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Influence of Seasonal Variations on Physicochemical Parameters of a Freshwater Ecosystem - Valiyakulam Pond Thiruvananthapuram, Kerala, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study deals with the water quality assessment of surface water from Valiakulam pond for a period of one year. The physico chemical parameters of water samples were analyzed based on standard laboratory procedures. The present study aimed to analyze the influence of seasonal

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variations on physicochemical parameters of pond water. The parameters of water such as temperature, PH, transparency, turbidity, conductivity, hardness, alkalinity, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and free carbon dioxide (CO_2) were studied from four stations of the pond. Results of the data were subjected for statistical analysis such as correlation and two way ANOVA with post hoc test. The results of ANOVA showed significant difference in all the twelve physicochemical parameters between the seasons and no significant difference was observed between study sites ($P<0.05$). The analysis of post hoc test in the form of Tukey also showed the same pattern. The results of the study concluded that the physicochemical parameters of pond water can be used for domestic propose. The results of the study may become useful data for productive water resource utilization in future.

Keywords: Water quality; physicochemical parameters; valiakulam pond; BOD; COD; alkalinity; dissolved oxygen.

1. INTRODUCTION

Ponds are the hotspots of biodiversity that collectively support far more species, including rare and threatened species than other freshwater habitats [1]. Ponds played a variety of ecosystem services such as flood alleviation [2], aquifer recharge [3], nutrient retention [4], carbon sequestration [5], mitigating urban heat islands (UHI) [6], fish production, and habitat conservation [7]. The emerging risks of bio invasion (invasive species) and climate change are also threatening the provision of the pond's ecosystem services.

Limnological investigations on water bodies based on physicochemical parameters and its various aspects pertaining to ponds are reviewed by many researchers in various perspectives - seasonal variations, ecological aspects of ponds, plankton and productivity etc. [8-15]. The reports revealed that pond ecosystems are unique in various aspects of physical and chemical characteristics with respect to the locality, interaction of human and other living things, climatic changes etc. Nowadays the water bodies in India, particularly in Kerala are experiencing an alarming rate degradation. The ponds of Kerala are fast disappearing due to the stress of urbanization and other developmental activities.

The aim of the present study was to analyse the effect of seasonal changes on the physicochemical parameters of surface water of one of the largest fresh water pond (Valiakulam) in Thiruvananthapuram district, Kerala. The study also tries to unfold the quality of the pond water for various day to day activities especially the suitability for drinking purpose.

The pond is one of the major groundwater resource for people residing in the Chenkal village in Thiruvananthapuram district of Kerala, presently people depend the pond to satisfy various needs such as bathing, washing clothes, cleaning the vehicles and domestic animals etc. Moreover the pond water is the main water source for carrying out the agricultural activities and recreation activities etc. No scientific and systematic studies are available regarding the hydrological parameters of the Valiakulam pond. Given these concerns, the present investigation was designed to study the seasonal variations on physicochemical characteristics of surface water of Valiakulam pond for a period of one year (from February 2017 to January 2018). The present scientific investigation satisfy the objectives such as monthly data collection of physicochemical parameters of surface water and to predict the seasonal variations of hydrological parameters for a period of one year.

2. MATERIALS AND METHODS

2.1 Study Area

Valiakulam pond which extends to an area of 0.101 sq.km and located at Chenkal village in Thiruvananthapuram District, Kerala. ($8^o21'31''$N latitude and $77^o5'58''$.E longitude).The pond is situated 31 km from Trivandrum railway station and 66 km from Kanyakumari, Tamil Nadu. The pond water has been used for domestic purposes and irrigation. Study was undertaken to investigate water quality of Valiakulam pond because of its importance in ground water recharging as well as irrigation, aquaculture and agriculture activities. Four study sites named as site 1, 2, 3 and 4 were selected for collecting samples. The four sampling sites were selected based on the intensity of anthropogenic disturbances in the pond. The major anthropogenic activities noticed were washing of

cloths, bathing, cleaning vehicles, dumbing of iron materials and cells etc. The pond serves the role as water reservoir for agriculture, washing cloths and for drinking and washing domestic animals. The pond is surrounded by semi urban and agricultural area with great potential and scope for agriculture and aquaculture .The mean depth of the pond is 0.765 m.

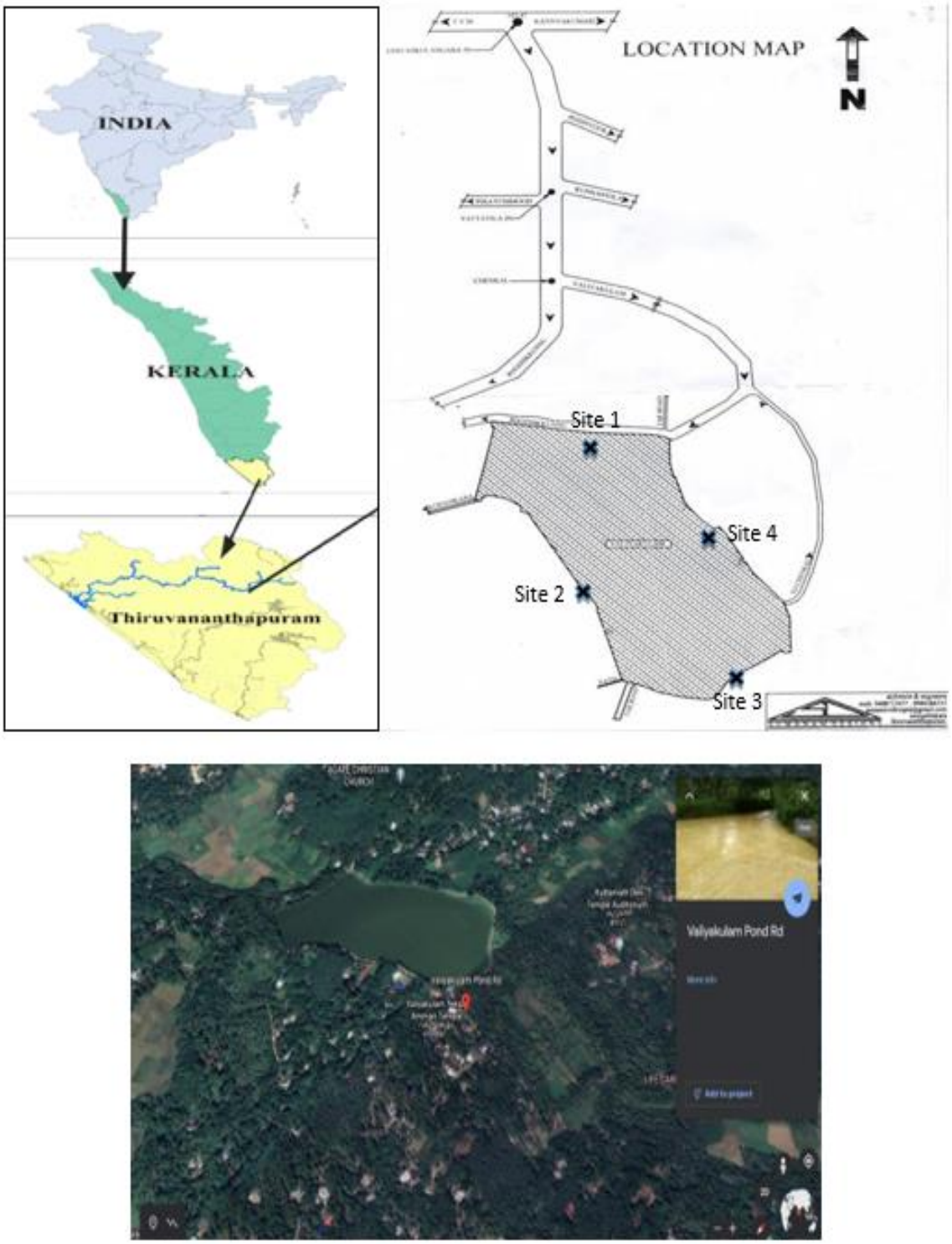

Fig. 1. Map of study area

3. METHODOLOGY

3.1 Collection of Samples

The present scientific investigation was carried out for a period of one year to get enough data covering all the seasons. The physicochemical parameters such as temperature, PH, Transparency, Turbidity, conductivity, total hardness, Alkalinity, Dissolved Oxygen (DO)Biological Oxygen demand (BOD), Chemical Oxygen Demand (COD) of surface water was analyzed using the standard methodologies.

Monthly water samples were collected between 7-8 A.M and each sample was kept in good quality polythene cans. The water samples were collected from the surface using a clean polythene bucket of 5 liter capacity. Each sample contains a combination of five sub samples. The parameters such as temperature (water and atmosphere), PH, and Secchi disc transparency, were recorded at the sampling site itself. Some physicochemical characteristics of water were recorded at the site, such as temperature, pH, and transparency were determined by thermometer, digital pH meter and Secchi disc respectively. While some parameters like dissolved oxygen, alkalinity, hardness were analyzed by titrimetric method in laboratory. The other parameters like turbidity, conductivity, Biological Oxygen Demand, (BOD), Chemical Oxygen Demand (COD)and free carbon dioxide (CO_2), were analyzed as per the standard procedures [16], and [17].

3.2 Statistical Analysis

The data related to physicochemical parameters of water were subjected to Pearson's correlation analysis. Pearson correlation coefficient was applied to measure the statistical relationship between different variables. Two way ANOVA of the physico chemical parameters and plankton were done to find out any significant difference between study sites and seasons, ($p<0.01$). The statistical analysis were done by using IBM SPSS -20 software. Correlation and analysis of variance carried out as prescribed by [18]. Two Way ANOVA followed by Post hoc test in the form of Tukey was carried out to find out the mean differences between multiple group mean values.

4. RESULTS AND DISCUSSION

The monthly values (Mean± SD) of hydrological parameters during February 2017 to January 2018 were pooled into three seasons: monsoon (February, March, April and May), Monsoon (June, July, August and September) and post monsoon (October, November, December and January). The results of seasonal values of the various physicochemical parameters; atmospheric temperature and water temperature, PH, transparency, turbidity, conductivity, hardness, alkalinity, Dissolved oxygen (DO),Biological oxygen demand (BOD),Chemical oxygen demand (COD) and free Carbon dioxide (CO_2) from the four study sites (site 1, 2,3 & 4) were presented in Figs. 2 to 13. The results of statistical analysis such as Pearson's correlation matrix, two way ANOVA and Post hoc analysis in the form of Tukey are presented in Tables 1 to 6.

Physicochemical parameters of water are considered as indicators which determine the quality of water for various purposes to satisfy the needs of all living things on the earth. Temperature is a measure of how much heat is present in the water at a particular time and temperature may fluctuate with various factors; the seasons, geographic location and sampling time etc. During the present study it was observed that the data on seasonal values on atmosphere temperature and water temperature were low during the monsoon and were high during pre-monsoon season (Fig. 2). Similar findings were reported by [19,20] and they opined that intensity of solar radiations and clear sky conditions may facilitate the variation in temperature during pre-monsoon season as well as cloudy sky may be one of the reasons for low temperature values during the monsoon season. The present study also supports the above findings.

The results of water temperature from Valiakulam pond during the study period showed that the highest temperature was observed during pre-monsoon season and the lowest value was during the monsoon season (Fig. 3).

Temperature is an important factor in all ecosystems especially aquatic ecosystem because no other single factor has so many profound influences directly and indirectly [21]. Temperature has major role in controlling most of the physicochemical and biological properties of the pond [22]. The statistical analysis (Two way ANOVA and Post Hoc Test and correlation analysis) revealed that the mean values are significant between seasons and between the sites the mean values shows no significant difference. The similar pattern of temperature values were reported [23].

The results of PH values (Fig. 4) of surface water was lowest during pre-monsoon season followed by monsoon season and the lowest values during the post monsoon season [24]. Opinionated that pH has direct and indirect effect on the biota in aquatic ecosystems and even the short span of change in PH can cause the lethal conditions in the aquatic biota. Results of the statistical analysis (ANOVA) showed statistical significance of PH values between the seasons but no significant difference was observed between study sites. The Post Hoc test also supports the same fact. The results of the present study were in agreement with studies conducted in different types of aquatic ecosystems in Kerala [25-28, 23].

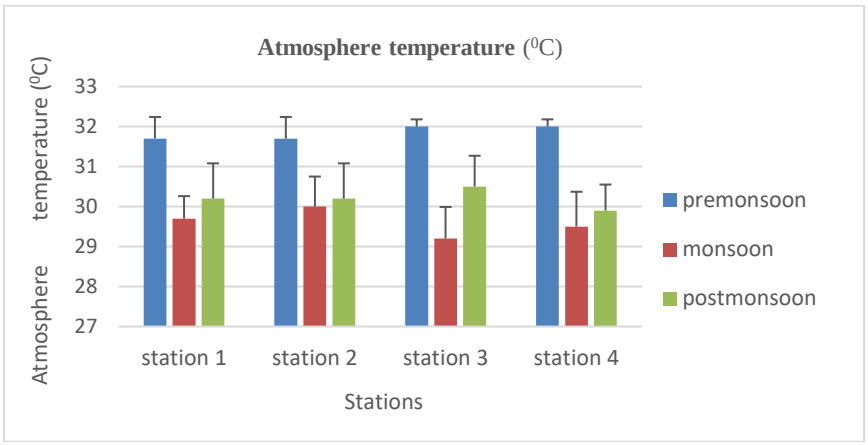

Fig. 2. Seasonal values of Atmospheric temperature (⁰C) (Mean ± SD) from Valiakulam pond during 2017 -2018

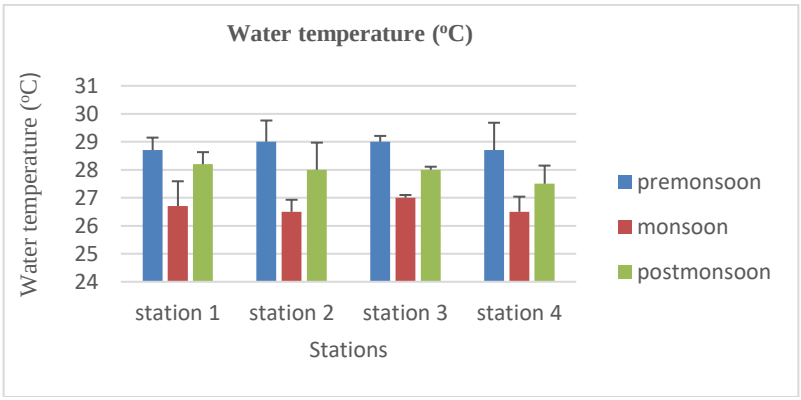

Fig. 3. Seasonal values of water temperature (⁰C) (Mean ± SD) from Valiakulam pond during 2017 -2018

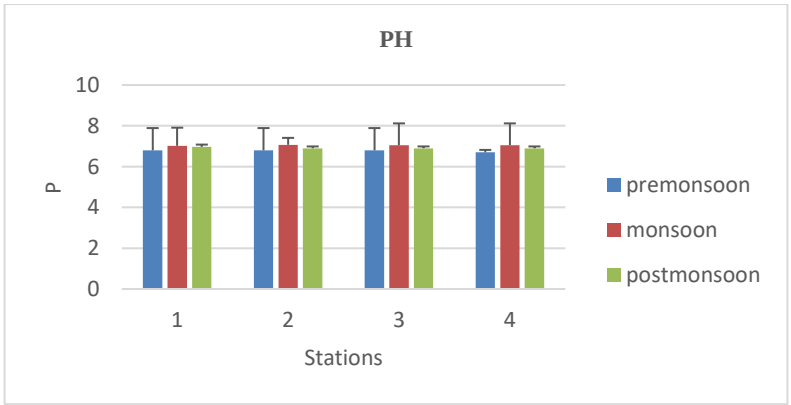

Fig. 4. Seasonal values of pH (Mean ± SD) from Valiakulam pond during 2017 -2018

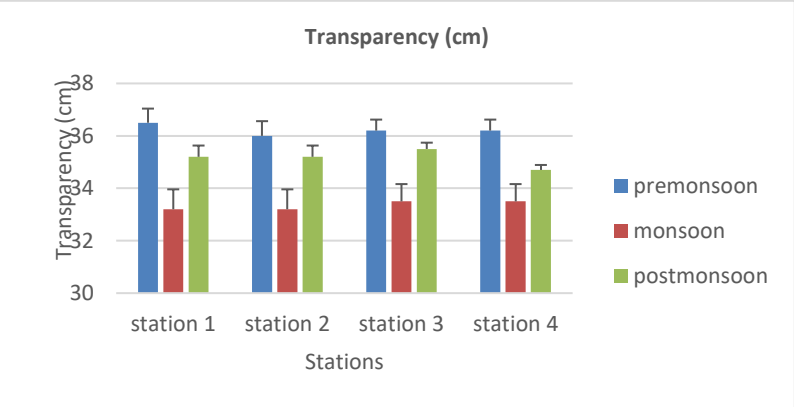

Fig. 5. Seasonal values of transparency (cm) (Mean ± SD) from Valiakulam pond during 2017 - 2018

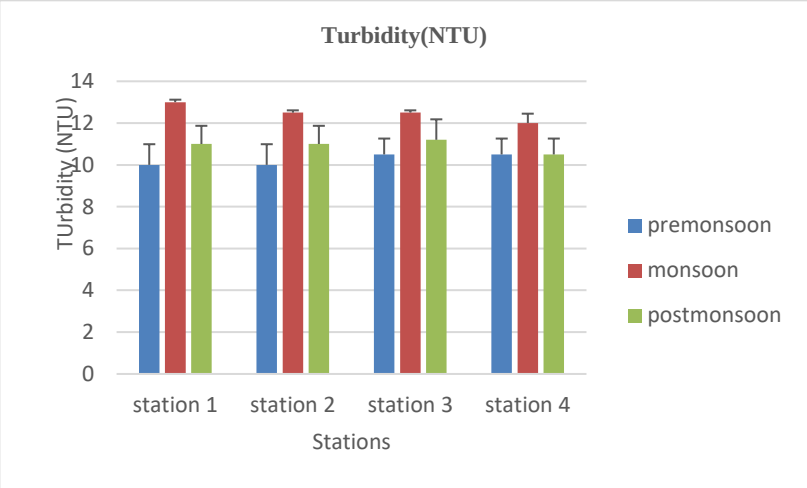

Fig. 6. Seasonal values of turbidity (NTU) (Mean ± SD) from Valiakulam pond during 2017- 2018

Turbidity of water is a measurement of how cloudy or murky the water in an ecosystem appears. Turbidity is caused by particles suspended or dissolved in water that scatter light making the water cloudy or murky. The results of turbidity values from Valiakulam pond water was comparatively lower with respect to the turbidity values reported from other ponds in Thiruvananthapuram [29]. In the present study statistical analysis supported the fact that turbidity values were maximum in monsoon and post monsoon [29]. The results of ANOVA of the turbidity values of the present study showed that no statistical significance was observed between the sites and statistical significance was observed between the seasons.

Electrical conductivity is the ability of current conduction and it is also the estimate of the amount of total dissolved salts or ions in water. Results of the conductivity values of Valiakulam pond during the study period shows statistical significance between seasons but between the study sites the values were not significant. The results of the present study are also in agreement with the results of the previous studies in India and abroad [30-34].

Water hardness is scientifically defined as the amount of dissolved Ca and Mg in water. Hard water is high in dissolved minerals and especially high in Ca and Mg. The water hardness is the property that is not a health concern, but it can be a nuisance. Results of the present study showed that the hardness values were within the range of WHO and is below the value of 50 mg/L. The results of hardness value of water during the study period showed the highest value during the pre-monsoon season and the lowest value during monsoon period. The hardness values showed statistical significance between seasons and no significant difference was observed between the four study sites.

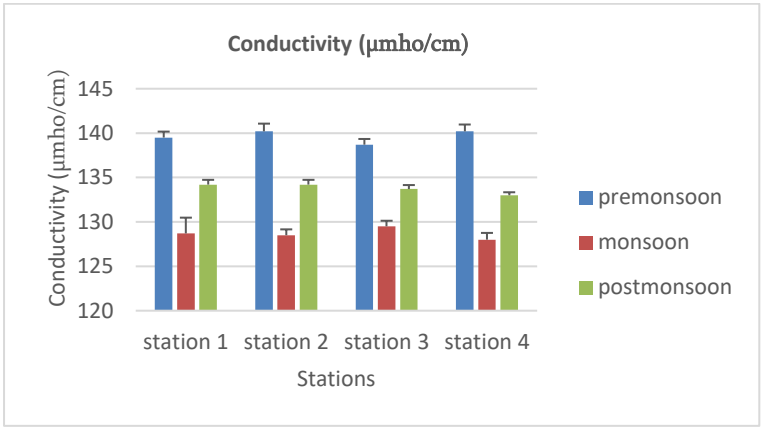

Fig. 7. Seasonal values of conductivity (µmho/cm) (Mean ± SD) from Valiakulam pond during 2017 -2018

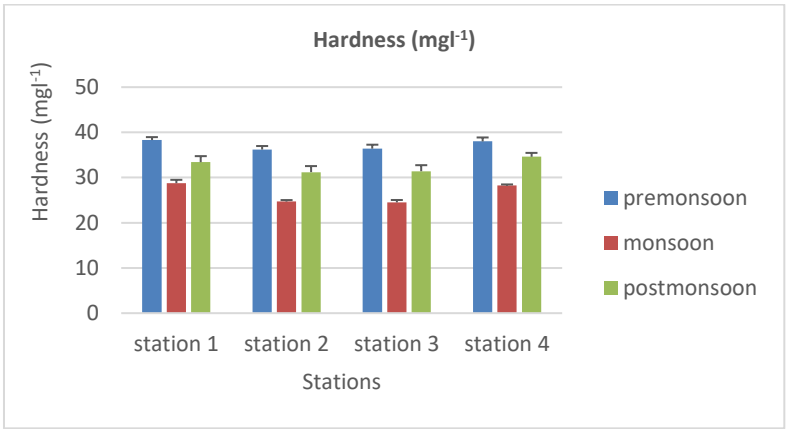

Fig. 8. Seasonal values of hardness (mg/L) (Mean ± SD) from Valiakulam pond during 2017-2018

Alkalinity is also a measure of the buffering capacity of water and it is a characteristic feature which is highly important for aquatic fauna and flora. According to [35] alkalinity helps to stabilize the pH changes to the aquatic environment as a result of photosynthesis of phytoplankton and microalgae in the ecosystem.

During the present study period alkalinity values were highest during the pre-monsoon season and the lowest values were recorded in monsoon season. The results of the present study agrees with the findings of [36] at Mamum river .It can be attributed to the fact that monsoon progresses the alkalinity values decreases in the natural waters or water quality stabilizes the lotic environment [37, 38].

Oxygen can be considered as a prerequisite for all systems. DO of water helps to quantify by the quantity of gaseous oxygen dissolved in organisms, solutions at a time.DO play a key role in an aquatic ecosystem [39]. Oxygen dissolved in water by diffusion from the surroundings by aeration (rapid movement) and as a product of photosynthesis. The seasonal average concentration of DO revealed high concentration during monsoon and post monsoon compared to pre-monsoon. The lower value of DO during pre-monsoon may be due to high water temperature, high respiratory activity of the heterotrophs, low flow rate and enhanced utilization of oxygen by microorganisms in the decomposition of organic matter [40]. In the present study the highest DO values were recorded during the monsoon season may be due to the influx of rain water into the pond. The variation in the concentrations of DO were also attributed too seasonal fluctuations of surface water as opinionated by [41,42].The present study results also agree with the findings of [43,36,23] that the solubility of DO increases with the decreases in water temperature.

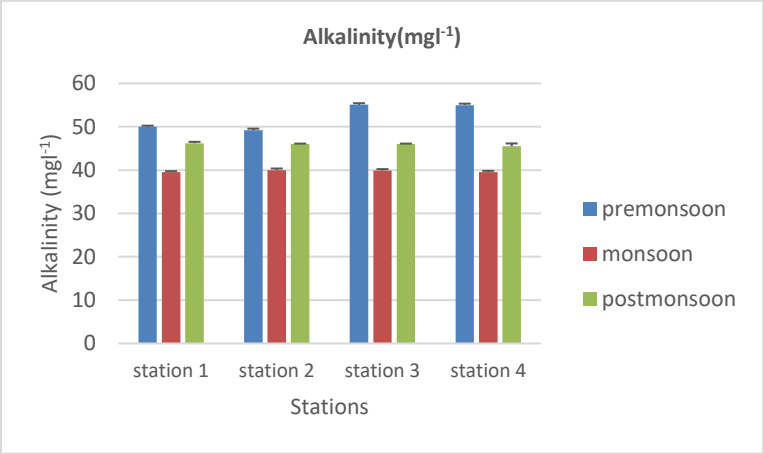

Fig. 9. Seasonal values of alkalinity (mg/L) (Mean ± SD) from Valiakulam pond during 2017-2018

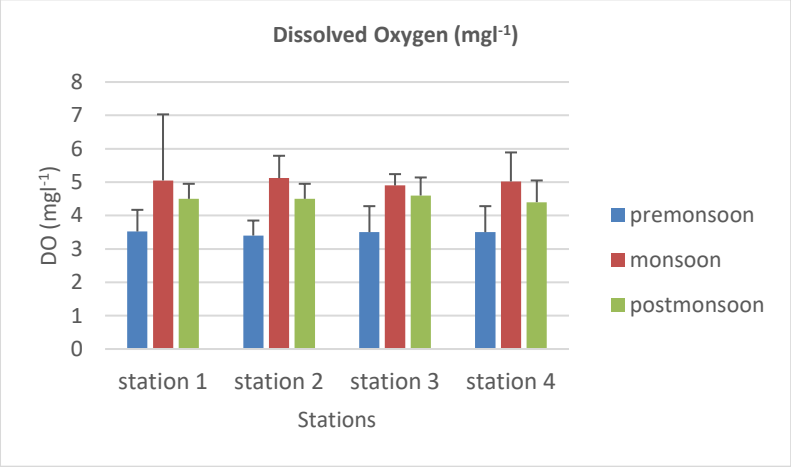

Fig. 10. Seasonal values of dissolved oxygen (mg/L) (Mean ± SD) from Valiakulam pond 2017 - 2018

BOD of water plays a vital role in the productivity of aquatic ecosystems. BOD generally represents how much oxygen is needed to break down organic matter in water. BOD represents the amount of oxygen consumed by bacteria and other microorganism while they decompose organic matter under aerobic condition at a specified temper According to [44] the highest BOD values during pre-monsoon season may be due to the accumulation of waste and reduced rate of water flow due to the disturbance of the ecosystem. [45] Communicated that quality of water cause harm to aquatic life especially fishes [46].

COD is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution. It is the capacity of water to consume oxygen during the decomposition of organic matter in water. It is the amount of oxygen that is needed to oxidize the organic matter present in the quantity of water. It is also used as an indirect measure of pollutants in a water sample and an important parameter in water quality analysis helps to reduce the risk to humans and the environment. In the present study the COD value of Valiakulam pond was highest at pre-monsoon season and the lowest value was at monsoon season. Higher COD values indicative that the sample contains higher levels of oxidisable material. Then the dissolved oxygen level became reduced [47].

In the aquatic ecosystem CO_2 arises from the respiration of aquatic biota, decay of organic matter and from bicarbonate salts. It may occur in the free form and vary with oxygen concentration. In all the water bodies it is one of

the vital components in predicting the quality. In the present study high value was observed during pre-monsoon and the lowest value from monsoon season. The solubility of CO_2 is 30 times more as compared with oxygen. According to [48] an inverse relationship was observed with CO_2 concentration and O_2 levels in water.

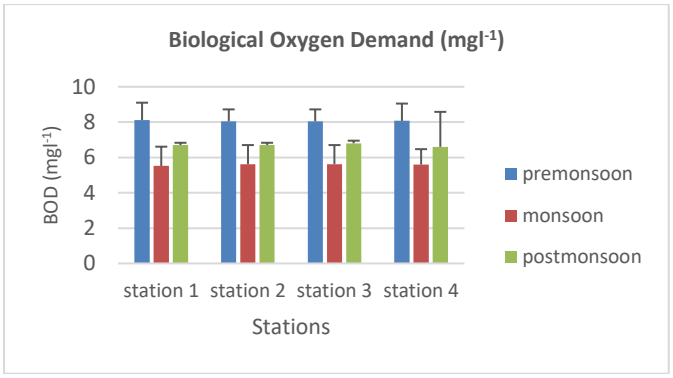

Fig. 11. Seasonal values of biological oxygen demand (mg/L) (Mean ± SD) from Valiakulam pond 2017 -2018

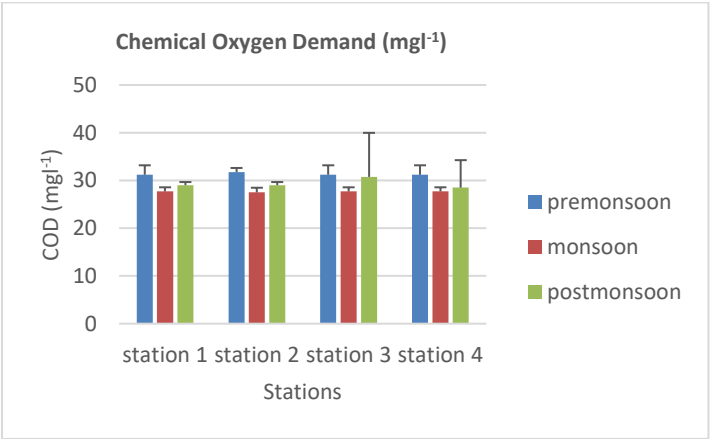

Fig. 12. Seasonal values of chemical oxygen demand (mg/L) (Mean ± SD) from Valiakulam pond 2017 -2018

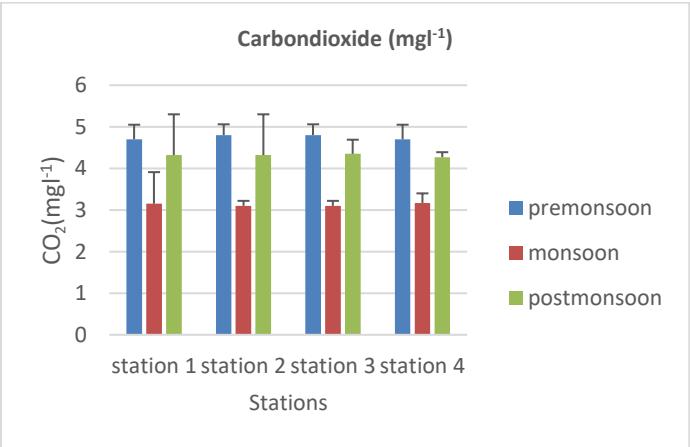

Fig. 13. Seasonal values of carbon dioxide (mg/L) (Mean ± SD) from Valiakulam pond 2017 – 2018

The results of correlation analysis were presented in Tables 1, 2, 3 & 4. All the physicochemical parameters analyzed showed significant correlation with each other positively and negatively. The values were significant at 5% level. All the parameters analyzed were statistically significant. During the correlation analysis Water temperature shows significant positive correlation with Transparency (r=0.71), Conductivity (r=0.80), Hardness (r=0.74), Alkalinity (r=0.76), BOD (r=0.83), CO_2 (r=0.83), Chloride (r=0.84), Sodium (r=0.82), Potassium (r=0.83), Nitrate (r=0.76), Nitrite (r=0.82), Sulphate (r=0.76), Phosphate (r=0.73) and GPP(r=0.76) and significantly negative correlation with pH (r=-0.76), turbidity (r=-0.72), DO (r=-0.79) and COD (r= -0.77).The results of the correlation analysis related to water temperature showed a similar pattern of positive and negative relationship in site 1,2,3 and 4 . The study showed significant linear relationship and the high correlation coefficient between different pairs of water quality parameters.

The results on correlation analysis of pH during study period in site 1,2,3 and 4 showed that the three physico chemical parameters - Turbidity, ,DO, and, COD showed positive correlation with PH and negative correlation with Transparency, Conductivity, Hardness, Alkalinity, Transparency values showed significant negative correlation with turbidity as well as positive correlations n with all other hydrological parameters.

Table 1. Correlation analysis of physicochemical parameters of Valiakulam Pond during 2017-2018 from Site-1

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
A1		0.896	-0.728	0.752	-0.630	0.771	0.656	0.716	-0.719	0.794	-0.681	0.773
A2			-0.762	0.712	-0.716	0.804	0.743	0.755	-0.787	0.834	-0.766	0.834
A3				-0.562	0.800	-0.703	-0.675	-0.598	0.856	-0.772	0.836	-0.735
A4					-0.578	0.898	0.813	0.909	-0.695	0.873	-0.580	0.908
A5						-0.783	-0.702	-0.730	0.923	-0.847	0.942	-0.825
A6							0.873	0.957	-0.879	0.972	-0.791	0.968
A7								0.819	-0.863	0.922	-0.664	0.880
A8									-0.799	0.918	-0.734	0.942
A9										-0.939	0.909	-0.897
A10											-0.843	0.976
A11												-0.840
A12												

Correlation coefficient values are significant 5% level

A1-Atmospheric temperature, A2-Water temperature, A3-PH, A4-Transparency, A5-Turbidity A6-Conductivity, A7-Hardness, A8-Alkalinity, A9-Dissolved Oxygen, A10-Biological Oxygen Demand, A11-Chemical Oxygen Demand,A12-Carbon dioxide

Table 2. Correlation analysis of physicochemical parameters of Valiakulam Pond 2017- 2018 from Site-2

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
A1		0.868	-0.704	0.677	-0.629	0.712	0.619	0.663	-0.692	0.760	-0.677	0.747
A2			-0.761	0.800	-0.788	0.851	0.791	0.813	-0.854	0.894	-8.20	0.906
A3				-0.567	0.790	-0.715	-0.684	-0.615	0.838	-0.776	0.844	-0.735
A4					-0.667	0.866	0.778	0.841	-0.713	0.868	-0.645	0.887
A5						-0.842	-0.751	-0.779	0.946	-0.892	0.947	-0.870
A6							0.884	0.950	-0.904	0.972	-0.826	0.964
A7								0.804	-0.877	0.928	-0.677	0.873
A8									-0.802	0.911	-0.769	0.942
A9										-0.947	0.921	-0.903
A10											-0.856	0.977
A11												-0.851
A12												

Correlation coefficient values are significant 5% level

Table 3. Correlation analysis of physicochemical parameters of Valiakulam Pond during 2017 - 2018 from Site-3

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
A1		0.893	-0.809	0.589	-0.547	0.861	0.700	0.723	-0.744	0.815	-0.623	0.800
A2			-0.813	0.545	-0.537	0.916	0.761	0.786	-0.837	0.858	-0.690	0.837
A3				-0.534	0.727	-0.869	-0.746	-0.667	0.844	-0.833	0.764	-0.781
A4					-0.519	0.665	0.707	0.758	-0.502	0.749	-0.346	0.762
A5						-0.638	-0.568	-0.539	0.720	-0.696	0.771	-0.697
A6							0.825	0.841	-0.878	0.924	-0.749	0.902
A7								0.815	-0.863	0.933	-0.570	0.892
A8									-0.796	0.917	-0.686	0.933
A9										-0.927	0.851	-0.876
A10											-0.738	0.975
A11												-0.741
A12												

Correlation coefficient values are significant 5% level

Table 4. Correlation analysis of physicochemical parameters of Valiakulam Pond 2017 -2018 from Site-4

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
A1		0.846	-0.730	0.684	-0.451	0.699	0.577	0.635	-0.679	0.736	-0.656	0.704
A2			-0.764	0.855	-0.682	0.865	0.791	0.829	-0.853	0.897	-0.694	0.906
A3				-0.634	0.684	-0.750	-0.796	-0.683	0.814	-0.815	0.726	-0.773
A4					-0.573	0.864	0.775	0.881	-0.711	0.869	-0.577	0.900
A5						-0.646	-0.676	-0.666	0.706	-0.708	0.759	-0.732
A6							0.853	0.936	-0.903	0.974	-0.733	0.965
A7								0.796	-0.873	0.917	-0.646	0.887
A8									-0.805	0.907	-0.687	0.939
A9										-0.948	0.781	-0.912
A10											-0.779	0.980
A11												-0.761
A12												

Correlation coefficient values are significant 5% level

Two-way ANOVA was carried out to find out the statistical significance between the mean values. The ANOVA showed that the physicochemical parameters were significant between the seasons and no significant difference was found between the study sites (site 1, 2, 3, & 4) (Table 5). Two Way ANOVA followed by Post hoc test in the form of Tukey was carried out to find out the mean differences between multiple group means of physicochemical parameters studied. It also helps to select the particular parameter of the study which is most significant. The results of post hoc analysis (Table 6) also revealed that significant difference was observed between the seasons.

The physicochemical characteristics of all aquatic ecosystems have a profound effect in predicting the quality of water, the diversity of the fauna and flora, and the mechanism of interaction within the system. The role of physicochemical characteristics were subjected to study in various perspectives in different aquatic ecosystems like ponds, rivers, estuaries and sea water [49-54]. The most important factor of an ecosystem is the interaction among the biotic and abiotic components. The physical and chemical changes in the ecosystem is largely influenced by the physicochemical characteristics of the water of the various levels and during different seasons. The changes in the abiotic components will remarkably influence the biotic components. The intensity of the interaction that occurs in the abiotic components are reflected through various ways in the biotic components. Moreover the studies on the physicochemical aspects of aquatic ecosystem helps to predict the suitability of water for various uses to human being like drinking, bathing, recreational, irrigation, animal husbandry agriculture, aquaculture and industrial applications. The data was subjected to comparative analysis with WHO values and BIS values and showed that some of the parameters were above the permissible range for drinking water standards.

Table 5. Two way ANOVA of physicochemical parameters of Valiakulam pond during February 2017 to January 2018

Sl. No	Parameters	Min	Max	Stations		seasons	
		Mean±S.D	Mean±S.D	F value	P value	F value	P value
1	Atmosphere temperature(^{0}C)	29.6±1.59	32.9±1.80	0.052	0.984	24.309	0.000**
2	Water temperature(^{0}C)	26±1.77	30±1.06	0.099	0.960	36.738	0.000**
3	PH	6.7±0.15	7.15±0.12	0.171	0.916	69.508	0.000**
4	Transparency(cm)	33.12±1.95	37.37±1.84	0.033	0.992	31.667	0.000**
5	Turbidity (NTU)	8.13±1.64	13.62±0.74	0.169	0.917	35.347	0.000**
6	Conductivity(µmho/cm)	126±6.76	144.7±2.76	0.075	0.973	46.164	0.000**
7	Hardness(mg/L)	23.12±4.22	37.62±5.26	0.018	0.997	32.266	0.000**
8	Alkalinity (mg/L)	3.70±0.89	5.83±0.52	0.002	1.000	40.692	0.000**
9	DO (mg/L)	2.8±0.62	6.7±1.02	0.015	0.997	40.457	0.000**
10	BOD (mg/L)	4.92±1.45	8.83±0.49	0.003	1.000	47.005	0.000**
11	COD (mg/L)	24.12±2.80	32±3.54	0.052	0.984	50.218	0.000**
12	Free CO_2(mg/L)	2.7±1.07	5.55±0.25	0.01	0.999	54.766	0.000**

*values with** - significant. Significance at 5% level ($p < 0.05$). Other F values without ** are not significant*

Table 6. Post HOC test of physicochemical parameters of sites and seasons during the study period 2017-2018

			Atmosphere temperature(^{0}C)		Water temperature(^{0}C)		PH		Transparency (cm)		Turbidity (NTU)		Conductivity (µmho/cm)	
	Source		**Mean Diff.**	**Prob.**	**Mean Diff.**	**Prob.**	**Mean Diff.**	**Prob.**	**Mean Diff**	**Prob.**	**Mean Diff**	**Prob.**	**Mean Diff**	**Prob.**
Sites	Site 1	Site 2	0.393	0.999	0.042	1.000	-0.021	0.975	0.167	0.992	0.208	0.992	0.208	1.000
		Site 3	0.393	1.000	0.125	0.994	0.013	0.994	0.042	1.000	-0.042	1.000	1.000	0.970
		Site 4	0.393	0.982	0.250	0.958	-0.013	0.994	0.125	0.997	0.417	0.940	0.333	0.999
	Site 2	Site 3	0.393	1.000	0.083	0.998	0.033	0.909	-0.125	0.997	-0.250	0.986	0.792	0.984
		Site 4	0.393	0.996	0.208	0.975	0.008	0.998	-0.042	1.000	0.208	0.992	0.125	1.000
	Site 3	Site 4	0.393	0.991	0.125	0.994	-0.025	0.959	0.083	0.999	0.458	0.922	-0.667	0.991
Seasons	Pre Monsoon	Monsoon	0.340	0.000**	3.594	0.000**	-0.453	0.000**	4.063	0.000**	-4.875	0.000**	18.219	0.000**
	Monsoon	Post monsoon	0.340	0.000**	2.469	0.000**	-0.428	0.000**	1.781	0.002	-4.219	0.000**	12.000	0.000**
	Monsoon	Post monsoon	0.340	0.756	-1.125	0.028	0.025	0.832	-2.281	0.000**	0.656	0.552	-6.219	0.005

			Hardness (mg/L)		Alkalinity (mg/L)		DO (mg/L)		BOD (mg/L)		COD (mg/L)		Free CO_2(mg/L)	
	Source		**Mean Diff.**	**Prob.**	**Mean Diff.**	**Prob.**	**Mean Diff.**	**Prob.**	**Mean Diff**	**Prob.**	**Mean Diff**	**Prob.**	**Mean Diff**	**Prob.**
Sites	Site 1	Site 2	0.393	0.999	0.042	1.000	-0.021	0.975	-0.004	1.000	0.042	1.000	0.008	1.000
		Site 3	0.393	1.000	0.125	0.994	0.013	0.994	-0.017	1.000	-0.208	0.996	0.004	1.000
		Site 4	0.393	0.982	0.250	0.958	-0.013	0.994	0.029	1.000	0.167	0.998	0.046	0.999
	Site 2	Site 3	0.393	1.000	0.083	0.998	0.033	0.909	-0.013	1.000	-0.250	0.994	-0.004	1.000
		Site 4	0.393	0.996	0.208	0.975	0.008	0.998	0.033	1.000	0.125	0.999	0.037	0.999
	Site 3	Site 4	0.393	0.991	0.125	0.994	-0.025	0.959	0.046	1.000	0.375	0.980	0.042	0.999
Seasons	Pre Monsoon	Monsoon	0.340	0.000**	3.594	0.000**	-0.453	0.000**	3.875	0.000**	-7.500	0.000**	2.688	0.000**
	Monsoon	Post monsoon	0.340	0.000**	2.469	0.000**	-0.428	0.000**	2.609	0.000**	-7.063	0.000**	1.491	0.000**
	Monsoon	Post monsoon	0.340	0.756	-1.125	0.028	0.025	0.832	-1.266	0.007	-0.438	0.861	-1.197	0.000**

*The values with **significant. Significant p<0.01*

Table 7. Comparison of the water quality parameters from Valiakulam pond with WHO value and BIS value

Parameters	Values of Valiakulam pond water	WHO value	BIS value
PH	6.7-7.15	6.5-9.5	6.5-8.5
Total Hardness	23.12-37.62	200	300-600 mg/L
Alkalinity	3.70-5.83	300	200-600
DO	2.8-6.7	5-7	6 mg/L
BOD	4.92-8.83	2	2
Turbidity	8.13-13.62	1 NTU	1-5 NTU

5. CONCLUSION

Access to safe drinking water is essential for health, a basic right and a component of effective policy for health protection [55]. Access to safe drinking water is important as a health and developmental issue at national, regional and local levels. Water quality is considered as an important part of environmental monitoring and which has an integral role in keeping the planet healthy and sustainable. The present study of physico chemical parameters of surface water from the Valiakulam pond during 2017-2018 (one year) revealed that all the parameters analysed were within the permissible range of WHO. In any aquatic habitat the physico chemical parameters such as (temperature, PH, transparency, turbidity, conductivity, hardness, and alkalinity, DO, BOD, COD and CO2) have a major role in governing the structure and function of the aquatic ecosystem. Moreover, the functional nature of the water bodies greatly influences the existing meteorological conditions. Hydrological conditions of water affect productivity, species composition of aquatic fauna, eutrophication etc. In addition, the metabolic activities in the pond ecosystem determine the utilisation of water for various domestic, agricultural and aquaculture activities. Though it was a maiden scientific attempt to evaluate the quality of water from Valiakulam pond with a view to explore its utilisation to improve the quality of life of people who are residing in the locality. The productive utilisation of water for domestic, aquaculture, agriculture activities are envisaged in the present study. The results were promising in this regard that the water can be used for any activities. The present study results also support the fact that the parameters studied were within the WHO limits. The study concluded that the Valiakulam pond water is not polluted during the study period.

The results of the study revealed that the seasons have a profound effect on hydrological parameters studied. The statistical analysis showed that seasonal values shows significance at 5% level . The study could not include the data on fish diversity because fishing activities are not permitted in the pond during the study period by the concerned local body. The study fails to collect the data on aquatic terrestrial interactions also. It can be concluded that the present study was preliminary and more comprehensive studies are to be conducted in future to predict the productivity and nutrient cycles in the ecosystem.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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