 mg/L, Porur lake 6.00 – 7.10 mg/L. As per CPCB criteria, the BOD level in the lake should be less than 3mg/L. BOD was observed more than the criteria level in all the lakes. BOD level in Ooty lake was in the range of 5 – 16 mg/L, Kodaikanal lake 2.01 - 10.8 mg/L, Yercaud lake 1 - 8.6 mg/L, Pulicat lake 2.08 – 3 mg/L, Poondi reservoir 2.08 – 3 mg/L, Red Hills lake 1.92 – 2 mg/L, Veeranam lake 1 – 2.94 mg/L, Porur lake 2.08 – 3.97 mg/L. Chemical Oxygen Demand (COD) is used to indirectly measure the amount of organic pollutant found in the surface water. It indicates the mass of oxygen consumed to oxidize the organic compounds in the water to carbon dioxide, ammonia, and water. COD level in Ooty lake was in the range of 46 – 70 mg/L, Kodaikanal lake 37 – 55 mg/L, Yercaud lake 26 - 63 mg/L, Pulicat lake 40 mg/L, Poondi reservoir 8 – 21 mg/L, Red Hills lake 8 - 21 mg/L, Veeranam lake 16 - 53 mg/L, Porur lake 8 – 35 mg/L.

#### 4.9. Total Coliform, Fecal Coliform, and E. Coli

Total coliform, Fecal coliform, and E.Coli are all indicators of water quality. The total coliform group is a large collection of different kinds of bacteria. Fecal coliform are types of total coliform that mostly exist in feces. E. coli is a sub-group of Fecal coliform [15]. They appear in great quantities in the intestines and feces of people and animals. The presence of fecal coliform in a water sample often indicates recent fecal contamination, meaning that there is a greater risk that pathogens are present. As per the CPCB criteria for Class C lakes, the TC should be less than 5000 MPN/100mL. Maximum TC level reordered in Ooty lake was  $5.95 \times 10^7$  MPN/100mL, Yercaud 133705 MPN/100mL, Veeranam lake 49009 MPN/100mL, Porur 8662 MPN/100mL. Others lakes were meeting the criteria. Fecal Coliform should be less than 2500 MPN/100mL. The maximum FC level reordered in Ooty Lake was  $1.05 \times 10^7$  MPN/100mL, Yercaud 13308 MPN/100mL, Veeranam lake 28964 MPN/100mL, Porur 4441 MPN/100mL. Others lakes were meeting the criteria.

#### 5. CONCLUSION

The study indicates that organic pollution as expressed in biochemical oxygen demand and coliform counts continue to be the major water quality issues. The following measures will conserve and restore the quality of lake [1], [17]. (i) Prevention of pollution from point source by intercepting, diverting and treating to the standard prescribed and recycled, (ii) In situ measures of lake cleaning such as de-silting, de-weeding, bioremediation, aeration, bio-manipulation, nutrient reduction, withdrawal of anoxic hypolimnion, (iii). Catchment area treatment which includes afforestation, storm water drainage, silt traps etc., (iv). Strengthening of bund, lake fencing, shoreline development, (v). Lake front eco-development including public interface, (vi). Prevention of pollution from non-point source by providing low cost sanitation, (vii). Public awareness and public participation.

#### REFERENCES

- [1] Ministry of Environment and Forests, Government of India, 'Conservation and Management of Lakes – An Indian Perspective', National River Conservation Directorate, 2010.
- [2] CPCB, 'Water Quality Status of Lakes & Reservoirs in Delhi', July 2001.
- [3] CPCB, 'Guidelines for Water Quality Monitoring, MINARS/27/2007-08.
- [4] CPCB, 'Status of Water Quality in India- 2009', Monitoring of Indian National Aquatic Resources, Series: MINARS/36 /2009-10.
- [5] CPCB, 'Status of Water Quality in India- 2012', Monitoring of Indian National Aquatic Resources, Series: MINARS/36 /2013-14.
- [6] TNCBPB, 'Annual Reports from FY 2000-2001 to FY 2014-2015'.

- [7] Neelakandan K.S., 'Conservation and Restoration of Lakes in Tamil Nadu', Proceedings of Taal 2007: The 12<sup>th</sup> World Lake Conference: 1669-1671.
- [8] Annamalai R, Thompson Jacob C and Senthil C, 'Rapid Assessment of Kodaikanal Lake', ENVIS Centre, Department of Environment, Government of Tamil Nadu, May 2009.
- [9] Danish International Development Agency – Danida, 'Project Identification Report on Three lakes - Ooty, Kodaikanal, Yercaud in Tamil Nadu' – May 1991.
- [10] Iowa Department of Natural Resources, 'Water Quality Standards Review:Chloride, Sulfate and Total Dissolved Solids', Consultation Package, February 9, 2009.
- [11] Jumbe A.S., and Nandini N., 'Evaluation of Chemical Impact of Polluted urban wet Lands of Bangalore', CPCB - Studies on Pollution Mitigation Volume II, 2010 pp. 1105-1132.
- [12] Sridhar Kumar A, K. Shankaraiah K, P.L.K.M.Rao and M. Sathyanarayana, 'Assessment of water quality in Hussainsagar lake and its inlet channels using multivariate statistical techniques', International Journal of Scientific & Engineering Research, Volume 5, Issue 9, September-2014, pp 327-333.
- [13] Suneela M, Radha Krishna G, Vamsi Krishnan K, Mangai Sai V, Bhargav V, Syama Sundara Reddy K, Srinivas D.S.S and Srinivas J.S., ' Water and Sediment Analysis of Hussainsagar Lake', Proceedings of Taal 2007: The 12<sup>th</sup> World Lake Conference: pp.304-306.
- [14] Clair N. Sawyer & Perry L. McCarty, 'Chemistry for Environmental Engineering', Third Edition, McGraw Hill International Editions, 1978.
- [15] Santo Domingo J.W., and Edge T.A., 'Identification of Primary Sources of Faecal Pollution', Safe Management of Shellfish and Harvest Waters. World Health Organization (WHO).Edited by G. Rees, K. Pond, D. Kay, J. Bartram and J. Santo Domingo. Published by IWA Publishing, London, UK. 2010.
- [16] Subramani T., 'Study of Pollution Prevention Strategies for Reclamation of Ooty Lake', International Journal of Engineering Research and Applications, Vol. 2, Issue 3, May-June 2012, pp.783-791.
- [17] Illangovan R., 'Restoration of Polluted Lakes – A New Approach', Proceedings of Taal 2007: The 12<sup>th</sup> World Lake Conference: 1321-1328.