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Seasonal variations in physicochemical characteristics of selected water bodies in Sivakasi town, Tamil Nadu, India

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Abstract
The present study was carried out in Periyar colony and Thiruthangal water bodies situated in Sivakasi town for the analysis of different physico-chemical parameters. The water samples in selected water bodies were collected during June 2014 to May 2015 in four periodic intervals viz., pre-monsoon, monsoon, early post monsoon and late post monsoon. The water quality parameters such as dissolved oxygen, free carbon ioxide, alkalinity, total hardness, calcium, magnesium, chlorinity, salinity, phosphate, calcium carbonate, iron, ammonia, nitrate, nitrite, fluoride and sulphate were investigated with standard methodologies during the present study. The results of observations made during the study period with regard to physico-chemical parameters are enumerated in tables along with season wise data collected during the course of investigation. The results obtained from the physico-chemical analysis of the water quality in ponds of Periyar colony and Thiruthangal indicates that most of the important quantities such as turbidity, total dissolved solids, pH, hardness, alkalinity, anion and cation contents water bodies are above the upper threshold of the WHO guidelines. So, there should be a constant monitoring of physicochemical parameters nearby the water bodies in future because of the increase in anthropogenic activities around the area.

Keywords: physico-chemical characteristics, pollution, sivakasi, water quality

1. Introduction
Water pollution interrupts the uses of water for irrigation, agriculture, industries, domestic water supply and aquatic life of various organisms. Water quality standards vary significantly due to different environmental conditions, ecosystems and intended human uses. Toxic substances and high populations of certain microorganisms can present a health hazard for non-drinking purposes such as irrigation, swimming, fishing, boating, and industrial uses. Water pollution can be classified mainly into four categories. They are physical, chemical, biological and physiological pollution [1].

Pond and lakes are inland depression containing standing water. Water quality characteristic of aquatic environment arise from a multitude of physical, chemical and biological interactions. The water bodies, rivers, lakes, ponds, dams and estuaries are continuously subject to dynamic state of change with respect to the geological age and geochemical characteristics. Ponds are socio-economically and bio-aesthetically vital aquatic ecosystem [2]. Where aquaculture is concerned, any characteristics of water that affects the survival, reproduction, growth or management of fish or other aquatic creatures in any way is a water quality variable. Reservoirs are biologically potential and rich in flora and fauna.

The quality of water may be described according to its physico-chemical and micro-biological characteristics. For effective maintenance of water quality through appropriate control measures, continuous monitoring of a large number of quality parameters is essential. However, it is very difficult and laborious task for regular monitoring of all the parameters even if adequate manpower and laboratory facilities are available. Therefore, in recent years an alternative approach based on statistical correlation, has been used to develop mathematical relationship for comparison of physic-chemical parameters. In view of this, the present study has been undertaken in Periyar colony and Thiruthangal water bodies situated in Sivakasi town for the analysis of different physico-chemical parameters.

2. Materials and Methods
2.1. Study Area and Period of study
The ponds selected for the study of water quality parameters with reference to season are located in and around Sivakasi town (Periyar colony and Thiruthangal). The depth of each pond is about 12 feet. It covered by different types of vegetation. The pond water is also being used by the people for bathing and washing purposes. It is rainfed area receiving sporadic rainfall during North-East monsoon and holds water throughout the year in some of the ponds. The water samples in selected water bodies were collected during June 2014 to May 2015 in four periodic intervals viz., pre-monsoon (June to August, 2014); monsoon (September to November, 2014); early post monsoon (December to February, 2015) and late post monsoon(March to May, 2015). Surface water samples were collected from pond using clean plastic container for the estimation for water quality parameters, once in a month at morning hours of the day (7 a.m.). The collected water samples was immediately brought to the laboratory and analysed. The water quality parameters such as dissolved oxygen, free carbon ioxide, alkalinity, total hardness, calcium, magnesium, chlorinity, salinity, phosphate, calcium carbonate,

iron, ammonia, nitrate, nitrite, fluoride and sulphate were investigated during the present study.

2.2 Physical examination of water

The different water quality parameters such as pH, colour, turbidity, total dissolved solids and electrical conductivity were analysed following the method adopted by Gupta and Shukla [3].

2.3 Chemical examination of water

Chemical examination of water samples were analysed using the standard methodologies. Dissolved oxygen of samples was estimated by wrinkler method. Free CO_2 of water sample was found out by titration method using phenolphthalein indicator. Alkalinity was estimated by standard procedure. The total hardness of water sample was estimated by EDTA titrimetric mehod using Eriochrome black. The calcium hardness of the sample was also estimated by EDTA titrimetric method by using murexide indicator. Magnesium and chloride content was estimated by titration method. Salinity was calculated from chlorinity of water sample. Phosphate, iron, ammonia, nitrite, nitrate, fluoride and sulphate contents were measured using spectrophotometer method.

3. Results

The detailed results of observations made during the study period with regard to physico-chemical parameters are enumerated in tables 1 and 2. Each table is provided with list of standard physico-chemical parameters for water bodies along with season wise data collected during the course of investigation.

3.1 Water quality Parameters of Periyar Colony Pond in Sivakasi Town

The appearance and colour of water samples in Periyar colony (Table 1) was turbid during pre-monsoon season, greenish during monsoon, early and late post-monsoon seasons. The odour of water samples was objectionable during all the seasons. The turbidity of water sample was high during early post-monsoon (9.8) followed by late post-monsoon season and pre-monsoon with 6.8 and 6.1.

The amount of total dissolved solids was within acceptable limit during early post-monsoon (281 mg/L) and late post-monsoon seasons (282 mg/L) and. It was higher than the acceptable limit, but within the permissible limit during pre-monsoon (632 mg/L) monsoon seasons (1760 mg/L). Electrical conductivity of water sample in Periyar colony was much higher during monsoon season with 2667 mho/cm followed by pre-monsoon season (957). EC was very low during early and late post-monsoon seasons with 401 and 403 respectively.

The p^H level of water samples in Periyar colony was high during early post-monsoon (9.3) followed by monsoon (8.7), late post-monsoon seasons (7.7) and pre-monsoon (7.2). Ph alkalinity as $CaCo_3$ was 0 in water samples during all the four seasons. The total alkalinity as $CaCo_3$ level was high during monsoon season (432 mg/L) and low during early post-monsoon season (77 mg/L). It was moderate during late post-monsoon and pre-monsoon seasons with 162 and 141 mg/L respectively. Total hardness was high during monsoon (152 mg/L) followed by pre-monsoon and early post-monsoon seasons with 137 and 111 mg/L respectively. It was low during late post-monsoon season (95 mg/L).

Calcium level was high during monsoon (42 mg/L) followed by pre-monsoon (38 mg/L), early post-monsoon (31 mg/L) and late post-monsoon seasons (29 mg/L). Magnesium level was high during monsoon (11 mg/L) followed by monsoon (10 mg/L), early post-monsoon and late post-monsoon seasons with 8 and 7 mg/L respectively. Iron level was high during early post-monsoon season (0.61 mg/L) followed by pre-monsoon (0.55 mg/L), monsoon and late post-monsoon seasons (0.49 mg/L). Manganese level high during early post-monsoon (0.29 mg/L) followed by pre-monsoon (0.26 mg/L), late post-monsoon (0.16 mg/L) and pre-monsoon seasons (0.03 mg/L). Free ammonia level was much higher during pre-monsoon season (4.60 mg/L) followed by monsoon (1.65 mg/L), late post-monsoon (1.35 mg/L) and early post-monsoon seasons (1.16 mg/L). The nitrite level was high during pre-monsoon season (0.27 mg/L) and very low during late post-monsoon season with 0.05 mg/L. The nitrate level was within the acceptable limit (45 mg/L) during all seasons. 7 mg/L of nitrate was recorded during monsoon season followed by 6 mg/L during pre-monsoon season.

Table 1: Water quality parameters in a water body of Periyar Colony

Physical Examination	Study period*			
	Pre-monsoon	**Monsoon**	**Early post-monsoon**	**Late post-monsoon**
Appearance & Colour	Turbid	Greenish	Greenish	Greenish
Odour	Objectionable	Objectionable	Objectionable	Objectionable
Turbidity NT units	6.1	5.3	9.8	6.8
TDS mg/L	632	1760	281	282
EC Micro mho/cm	957	2667	401	403
Chemical Examination				
P^H	7.2	8.7	9.3	7.7
Ph alkalinity as $CaCo_3$ mg/L	0	36	0	0
Total alkalinity as $CaCo_3$ mg/L	141	432	77	162
Total hardness as $CaCo_3$ mg/L	137	152	111	95
Calcium mg/L	38	42	31	29
Magnesium mg/L	10	11	8	7
Iron mg/L	0.55	0.49	0.61	0.49
Manganese mg/L	0.03	0.26	0.29	0.16

Free Ammonia mg/L	4.60	1.65	1.16	1.35
Nitrite mg/L	0.84	0.18	0.22	0.05
Nitrate mg/L	6	7	2	2
Chloride mg/L	178	465	83	21
Fluoride mg/L	0.4	0.8	0.4	0.4
Sulphate mg/L	51	334	17	23
Phosphate mg/L	1.17	1.82	1.84	3.21

* Pre-monsoon - June to August, 2014; Monsoon - September to November, 2014; Early post-monsoon - December to February, 2015; Late post-monsoon - March to May, 2015

Chloride level was very high during monsoon (465 mg/L) and pre-monsoon seasons (178 mg/L). The chloride level was very low and within the accepted limit during early post-monsoon and late post-monsoon seasons with 83 and 21 mg/L respectively. Fluoride level was within the acceptable limit (1.0 mg/L) during all the seasons. It was high during monsoon (0.8 mg/L) and moderate during pre-monsoon, and early and late post-monsoon seasons (0.4 mg/L). Sulphate level was high during monsoon season with 465 mg/L and low during early and late post-monsoon seasons with 17 and 23 mg/L respectively. Moderate level of sulphate was recorded during pre-monsoon season (51 mg/L). Phosphate level was high during late post-monsoon season (3.21 mg/L), moderate level during monsoon (1.82 mg/L) and early post-monsoon seasons (1.84 mg/L). Low level of phosphate was recorded during pre-monsoon season (1.17 mg/L).

3.2 Water quality parameters water body in Thiruthangal pond

The appearance and colour of water samples in Thiruthangal pond (Table 2) was turbid during pre-monsoon season and greenish during monsoon, early and late post-monsoon seasons. The odour of water samples was objectionable during all the seasons. Turbidity of water sample was much higher during early post-monsoon (21.3) and pre-monsoon seasons (14.9), low during monsoon season (4.8) and moderate during late post-monsoon season with 7.8. Amount of total dissolved solids was beyond the acceptable limit in all study seasons but within the permissible limits. In which, turbidity was high during monsoon (1529 mg/L) followed by late post-monsoon (988 mg/L), early post-monsoon (670 mg/L) and low during late pre-monsoon season (548 mg/L). Electrical conductivity of water sample in Thiruthangal pond was much higher during monsoon season with 2316 mho/cm followed by late post-monsoon season (1412 mho/cm). EC was very low during early post-monsoon and pre-monsoon seasons with 957 and 831 mho/cm respectively.

Table 2: Water quality parameters in a water body of Thiruthangal near Sivakasi town during different seasons

Physical Examination	**Study period**			
	Pre-monsoon	**Monsoon**	**Early post-monsoon**	**Late post-monsoon**
Appearance & Colour	Turbid	Greenish	Greenish	Greenish
Odour	Objectionable	Objectionable	Objectionable	Objectionable
Turbidity NT units	14.9	4.8	21.3	7.8
TDS mg/L	548	1529	670	988
EC Micro mho/cm	831	2316	957	1412
Chemical Examination				
P^H	7.3	8.5	9.1	8.5
Ph alkalinity as $CaCo_3$ mg/L	0	24	0	0
Total alkalinity as $CaCo_3$ mg/L	101	141	178	121
Total hardness as $CaCo_3$ mg/L	89	253	230	293
Calcium mg/L	25	70	64	81
Magnesium mg/L	7	19	17	22
Iron mg/L	1.45	0.43	1.16	0.55
Manganese mg/L	0.10	0.24	0.85	0.18
Free Ammonia mg/L	2.46	1.52	2.90	3.00
Nitrite mg/L	0.29	0.18	0.20	0.04
Nitrate mg/L	8	6	2	4
Chloride mg/L	125	566	152	236
Fluoride mg/L	0.8	0.6	0.6	0.4
Sulphate mg/L	114	245	109	253
Phosphate mg/L	4.01	1.48	2.66	2.46

The p^H level of water samples in Thiruthangal pond was higher than the permissible limit during early post-monsoon (9.1) and within the permissible limit as 8.5 during monsoon and late post-monsoon seasons and 7.3 during pre-monsoon season. Ph alkalinity as $CaCo_3$ was 0 in water samples during all the four seasons. Total alkalinity as $CaCo_3$ level was was high during early post-monsoon (178 mg/L) and low during pre-monsoon (101 mg/L). It was moderate during monsoon and late post--monsoon seasons with 141 and 121 mg/L respectively. Total hardness as $CaCo_3$ level was within the acceptable limit (200 mg/L) during pre-monsoon season (93 mg/L). During other study seasons, it was higher than the acceptable limit but within the permissible limit (600 mg/L). In which, total hardness was high during late post-monsoon season (293 mg/L) followed by monsoon and early post-monsoon seasons with 253 and 230 mg/L respectively.

The calcium level was within acceptable limit (75 mg/L) during by pre-monsoon (25 mg/L), monsoon (70 mg/L) and early post-monsoon seasons (64 mg/L). Calcium level was higher than the acceptable limit but within the permissible limit (200 mg/L) during late post-monsoon season (81 mg/L). Magnesium level was within the acceptable limit (30 mg/L) during all study seasons. It was high during late post-monsoon (22 mg/L) followed by monsoon (19 mg/L), early post-monsoon and pre-monsoon seasons with 17 and 7 mg/L respectively. Iron level was high during pre-monsoon (1.45 mg/L) and early post-monsoon seasons (1.16 mg/L). Iron level was low during monsoon and late post-monsoon seasons with 0.43 and 0.55 mg/L respectively. Manganese level was high during early post-monsoon (0.85 mg/L) and low during pre-monsoon season (0.10 mg/L). It was moderate during monsoon (0.24 mg/L) and late post-monsoon seasons (0.18 mg/L).

The free ammonia level was high during late post-monsoon season (3.00 mg/L) followed by early post-monsoon (2.90 mg/L), pre-monsoon (2.46 mg/L) and monsoon seasons (1.52 mg/L). The nitrite level was high during monsoon season (0.27 mg/L) and very low during late post-monsoon season with 0.04 mg/L. Presence of nitrite level was moderate during monsoon (0.18 mg/L) and early post-monsoon seasons (0.20 mg/L). Nitrate level was within the acceptable limit (45 mg/L) during all seasons. 8 mg/L of nitrate was recorded during pre-monsoon season followed by 6 mg/L during monsoon season. Early post-monsoon and late post-monsoon seasons were recorded with low level of nitrate as 4 and 2 mg/L respectively.

Chloride level was very high during monsoon (566 mg/L) and low during pre-monsoon seasons (125mg/L). The chloride level was moderate during early post-monsoon and late post-monsoon seasons with 152 and 236 mg/L respectively. Fluoride level was within the acceptable limit (1.0 mg/L) during all the seasons. Fluoride level was high during monsoon (0.8 mg/L) and moderate during pre-monsoon, and early post-monsoon (0.6 mg/L) and low during late post-monsoon season (0.4 mg/L). Sulphate level was high during late post-monsoon (253 mg/L) and monsoon seasons (245 mg/L) and low during pre-monsoon (114 mg/L) and early post-monsoon seasons (109 mg/L). Phosphate level was much higher during pre-monsoon season (4.01 mg/L), moderate level during early post-monsoon (2.66 mg/L) and late post-monsoon seasons (2.46 mg/L). Low level of phosphate was recorded during monsoon season (1.48 mg/L).

4. Discussion

Ponds, as sources of water, are of fundamental importance to man. However, pond may have been natural water source exploited by man to meet different needs or created for multitude of different purpose [4]. Due to uncontrolled increase in human population and development of township at large, these freshwater bodies are under tremendous pressure owing to their overuse on one hand and enrichment due to nutrients and organic matter, leading to cultural eutrophication. The parameters influence each other and govern the distribution and abundance of flora and fauna [5].

The odour of pond water is objectionable in all the studied sites throughout the year when compared to agreeable limit. It may be due to the drainage of several wastes into the pond which confirms that, the studied water bodies are slightly polluted [6]. The obtained levels of TDS in the present study may have resulted from presence of silt and other suspended materials observed in the water body. Electrical conductivity showed significantly negative correlation with chlorinity and salinity [7]. Major changes associated with electro-chemical properties of pond water are reflected by the pH and electrical conductivity. Mondal *et al*. [8] reported positive relationship between quality of pond water and pH of water.

The level of minerals such as Calcium, Magnesium and Manganese are observed in the studied sites showed the presence of acceptable and permissible limit during the pre-monsoon and monsoon seasons. Higher calcium content in drinking water cause incrustation in water supply and adversely affects the domestic usage [9]. The values of present study are found to desirable limit for the domestic use. During the period early post-monsoon and late post-monsoon seasons, all the sites are recorded with the permissible level of Calcium and Magnesium. Iron, Manganese and free Ammonia are recorded with much higher permissible level in a few study sites. Highest seasonal values were reported during rainy and lowest during winter is in conformity with the findings of various workers [10, 11].

5. Conclusion

Physico-chemical properties (pH, conductivity, CO_2, alkalinity, chlorinity, salinity, ions, etc.) of water in any aquatic system are largely governed by existing meteorological condition and are essential for determining the structural and functional status of natural water. The results obtained from the physico-chemical analysis of the water quality in ponds of Periyar colony and Thiruthangal indicates that most of the important quantities such as turbidity, total dissolved solids, pH, hardness, alkalinity, anion and cation contents water bodies are above the upper threshold of the WHO guidelines. So, there should be a constant monitoring of physicochemical parameters nearby the water bodies is essential. Because of the increase in anthropogenic activities around the area, proper education, monitoring and clean up procedure is recommended in the study regions as the area is stressed by pollutants generated from domestic, agricultural and industrial activities as well as effect of oil spills.

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7. References

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