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ASSESSMENT OF WATER QUALITY AND POLLUTION OF PORUR DOUBLE LAKE (ERETTAI ERI), CHENNAI

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Key words : Porur double lake (Erettai Eri), Physico-chemical parameters.

ABSTRACT

Water samples were collected from Porur double lake which is also called as "Erettai Eri", one of the primary water resource for people residing in Chennai. Water samples were collected from five different sampling sites including lake, which is the source, treatment (T) and distribution sites (DS). Analyses of physico-chemical parameters like turbidity (NTU), total dissolved solids (mg/L), total suspended solids (mg/L), electrical conductivity (μm/cm), pH, total alkalinity (as $CaCO_3$) (mg/L), total hardness (as $CaCO_3$) (mg/L), calcium (as Ca) (mg/L), magnesium (as Mg) (mg/L), iron (as Fe) (mg/L), nitrite (as NO_2) (mg/L), nitrate (as NO_3) (mg/L), chloride (as Cl) (mg/L), flouride (as F) mg/L), residual chlorine mg/L, sulphate (as SO_4) mg/L, phosphate (as PO_4) (mg/L, dissolved oxygen (DO) (mg/L), biochemical oxygen demand (BOD) (mg/L) and chemical oxygen demand (COD) (mg/L) showed that turbidity, alkalinity, iron, nitrite, phosphate, dissolved oxygen (DO) and residual chlorine in the samples were not observed to be in confirmation with the prescribed limits of BIS (1991) and WHO (1993).

INTRODUCTION

Life on earth would be non-existent without water. Water Comprises over 71% of the earth's surface (Tyler, 1991). Human activities pollute rivers, lakes, and oceans. Subsequently, the drinking water has become greatly affected, along with our ability to use water for recreational purposes. Pollution of fresh water have been reported to occur due to three major reasons ie., excess nutrients from sewage, wastes from industries, mining and agriculture (Mayback *et al*. 1989). World Health Organisation (WHO) has prescribed a set of standard values for drinking water quality (WHO, 2004). These guideline values, alongwith tolerance limits prescribed by the Indian Standard Institute (ISI) (Trivedy, 1990) are considered in determining the quality of the water for human use (Train, 1979)

The importance of water quality is evident from the fact that water borne diseases kill about 50,000 people every day (Herschy, 1999); Warner (1998) has reported that every year about 4 million children under the age of five, die in developing countries due to water - borne diseases. Worldwide about 2.3 billion people suffer from diseases that are linked to

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water and related problems (WHO, 1997) which in turn undermine developmental efforts (Nash, 1993; Olshansky *et al*. 1997 and Asonye *et al*. 2007).

Realizing the importance of the water quality, this study was carried out with an aim to evaluate the physico-chemical quality of the water from Porur double lake (Erettai eri), an important drinking water source for Chennai City, Tamilnadu.

MATERIALS AND METHODS

Water samples were collected on weekly basis for a period of 3 months during November 2007 to January 2008 from five different sampling sites (site-I Porur Lake water which is the water source, site-II K.K.Nagar double tank sump house where the water is treated before distribution and three distribution points viz., site-III K.K.Nagar double tank, site-IV MGR nagar distribution point and site-V Jaffarkhanpet distribution point). The positions of various sampling sites are shown in Fig. 1. Collection and analysis of water samples were carried out following standard methods (APHA,1995).

RESULTS AND DISCUSSION

The physico-chemical parameters recorded in the sampling sites are presented in Table 1a and 1b. Physico-chemical parameters observed in different samplings in the sampling sites during the sampling period are presented in Fig. 2, 3, 4 and 5.

Significant turbidity levels were observed in water samples. The turbidity values in various sites ranged from 1.2 (NTU) to 7.5 (NTU). The turbidity value was maximum and above the permissible limits (BIS, 1991) in site-I during November 2007 and was minimum in site-IV and site-III during November 2007 and January 2008 respectively and Increased turbidity levels recorded in site-I, which is the water source could be attributed to the organic matter and the salts that enter into the lake through various sources.

The total dissolved solids (TDS) values in various sites ranged between 540 mg/L and 190 mg/L. The total dissolved solids values were within the permissible limit prescribed by BIS 1991, WHO 1993. Maximum TDS value was observed in site-I during November 2007 and minimum in the site-III during November 2007. Higher TDS values due to contamination by domestic wastewater, garbage, fertilizer runoff, etc have been documented by various researchers (Singh and Mathur, 2005; Swaranlatha and Rao, 1998; Chaurasia and Pandey, 2007).

The values of the total suspended solid ranged between 2 mg/L and 42 mg/L. The total suspended solids value was maximum at site-I during December 2007 and was minimum in site-III and site-IV during January 2008.

The electrical conductivity (EC) values ranged between 586 micro ohm/cm and 220 micro ohm/cm. The maximum electrical conductivity value was recorded in site-I during December 2007 and minimum was recorded in site-III during November 2007. Higher electrical conductivity values observed in the water samples may be attributed to the release of minerals from the sediments (Abbasi *et al*. 1996) and due to increased concentration of salts at the bottom by siltation and sedimentation (Radhika *et al*. 2004). Decrease in the conductivity could be the result of absorption of settled minerals by the submerged macrophytes, which are normally present in abundance in lakes (Iqbal and Kataria, 1995; Kaushik and Saksena, 1999; Radhika *et al*. 2004).

The pH values in various sites ranged between 8.70 mg/L and 6.08 mg/L. The maximum pH value was recorded at site-I during December 2007 and the minimum pH in site-V during December 2007. These recorded values were within the permissible limits prescribed by BIS 1991 and WHO 1993.

The alkalinity values observed in samples ranged between 320 mg/L and 89 mg/L. The alkalinity value was observed to be maximum in site -I during November 2007 and was minimum in site -II during November 2007. The values were observed to be well above the permissible limits prescribed by BIS (1991) and WHO (1993). High alkalinity levels have been reported to be due to increase in concentration of salts in water due to evaporation and entry of more domestic wastes when the flow rate of water was low (Sankar *et al*. 2002).

The total hardness value was maximum at site-I during December 2007 and in site-IV during January 2008. The minimum value was observed in site -V during December 2007 which was well within the permissible limits of BIS (1991) and WHO (1993).

Calcium as such has no hazardous effect on human health. At low concentration it is known to be non-toxic (Mohan *et al*. 2007).The calcium levels in various sites ranged between 50 mg/L and 22.5 mg/L. Maximum value above the permissible limit (75 mg/L) was observed in site-I & site-IV during November 2007. Minimum value was observed in site-V during December 2007.

Table 1a. Physico-chemical parameters observed in sampling sites - I, II and III during different sampling periods

S. No.	Description	Site - I						
		Nov. 2007	Dec. 2007	Jan. 2008	±SD	ANOVA	WHO 1993	BIS 1991
	PARAMETERS							
PHYSICAL EXAMINATION								
1.	Turbidity NTU	7.5	5.9	6.1	0.8718	34.52	-	5
2.	TDS mg/L	540	398	272	134.0796	26.87	500-1500	500
3.	TSS mg/L	39	42	8	18.8237	6.46		
4.	EC (µ/cm)	510	586	388	99.8866	72.97		
CHEMICAL EXAMINATION								
5.	pH	8.25	8.70	7.8	0.4500	97.45	6.5-9.2	6.5-8.5
6.	Alkalinity Total (as $CaCO_3$) mg/L	320	287	108	114.0716	12.87	0-120	200
7.	Total Hardness (as $CaCO_3$) mg/L	94.5	108	92	8.6072	369.51	100-500	300
8.	Calcium (as Ca) mg/L	50	45.4	24	13.8752	22.15	-	75
9.	Magnesium (as Mg) mg/L	17	10	7	5.1316	9.56	-	-
10.	Iron (as Fe) mg/L	0.6	0.52	0.54	4.163E-02	6.27	-	0.3
11.	Nitrite (as NO_2) mg/L	0.68	0.92	0.04	0.4549	5.25	< 0.1	
12.	Nitrate (as NO_3) mg/L	1.5	1.43	4	1.4640	0.09	45	45
13.	Chloride (as Cl) mg/L	88	92	46	25.4820	24.80	200.600	250
14.	Residual Chlorine mg/L	Nil	Nil	Nil	Nil	Nil	-	0.2
15.	Flouride (as F) mg/L	0.81	0.34	0.28	0.2902	6.42	-	1.0
16.	Sulphate (as SO_4) mg/L	40	32	13	13.8684	10.76	200.400	200
17.	Phosphate (as PO_4) mg/L	1.22	0.53	0.06	0.5835	4.36	0.1	-
18.	DO mg/L	8.1	7.5	4.0	2.2143	10.44	4.0-6.0	
19.	BOD mg/L	5.6	5.7	5	0.3786	30.93	13.59	6.0
20.	CODmg/L	27.6	18.9	15	6.4506	24.9	16.45	

Magnesium (mg) values in various sites ranged between 19 mg/L and 7 mg/L. The magnesium values was maximum in site-II during November 2007 and was minimum in site-V during December 2007 and site-I during January 2008. Higher magnesium concentrations have been previously reported to be due to presence of soluble magnesium salts in sedimentary rock beds (Mohan *et al*. 2007).

Iron (Fe) values in various sites ranged between 0.72 mg/L and 0.29 mg/L. The iron value was maximum and above the permissible limit (0.3 mg/L) (BIS, 1991) in all sites except during site-IV in January 2008. Higher iron levels observed in the sampling sites necessitates the need for adopting some treatment measures to reduce the iron level to improve the potability of the water.

Nitrite (NO_2) values in various sites ranged between 0.92 mg/L and 0.04 mg/L. The maximum value was observed in site-I during December 2007. Minimum value was observed in site-I during January 2008 which shows that the values were well above the permissible limit (<0.1 mg/l) WHO, 1993) for all months, during all the sampling sites except during January 2008 in site-I. Higher values of nitrite have been reported to be due to concentration followed by evaporation and anthropogenic influence and such high levels of nitrite leads to methemoglobinemia (Kaushik *et al*. 1991; Khatavkar and Trivedy, 1992 and Radhika *et al*. 2004).

Nitrate (NO_3) values in various sites ranged between 2.88 mg/L and 1.06 mg/L. The maximum value was observed in site-V during December 2007 and the Minimum value in site-V during November 2007. The values were observed to be within the permissible limits (BIS 1991; WHO 1993).

Chloride (Cl) values in various sites ranged between 99 mg/L and 46 mg/L. The maximum values was in site-II during November 2007 and minimum was in site-I during January 2008. The values were within the permissible limits (BIS, 1991; WHO, 1993).

Residual chlorine values in various sites ranged

Table 1a. Physico-chemical parameters observed in sampling sites - I, II and III during different sampling periods

S. No.	Description	Site - II						
		Nov. 2007	Dec. 2007	Jan. 2008	±SD	ANOVA	WHO 1993	BIS 1991
	PARAMETERS							
PHYSICAL EXAMINATION								
1.	Turbidity NTU	2.0	1.8	1.3	.3606	0.23	-	5
2.	TDS mg/L	308	370	288	42.7551	167.96	500-1500	500
3.	TSS mg/L	22	8	4	9.4516	2.89		
4.	EC (µ/cm)	452	348	410	52.3195	176.45		
CHEMICAL EXAMINATION								
5.	pH	7.80	7.16	7.70	0.3443	82.71	6.5-9.2	6.5-8.5
6.	Alkalinity Total (as $CaCO_3$) mg/L	89	136	104	24.0069	60.23	0-120	200
7.	Total Hardness (as $CaCO_3$) mg/L	82.35	55	102	23.6049	32.51	100-500	300
8.	Calcium (as Ca) mg/L	39	28.5	27	6.5383	59.67	-	75
9.	Magnesium (as Mg) mg/L	19	12	8	5.5678	11.34	-	-
10.	Iron (as Fe) mg/L	0.72	0.67	0.52	0.1041	5.51	-	0.3
11.	Nitrite (as NO_2) mg/L	0.5	0.39	0.16	0.1735	7.92	< 0.1	
12.	Nitrate (as NO_3) mg/L	2.52	2.1	3	0.4503	0.72	45	45
13.	Chloride (as Cl) mg/L	99	70	47	26.0576	21.61	200.600	250
14.	Residual Chlorine mg/L	2	3	3.0	0.577	1.0	-	0.2
15.	Flouride (as F) mg/L	0.9	0.71	0.29	0.3121	5.10	-	1.0
16.	Sulphate (as SO_4) mg/L	28	13	15	8.1445	12.37	200.400	200
17.	Phosphate (as PO_4) mg/L	Nil	Nil	Nil	Nil	Nil	0.1	-
18.	DO mg/L	5.8	6.1	5.3	0.4041	35.94	4.0-6.0	
19.	BOD mg/L	5.8	5.4	4	0.9452	14.90	13.59	6.0
20.	CODmg/L	16.5	15.4	12	2.3459	8.29		

between 3.0 mg/L and 2.0 mg/L. The maximum value above the permissible level of 0.2 mg/l (BIS, 1991) was recorded in site-II during November 2007 and in sites II and III during the months of December 2007 and January 2008. Minimum value was in site-II during November 2007.

Flouride (F) values in various sites ranged between 0.9 mg/L and 0.28 mg/L. The values was maximum in site-II and site-V during November 2007 and was minimum in site-I during January 2008. The observed values were within the permissible limits (BIS 1991). Higher concentration of fluoride has been implicated to cause dental and skeletal fluorosis.

Sulphate (SO_4) values in various sites ranged between 40 mg/L and 13 mg/L. The maximum value was observed in site-I during November 2007. Minimum value was observed in site-II and site-IV during December 2007 and during January 2008 in site-I. The values were observed to be within the permissible limits (BIS 1991, WHO 1993).

Phosphate (PO_4) values in various sites ranged between 1.22 mg/L and 0.06 mg/L which were observed to be higher than the limits (0.1 mg/L) prescribed by WHO, 1993. The phosphate value was maximum in site-I during November 2007 and was minimum in site-I during January 2008. Higher phosphate value could be attributed to continuous disposal of sewage into the lake (Sunkad *et al*. 2004).

Dissolved oxygen (DO) values in various sites ranged between 8.1 mg/L and 4.0 mg/L. The values was maximum in site-I during November 2007 and was minimum in site-I during January 2008. The values were observed to be above the permissible limits (WHO 1993) in sampling sites-I, II and V during November 2007 and in sites-I, II and IV during December 2007 and in site-III during January 2008. Higher levels of DO have been reported due to high rainfall (Radhika *et al*. 2004). Depleted DO content might be the result of low rainfall and high rate of oxygen consumption by oxidisable matter coming along with sewage and agricultural runoff (Sharma and Sarang, 2004).

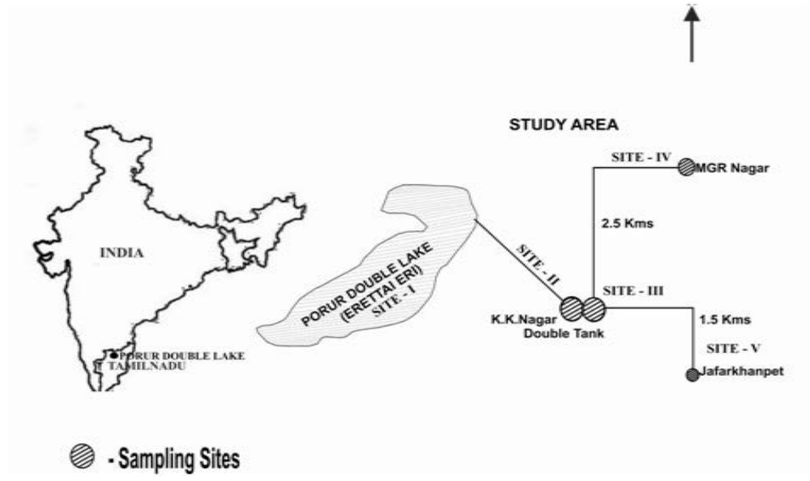

Fig. 1 Location Map of Study Area
Site I - Porur Double Lake (Erettai Eri); Site II - K.K.Nagar Double Tank (Treatment System) ; Site III - K.Nagar Double Tank (Distribution Point) ; Site IV - MGR Nagar ; Site V - Jaffarkhanpet

Table: 1a Physico-chemical parameters observed in sampling sites - I, II and III during different sampling periods

S. No.	Description	Site - III						
		Nov. 2007	Dec. 2007	Jan. 2008	±SD	ANOVA	WHO 1993	BIS 1991
	PARAMETERS							
PHYSICAL EXAMINATION								
1.	Turbidity NTU	1.8	1.4	1.2	.3055	0.78	-	5
2.	TDS mg/L	190	354	286	82.3974	33.33	500-1500	500
3.	TSS mg/L	8	14	2	6.0000	2.91		
4.	EC (µ/cm)	220	319	409	94.5357	33.09		
CHEMICAL EXAMINATION								
5.	pH	7.16	6.50	7.65	0.5771	58.61	6.5-9.2	6.5-8.5
6.	Alkalinity Total (as $CaCO_3$) mg/L	140	122	104	18.0000	132.92	0-120	200
7.	Total Hardness (as $CaCO_3$) mg/L	80.8	63.2	100	18.4058	55.57	100-500	300
8.	Calcium (as Ca) mg/L	46	34.5	26	10.0374	33.08	-	75
9.	Magnesium (as Mg) mg/L	14	12	8	3.0551	25.29	-	-
10.	Iron (as Fe) mg/L	0.53	0.6	0.40	0.1015	6.59	-	0.3
11.	Nitrite (as NO_2) mg/L	0.62	0.19	0.14	0.2639	7.94	< 0.1	
12.	Nitrate (as NO_3) mg/L	1.6	2.52	3	0.7114	0.27	45	45
13.	Chloride (as Cl) mg/L	65	82	47	17.5024	38.33	200.600	250
14.	Residual Chlorine mg/L	3	3	3.0	0.0	3.0	-	0.2
15.	Flouride (as F) mg/L	0.6	0.3	0.29	0.1762	7.47	-	1.0
16.	Sulphate (as SO_4) mg/L	36	29	14	11.2398	13.95	200.400	200
17.	Phosphate (as PO_4) mg/L	Nil	Nil	Nil	Nil	Nil	0.1	-
18.	DO mg/L	5.54	4.1	6.5	1.2080	13.93	4.0-6.0	
19.	BOD mg/L	4.8	5.8	4	0.9018	13.59	13.59	6.0
20.	CODmg/L	26.3	18.5	12	7.1598	16.45		

Table. 1b. Physico-chemical parameters observed in sampling sites - IV and V during different sampling periods

Sl. No.	Description	Site - IV					Site - V					
		Nov. 2007	Dec. 2007	Jan. 2008	+SD	ANOVA	Nov. 2007	Dec. 2007	Jan. 2008	+SD	ANOVA	WHO 1993	BIS 1991
	PARAMETERS												
	PHYSICAL EXAMINATION												
1.	Turbidity NTU	1.2	1.9	2.0	0.4359	0.22	3.8	2.6	4.1	0.7937	4.14		5
2.	TDS mg/L	310	270	296	20.2978	610.89	430	356	292	69.0604	80.30	500-1500	500
3.	TSS mg/L	19	12	2	8.5440	3.28	14	6	3	6.8069	2.89		
4.	EC (µ/cm)	559	437	422	75.1421	117.68	329	522	416	96.6557	56.72		
	CHEMICAL EXAMINATION												
5.	pH	6.94	6.20	7.58	0.6906	48.90	7.95	6.08	7.44	0.9667	41.23	6.5-9.2	6.5-8.5
6.	Alkalinity Total (as $CaCO_3$) mg/L	265	178	108	78.6532	16.0	285	158	108	91.2487	11.88	0-120	200
7.	Total Hardness (as $CaCO_3$) mg/l	76.3	52	108	28.0814	22.39	85.6	48.2	107	29.7606	20.72	100-500	300
8.	Calcium (as Ca) mg/L	50	32.5	27	12.0104	24.58	43	22.5	28	10.6105	22.46		75
9.	Magnesium (as Mg) mg/L	11	8	10	1.5275	52.9	16	7	9	4.7258	9.65		
10.	Iron (as Fe) mg/L	0.45	0.51	0.29	0.1137	7.42	0.31	0.48	0.55	0.1234	7.12		0.3
11.	Nitrite (as NO_2) mg/L	0.32	0.24	0.21	5.686E-02	9.08	0.12	0.18	0.23	5.508E-02	9.94	<0.1	
12.	Nitrate (as NO_3) mg/L	1.55	1.21	2	0.3963	0.44	1.06	2.88	3	1.0871	0.13	45	45
13.	Chloride (as Cl) mg/L	76	70	49	14.1774	58.94	59	65	48	8.6217	121.92	200-600	250
14.	Residual Chlorine mg/L	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil		0.2
15.	Flouride (as F) mg/L	0.3	0.5	0.30	0.1155	7.89	0.9	0.6	0.29	0.3050	5.40		1.0
16.	Sulphate (as SO_4) mg/L	28	13	16	7.9373	13.54	38	42	16	14.0000	13.70	200-400	200
17.	Phosphate (as PO_4) mg/L	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.1	
18.	DO mg/L	6.7	6.2	5.5	0.6028	37.59	6.2	5.03	6	0.6258	30.20	4.0-6.0	
19.	BOD mg/L	5.6	4.6	6	0.7211	22.81	5.0	4.0	6	1.0000	13.5	6.0	
20.	COD mg/L	18.7	19.6	21	1.1590	404.10	16.5	12	21	4.5000	29.68		

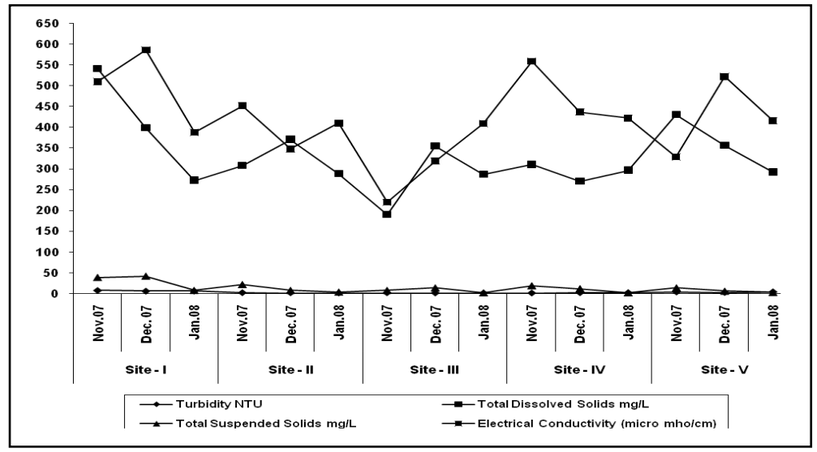

Fig. 2 Turbidity, Total Dissolved Solids, Total Suspended Solids and Electrical Conductivity levels in various sampling sites of Porur Double Lake (Erettai Eri) during the study period (Nov. 2007 - Jan. 2008).

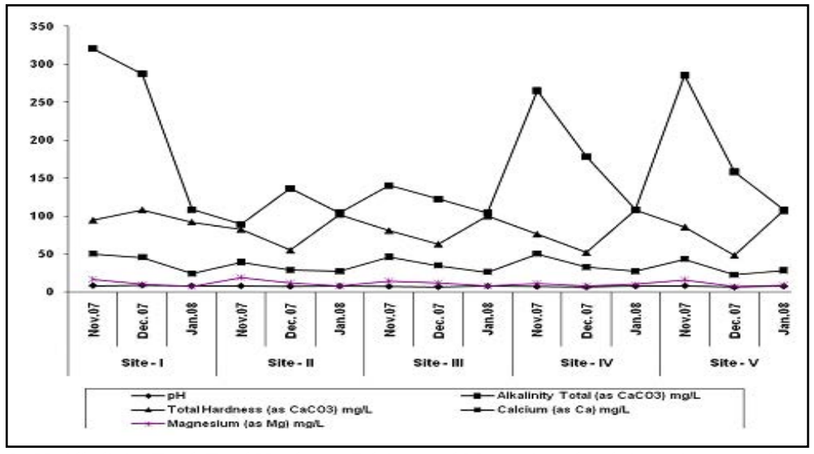

Fig. 3 pH, Alkalinity Total, Total Hardness, Calcium and Magnesium levels in various sampling sites of Porur Double Lake (Erettai Eri) during the study period (Nov. 2007 - Jan. 2008).

Biological oxygen demand (BOD) values in various sites ranged between 6 mg/L and 3.0 mg/L. The value was maximum in site-IV and site-V during January 2008 and minimum in site-V during November 2007 and were within permissible limits (WHO 1993). The low values of BOD observed might be due to low temperature, lesser quantity of total solids, suspended solids and dissolved solids in water as well as the higher microbial population as reported by various researchers (Shardendu and Ambasht 1988; Radhika *et al*. 2004).

Chemical oxygen demand (COD) values in various sites ranged between 27.6 mg/L and 12.0 mg/L. The maximum value was recorded in site-I during November 2007. The minimum value was observed in site-V during December 2008 and also in site-II and site-III during January 2008. Site II and site III showed minimum COD values during January 2008. High values of COD is due to algal biomass and other organic matter (Tiwari, 2005). Sedimentation of organic materials to the bottom, results in low COD (Dakshini and Soni, 1979; Ajmal and Raziuddin, 1988;

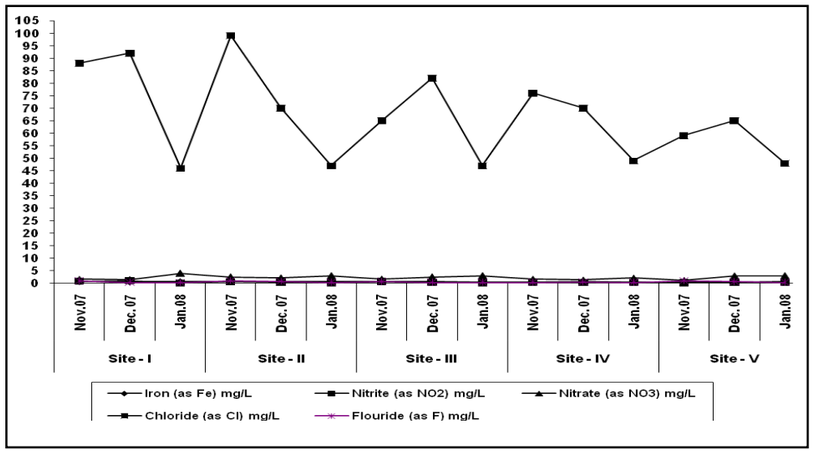

Fig. 4 Iron, Nitrite, Nitrate, Chloride and Flouride levels in various sampling sites of Porur Double Lake (Erettai Eri) during the study period (Nov. 2007 - Jan. 2008).

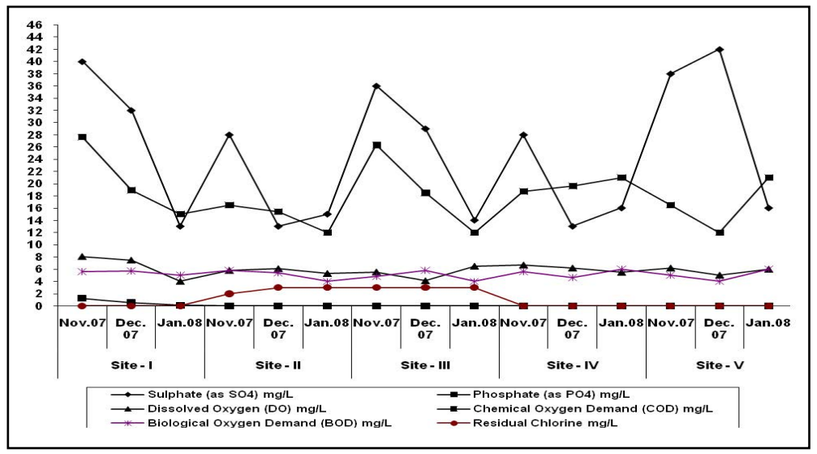

Fig. 5 Sulphate, Phosphate, Dissolved Oxygen, COD, BOD and Residual Chlorine levels in various sampling sites of Porur Double Lake (Erettai Eri) during the study period (Nov. 2007 - Jan. 2008).

Radhika *et al*. 2004).

CONCLUSION

In conclusion, the results of this study shows that the water quality in the Porur double lake, that serves as the drinking water source is severely deteriorated in terms of physico-chemical parameters. This condition could affect the health of the consumers. Hence, there is an urgent need to undertake appropriate management measures to restore the water quality of this water source.

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