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ORIGINAL ARTICLE

STUDIES ON THE PHYSICO-CHEMICAL ANALYSIS OF WATER OF PERUMAL LAKE, ALAPPAKKAM, CUDDALORE DISTRICT, TAMIL NADU, INDIA

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ABSTRACT

The present investigation has been conducted to assess the physico- chemical analysis of Perumal Lake. The physical parameters analysed include colour, odour, temperature, turbidity, total dissolved solids, electrical conductivity and pH.The chemical parameters analysed include total alkalinity, total hardness,calcium, magnesium,chloride,iron, fluoride,sulphate,phosphate, nitrates and ammonia. Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) were also analysed. The results showed that the water samples were clear,colourlessin all the seasons and had muddyodour in summer season. It may bedue to chemical and biological reactions of the organisms in water and the growth of pathological organism were enhanced by warm water condition. Temperature, pH, EC and TDS showed seasonal fluctuations. The increasing trendin summer season may be due to low water level, high evaporation rate and human activity including cattle grazing in and around the stations and decrease in rainy season may be due to dilution by rain water. The chemical parameters showed an increasing trend in summer season and decreasing trend in monsoon. The increase may be due to the availability of organic and inorganic complexes, low water level and high temperature.In all the seasons, the physico-chemical parameters observed during the year 2018 is higher than 2019. Fluctuations of seasonal values indicate that the water bodyis influenced by seasonal variations and the water quality of Perumal Lake is suitable for drinking, domestic use and for irrigation purposes except the EC, BOD and COD values. All the parameters showed a significant difference ($p < 0.05$) between different seasons.

Keywords: : Perumal Lake,Physico-chemical parameters

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1.INTRODUCTION

Availability of well-analyzed safe water is required for everyday activities like human consumption, agriculture, and human purposes (Agarwal *et al.,* 2003). the quality of water in both lentic and lotic systems has deteriorated due to various types of pollution. Industrial effluents, sewage water, pesticides and fertilizers are contaminating the surface and ground water.there by Assessment of water quality today implies the need for a reference point against which result of monitoring can be measured and weighed. Aquatic ecosystems as a part of the natural environment are balanced both within themselves and with other environmental components. This equilibrium is subjected to natural variations and evaluations caused by human intervention.

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Hence the present investigation has been conducted to assess the physico- chemical analysis of Perumal Lake water. The physical parameters such as colour, odour, temperature, turbidity, total dissolved solids, electrical conductivity and pH and the chemical parameters analysed include total alkalinity, total hardness,calcium, magnesium,chloride,iron, fluoride,sulphate,phosphate nitrates and ammonia. Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) are also analysed from January 2018 to December 2019.

2.MATERIALS AND METHODS

Study Area: The Perumal lake, spread over an area of 500 acres, selected as a model water body for the present investigation, is a natural perennial lake located near Kullanchawadi, Cuddalore, Tamil Nadu. The bottom of the lake is composed of 40% sand, 20% silt and dead planktonic

organisms, fishes and other wind flown materials. Perumal lake is a community lake and constitutes as a major water resource for agriculture and fishing activities (Fig 1.).

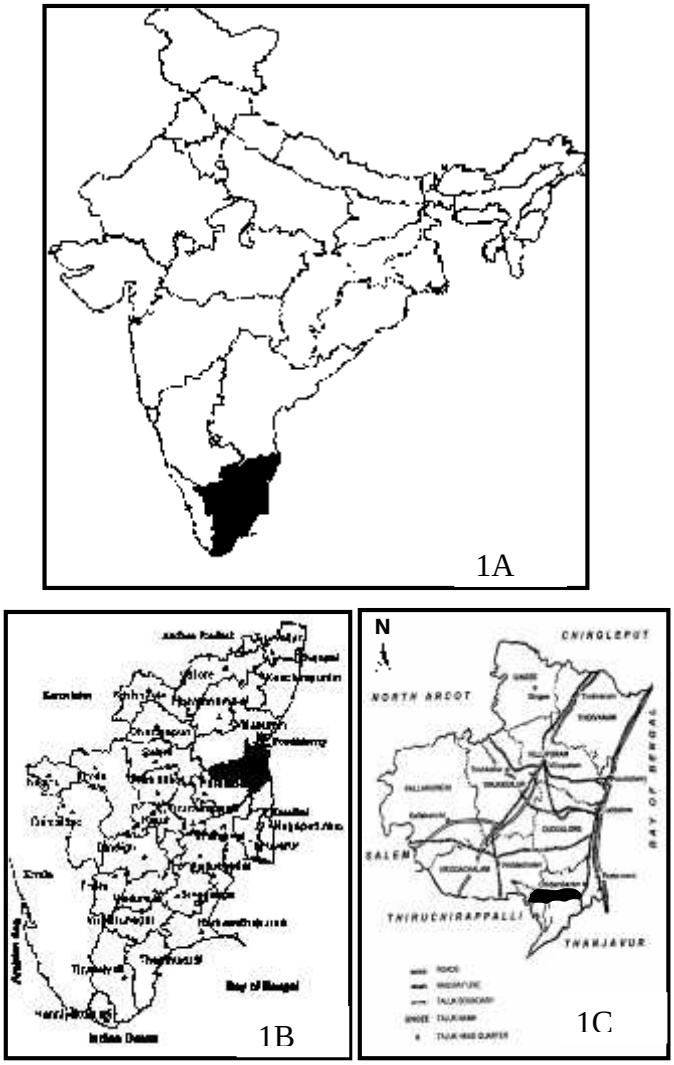

Fig 1A-D Showing Study area , Perumal Lake

The present study was carried out for a period of 2 years from January 2018 to December 2019. Water samples were collected for physico-chemical analysis from two sampling stations a tPerumalLake.Samples weretaken once in every month between 8.00am to 10.00am in 2 litre clean well dried polythene bottle with necessary precautions and labeled for collecting points. For each sampling event, temperature was noted down the spotusing Celsius thermometer. For BOD estimation, water samples were collected separately in dark bottles. Collected samples were brought to the laboratory on the same day and analysed by following the standard methodologyofAPHA(2005).Data are presented as mean ± standard deviation of means. One-way analysis of variance (ANOVA) with multiple mean test DMRT (Duncan's MultipleRangeTest),Duncan(1995)inalltheparameterstoinvestigatethe difference existing between the seasons.

3.RESULTS

The mean variations of physico-chemical characteristics of water in two stations of Perumal Lake at different seasons of pre-monsoon, monsoon, post-monsoon and summer were presented in tables 1 and 2.

Colour and Odour: In two stations, during the study period water were colourless during pre-monsoon, monsoon and post-monsoon but during summer slightly muddycolour were observed in the site in the two stations. The odour of the water were unobjectable and odourless during pre- monsoon, monsoon and post-monsoon, but during summer object able odour were noted in stations I and II.

Air Temperature:The mean seasonal variations in air temperature divulge that the patterns of deviation in the two stations were alike throughout the phase of the investigation.Theair temperature varied between 30.72±0.24to34.68±0.17in2018and30.00±0.41to33.88±0.16in 2019. The lowest temperature of 28.26 ± 0.29 was recorded in the monsoon season 2019. The highest temperature of 34.68 ± 0.17 was recorded in the summer season 2018.The season dependent variations in air temperature of the two stations average of the Perumal Lake water results revealed that air temperature has highly significant differences ($p > 0.05$) among the different seasons. During the study period, all the seasons the air temperature were higher in the year 2018(30.72±0.38; 29.50±0.70; 28.62±0.24; 34.68±0.17) than the year 2019(30.00±0.41;28.26±0.26; 29.08 ± 0.08; and 33.88 ± 0.16) except in the post-monsoon season. The overall mean value of 31.1 ± 2.511 was recorded during the study period.

Water temperature:During the year 2018, the highest water temperature was noted during summer season as about 30.36 ± 0.13, whereas the lowest watertemperature was noted during post-monsoon season as about 23.94 ± 0.93. During the year 2019, the highest water temperature was recorded during summer season as about 29.24 ± 0.13 and the lowest water temperature was documented during monsoon season as about 23.76 ± 0.13. The disparity in the water temperature among the different stations were insignificant, but the water temperature showed significant difference between the seasons ($p > 0.05$). The disclose in the water temperature during the period of investigation were found in 28.60 ± 0.54, 25.62 ± 0.24, 23.94 ± 0.93 and 30.36 ± 0.13, pre-monsoon, monsoon, post- monsoon and summer respectively, in the year 2018. In the year 2019 maximum temperature observed during summer season (29.24 ± 0.13) and minimum temperature was recorded during monsoon season as about 23.76 ± 0.13. The overall mean water temperature of the study period was 26.54 ± 2.47.

Turbidity: The disparity in turbidity among the different stations were insignificant but the turbidity showed significant different between the seasons. This disclose in the

turbidity during the study period were present in the Tables 1 and 2. The maximum value observed as 2.36 ± 0.37 in the summer season during the year 2018 and minimum value observed as 1.50 ± 0.07 the post-monsoon season in the year 2019. The overall mean turbidity of the study period was recorded as 1.82 ± 0.37.

Total dissolved solids (TDS): Seasonal variations in TDS in the two stations are alike throughout the phase of the investigation. The mean TDS varied between 423.86 ± 5.08 to 598.40 ±29.97.. The disclose in the TDS during the period of the investigation were found in 598.40 ± 29.97, 439.60 ± 8.87,439.80± 18.34 and 544.20 ± 23.46 and pre-monsoon, monsoon, post-monsoon and summer respectively in the year 2018 and 525.15 ± 12.94, 441.68 ± 3.52 ,423.86 ± 5.08 and 572.14 ± 5.53 respectively in the year 2019. The result revealed that the disclosed of TDS has highly significant difference ($p > 0.05$) among the different seasons. as 499.02 ± 69.23.

Electrical conductivity (EC): Electrical conductivity is directly related to the concentration of ionized substance in water. The maximum value (933 µmol/cm) of EC obtained in the month of June 2019 and minimum value (608 µmol/cm) observed in the month of October, 2018. The seasonal average EC value ranged from 638.00 ± 22.80 to 880.00 ± 33.91 during the year 2018.The lowest value observed during monsoon season and the highest value observed during the summer season. During the year 2019, themaximum value observed as 892.98 ± 20.21 in summer season and the minimumvalueobservedas666.16±16.50in monsoon season.The overall mean value of the EC was 757.2 ± 92.2 and the analysis of variance reveals that the EC values in different seasons during the present study shows significant difference ($p < 0.05$).

pH: The pH of water is an important indication of its quality and provides significant information in many types of geochemical equilibrium solubility calculation. GenerallypH of water is influenced by geology of catchment area and buffering capacity of water. The seasonal average of the pH values ranged between 7.24 ± 0.151 and 8.46 ± 0.040 with a mean of 7.85 ± 0.377. The maximum value was documented at the summer season and minimum value was recorded at the monsoon season. Comparison between the two years season, the pH values were more or less similar in the pre-monsoon, monsoon and post-monsoon seasons but in summer seasons the pH value is7.62 ± 0.19 during the year 2018 and the pH value is 8.46 ± 0.04 in the year 2019. The pH has significant difference ($p > 0.05$) among the seasonsduring the period of investigation. The overall mean value of pH was7.8 ± 0.37. The analysis of variance reveals that the values of pH differ significantly ($p < 0.05$) in the different season.

Total alkalinity: Alkalinity of water is defined as the ionic concentration, which can be neutralized by hydrogen ions. The presence of carbonates, bicarbonates and hydroxides are the main cause of alkalinity in natural waters. The seasonal variation in the total alkalinity reveal that the maximum value of221.40 ± 9.91 mg/l was recorded during the summer season 2018 and minimum value of 136.74 ± 5.42 mg/l was recorded during the monsoon season 2019. The overall mean value of total alkalinity was recorded as170.23 ± 28.84 mg/l and the analysis of variance reveals that the difference in total alkalinity showed significant ($p < 0.05$) difference between the seasons.

Total Hardness: The water hardness is primarily due to the results of interaction between water and geological formations. The highest value recorded during summer season 2018 and lowest value recorded during post-monsoon season 2019(table 1 &2).The overall mean value of total hardness was recorded as 163.12 ± 22.95 mg/l. The analysis of variance showed that there was a significant difference ($p < 0.05$) in total hardness values among the different seasons.

Calcium: Calcium is essential nutrient which play an important role in biological system. During the study period seasonal mean values varied from 38.08 ± 1.92 to 62.80 ± 3.11 mg/l. The highest value recorded as 62.8 mg/l at post-monsoon season in the year 2018 and the lowest value observed during the monsoon season 2018. The overall mean value of calcium level 53.35 ± 7.72 was recorded during the study period.

Magnesium: Magnesium is a common constituent of natural water and is usually present in association with calcium in all kinds of natural water contributing to the total hardness of water. The maximum value of 31.86 ± 1.98 mg/l was recorded in the post-monsoon season 2018 and minimum level was noted as 20.96 ± 1.28 mg/l in the summer season 2018. The seasonal mean values reveal that the occurrence of magnesium is in the following order summer < monsoon < pre-monsoon < post-monsoon during 2018and pre-monsoon < monsoon < post-monsoon < summer during the year 2019. The overall mean value of 25.67 ± 3.54 was recorded during the study period.

Iron: Iron as an essential micronutrient needed in trace for proper metabolic activities of both plants and animals. The maximum value observed as 1.14 ± 0.74 mg/l in the summer season 2018 and minimum value occurs as 0.25 ± 01 mg/l in the post-monsoon season 2019. The overall mean value of iron was recorded as 0.40 ± 0.37 mg/l. The results of the analysis of variance reveal that there is a significant difference ($p < 0.05$) in iron concentration among the different seasons.

Ammonia: The occurrence of ammonia in water resulted from denitrification process of nitrates. The seasonal average variations ranged from 0.47 ± 0.01 mg/l to 0.80 ± 0.04 mg/l. The lowest values observed during the monsoon season 2019 and the highest value observed during the post-monsoon season 2018 and pre-monsoon seasons 2019. There was a significant difference ($p < 0.05$) in the ammonia levels among the different seasons.(tab1and2)

Nitrate: Seasonal average variations in the nitrate level of Perumal Lake water ranged between 1.01 ± 0.37 and 3.53 ± 2.05. The maximum value of 3.53 ± 2.05 mg/l was observed in summer season 2018 and minimum level of nitrate was recorded as 1.01 ± 0.03 mg/l during the pre-monsoon season 2019. The overall mean value of Nitrate value recorded as 1.65 ± 1.01. The results of the analysis of variance revealed that there was a significant difference ($p < 0.05$) in nitrate concentration among the different season.(tab1and 2)

Nitrite: The nitrite values ranged between 0.09 ± 0.01 and 0.41 ± 0.19. During the study period, the maximum values recorded in the pre-monsoon season 2019 and the minimum value recorded in the monsoon season 2019. The overall mean value of nitrite recorded as 0.19 ± 0.10. The results of the analysis of variance reveal that there was a significant difference ($p < 0.05$) among the different seasons.(tab 1 and 2)

Chloride: Chloride occurs naturally in all types of water. It is an important element in plants and animal life. During the studyperiod the chloride value ranged from 66.14 ± 0.70 mg/l to 88.40 ± 1.81 mg/l. The highest value observed during

summer season 2018 and the lowest value recorded in the monsoon season 2019. The overall mean value of chloride observed as 74.30 ± 7.30 mg/l. The results reveal that the difference in the chloride levels has significant ($p < 0.05$) among the different seasons. (tab 1and 2)

Fluoride: Fluoride in drinking water is considered to be a neurotoxin. Seasonal variations in the occurrence of fluoride in the water sample of Perumal Lake during the present investigations were presented in Table 1 and 2. The fluoride concentration was low (0.15 ± 0.02 mg/l) during monsoon

Table1. Physico-chemical parameters at different seasons of Perumal Lake water during the year 2018

Parameters	Pre-monsoon	Monsoon	Post-monsoon	Summer	'F' value
Colour	Colourless	Colourless	Colourless	Muddycolou	-
Odour	Odourless	Odourless	Odourless	MuddyOdou	-
AirTemperature(ºC)	30.72 ± 0.38*	29.50 ± 0.70*	28.62±0.24*	34.68±0.17*	248.679
WaterTemperature(ºC)	28.00 ± 0.54*	25.62 ± 0.24*	23.94±0.93*	30.36±0.13*	132.750
Turbidity(NTU)	1.82 ± 0.08*	1.54 ± 0.11*	1.55±0.05*	2.36±0.37*	17.692
TotalDissolvedSolids(mg/l)	598.40±29.97*	439.60 ± 8.87*	439.80±18.34*	544.20±23.46*	73.372
ElectricalConductivity(µmol/cm)	798.00±25.88*	638.00 ± 22.80*	708.00±16.43*	880.00±33.91*	88.610
pH	8.08 ± 0.04*	7.24 ± 0.15*	8.00±0.07*	7.62±0.19*	44.527
Totalalkalinity(mg/l)	166.40 ± 2.30*	153.80 ± 12.5*	156.40±7.73*	221.40±9.91*	62.925
TotalHardness(mg/l)	140.80 ± 1.48*	145.00 ± 5.09*	154.20±3.42*	194.40±6.69*	110.350
Calcium(mg/l)	55.30 ± 2.25*	45.62 ± 1.15*	56.38±2.38*	58.46±0.89*	84.077
Magnesium(mg/l)	26.20 ± 2.16*	22.14 ± 1.52*	31.86±1.98*	20.96±1.28*	38.343
Iron(mg/l)	0.35 ± 0.05*	0.26 ± 0.01*	0.27±0.01*	1.14±0.74*	6.515
Ammonia(mg/l)	0.74 ± 0.02*	0.50 ± 0.02*	0.80±0.04*	0.59±0.07*	45.270
Nitrate(mg/l)	1.01 ± 0.03*	1.52 ± 0.13*	1.26±0.11*	3.53±2.05*	6.257
Nitrite(mg/l)	0.11 ± 0.02*	0.16 ± 0.01*	0.20±0.00*	0.15±0.02*	22.239
Chloride(mg/l)	71.4 ± 0.89*	76.04 ± 2.05*	68.20±3.56*	88.40±1.81*	74.745
Fluoride(mg/l)	0.28 ± 0.02*	0.15 ± 0.02*	0.34±0.01*	0.33±0.02*	72.301

Note: Valuesareexpressedasmean±SD;Numberofsampleperseason(n=15);*–Significantatp<0.05.

Table2. Physico-chemical parameters at different seasons of Perumal Lake water during the year 2019

Parameters	Pre-monsoon	Monsoon	Post-monsoon	Summer	'F' value
Colour	Colourless	Colourless	Colourless	SlightlyMuddycolour	-
Odour	Odourless	Odourless	Odourless	MuddyOdour	-
AirTemperature(ºC)	30.00±0.41*	28.26±0.26*	29.08±0.08*	33.88±0.16*	296.885
WaterTemperature(ºC)	27.00±0.35*	23.76±0.13*	24.31±0.23*	29.24±0.13*	570.141
Turbidity(NTU)	2.06±0.20*	1.51±0.16*	1.50±0.07*	2.28±0.3*	66.377
TotalDissolvedSolids(mg/l)	525.15±12.94*	441.68±3.52*	423.86±5.08*	572.14±5.53*	411.103
ElectricalConductivity(µmol/cm)	732.25±11.23*	666.16±16.50*	715.00±17.65*	892.98±20.21*	170.553
pH	7.92±0.05*	7.47±0.07*	8.00±0.10*	8.46±0.04*	162.895
Totalalkalinity(mg/l)	175.60±2.46*	136.74±5.43*	143.82±2.55*	204.74±5.68*	270.072
TotalHardness(mg/l)	142.70±0.97*	153.86±6.37*	140.68±3.80*	203.34±5.63*	191.612
Calcium(mg/l)	54.25±2.25*	45.62±1.15*	56.38±2.38*	58.46±0.89*	50.357
Magnesium(mg/l)	24.75±0.77*	25.86±1.49*	26.40±0.96*	28.26±0.79*	15.601
Iron(mg/l)	0.38±0.017*	0.30±0.011*	0.25±0.018*	0.31±0.010*	59.793
Ammonia(mg/l)	0.80±0.016*	0.47±0.015*	0.73±0.016*	0.75±0.043*	162.143
Nitrate(mg/l)	1.96±0.06*	1.30±0.04*	1.28±0.08*	1.37±0.09*	95.973
Nitrite(mg/l)	0.411±0.019*	0.092±0.013*	0.224±0.047*	0.170±0.141*	16.045
Chloride(mg/l)	76.30±2.13*	66.14±0.70*	68.72±2.23*	79.20±4.75*	23.281
Fluoride(mg/l)	0.277±0.032*	0.186±0.008*	0.274±0.018*	0.332±0.022*	36.223
Sulphate(mg/l)	33.40±0.65*	24.22±0.45*	32.46±1.77*	30.88±1.44*	58.692
Phosphate(mg/l)	0.252±0.01*	0.296±0.11*	0.202±0.17*	0.260±0.21*	30.528
BOD(mg/l)	19.17±0.34*	14.78±0.46*	9.26±0.51*	9.04±0.34*	664.472
COD(mg/l)	26.10±0.22*	25.86±0.43*	23.20±0.70*	25.00±0.73*	27.359

Note: Valuesareexpressedasmean±SD;Numberofsampleperseason(n=15);*–Significantatp<0.05.

season 2018 and high during the post-monsoon season (2018) as 0.33 ± 0.02 mg/l. The overall mean value of fluoride occurs as 0.27 ± 0.68 during the study period. Analysis of variance revealed that the difference in fluoride among the different seasons as significant ($p < 0.05$).

Sulphate: Seasonal wise occurrence of sulphate in the lake water during the study period was shown in the(tab 1 and 2) The seasonal average sulphate ranged from 22.64 ± 1.52 to 32.46 ± 0.65 mg/l. The highest value recorded during the post-monsoon season 2019 and the lowest values occursduring the monsoon season 2018. The analysis of variance reveals that the levels of sulphate differ significantly ($p < 0.05$) in the different seasons during the study period, the overall mean value of sulphate was recorded as29.00 ± 3.99.

Phosphate: Phosphate is required for plant growth and its natural occurrence in lakes is very small. Seasonal wise occurrence of phosphate in the water samples of Perumal Lake during the present investigations were presented in (tab 1and 2) The seasonal variations of phosphate in the water samples ranged from 0.20 ± 0.01 to 0.29 ± 0.01 mg/l. The maximum value observed in monsoon season 2019 and minimum value occurred in post-monsoon season 2019 during the study period. Analysis of variance reveals that the phosphate levels in different seasons during the present investigation shows significant difference ($p < 0.05$). The overall mean value occur in the present study was 0.25 ± 0.03.

Biological Oxygen Demand (BOD): The results of the present studytab 1 and 2 reveal that there is a wide fluctuation in the biological oxygen demand. It showed a maximum of20.64 ± 0.47 mg/l and a minimum of 7.02 ± 0.29 mg/l. during 2018 The seasonal meanvalues reveal that the gradation in BOD is as follows: pre-monsoon < post-monsoon < monsoon < summer during 2018 and summer > post-monsoon > monsoon > pre-monsoon during 2019. Analysis of variance reveals that the BOD showed significant difference ($p < 0.05$) between the seasons. The overall mean value of BOD of the study period was recorded as 13.25 ± 4.75.

Chemical Oxygen Demand (COD): Seasonal mean value of the lake water COD were presented in the Table 1 and 2. The seasonal variation in COD reveals that the maximum value of31.00 ± 3.53 mg/l was recorded during the summer season 2018 and minimum value of 21.40 ± 0.89 mg/l was observed during the pre-monsoon season 2018. Analysis of variance reveals that the COD showed a significant ($p < 0.05$) different between the seasons. The overall mean value of COD of the present investigation was recorded as 25.44 ± 2.93.

Clean water is one of the nature's greatest gifts to mankind. Mostly, water remains colourless, when pollutant like sewage or industrial waste mix with itwhich reveals the colour of pollutants.The samples inthe study during most months,were found predominant to be colourless. Colour of water is indicative of the degree of pollution caused by humus material, plant, weeds, metallic substances and protozoans (Arthi*et al.,* 2011). Estimation of pollutants largely depends on the physical appearance like colour, odour and turbidity. The samples in the study during most months were found predominantly to be colourless. Natural waters have different tastes and odours. Bad tastes and odours in water is usually due to waste discharged from different industrial establishments and domestic sewage which contain organic matter and various chemicals. Chemical and biological reactions of the organisms in water and the growth of nuisance organism are enhanced by warm water conditionandcouldleadtothedevelopmentofunpleasanttasteando dour(Sacramento, 1963; Mechalas*et al.,* 1972). The samples in the presentstudy during most months were found odourless. And theodourwas predominant (muddy) in April to June

Temperature plays an important role in limnological studies. It is one among the factors that influence the geochemical aspects and eco-biology of ecosystems. The surface water temperature influences the rate of photosynthesis by algae and large water plants. According to Garg et al. (2007), temperature is an important factor for various chemical and biochemical reactions in water and solubility of most substances is also largely depends on temperature. A rise in temperature of the water leads to the speeding up of the chemical reactions in water, reduces the solubility of gases and amplifies the taste and odour (Murugesan *et al.,* 2004). The result of the present study reveals that all the stations were hot during the months fromMarch to Julyand dropped in October to December gradually. The overall variation is almost similar during all the stations inall the seasons. The gradual increase of temperature during the summer and subsequentlydecrease inthe monsoon season mightbe duetothelowwater level, low velocity, atmospheric condition and greater solar radiation in summer and lesser solar radiation, frequent clouds, high humidity, high current velocity, more rainfall and high water level during the monsoon season gradually reduce the air and water temperature.Jain *et al.* 1996; Sampathkumar and Kannan, 1998; Swaranalatha and Narsing Raj, 1998; Karuppasamy*et al.* 1999; Yogesh Shastri and Pendse, 2001). Further, the water temperature was not parallel with air temperature duringthestudyperiod.and it could be assumed that thecooler water flowing into the reservoir has reduced the water temperature more than the local air temperature. The maximum difference of 5.4°C between the air temperature and water temperature was recorded during the period of investigation. The correlation of the air temperature and water temperature of Perumal Lake showed a high degree of positive relationship.

Turbidity is caused by particulate matter in suspension. In the present study, turbidity shows seasonal variation. High levels of turbidity can cause several problems for aquatic system. It can result in low dissolved oxygen levels by preventing photosynthesis by blocking sunlight and raising water temperature by absorbing more heat from the sunlight. Turbidity of water in the Indian reservoirs are mainly attributed of run-off process that brings huge load of silt particles from the adjacent landmasses and agricultural level. This contributes considerable amount of colloidal and finally divided suspended matter in the aquatic subsystem (Sathyanarayanan, 1990). Suspended particles may also carry nutrients, pesticides and bacteria throughout water ways. Turbidity measurement provides a good correlation with the concentration of particles in water that affect clarity. In the present investigation, the maximum value observed (2.3 NTU) in the summer and the minimum value observed (1.5 NTU) in the post- monsoon. The high value in summer may be due to low water level and human activities including cattle grazing in and around the stations. The low depth and the suspended clay in addition to turbidity caused by inflowing water,

geographical location and the shadow of the canopy around the stations may cause low transparency.

Total dissolved solids denote the concentration of mineral constituents dissolved in water. TDS of natural waters are mainly composed of carbonates, bicarbonates, chlorides, sulphate, phosphates, silicate, calcium and magnesium (EPA, 1976). TDS present in water limits, light penetration and influence the productivity and distribution of planktons. TDS values ranging between 0 mg/l and 1000 mg/l are classified as freshwater and potable. The results of the present study reveal that the TDS values ranged between 423.86 mg/l and 598.40mg/l Hence, the water can be potable. The most important aspect of TDS with respect to drinking water quality is its effect on taste (Bruvold and Pangborn, 1966). It shows that in all the seasons the value is higher in the year 2018 when compared to the year 2019 except pre-monsoon season. But, during the year 2018 there is no variation between monsoon and post-monsoon season.

The conductivity measurement provides an indication of ionic concentration The EC shows seasonal variation and is also site specific. EC is highly depended on the amount of dissolved solids in waters, temperature, types and concentration of ions present (Kumar *et al.,* 2005). The mineral components of the water are directly related to agricultural utility and its parametric value decides the suitability for drinking and irrigation purposes. The EC values in the present study vary from 638.00 to 892.98 µmho/cm. The EC values were higher than the WHO (1998) permissible limit (300 µmho/cm). The higher EC value obtained were in good agreement with the EC values reported by (Pazhanisamy, 2005; Palanisamy*et al.,* 2007; Karunakaran *et al.,* 2009). The high values of EC are due to concentration of ionic salts and nutrients constituents present in the water. According to the EC value greater than 400 µmhos/cm may be attributed to a high chloride concentration in water. Srinivas et al. (2000) reported that, the germination of almost all the crops would be affected and it may result in much reduced yield.The acidity or alkalinity nature of water is important in determining the distribution of aquatic organisms. The pH show significant changes during the months of the study period in Perumal Lake. The microbiological integrity of water also depends upon its pH valueYadav *et al.,* 1987). The pH of the Perumal Lake water during the study period was between 7.24 to 8.46, Pazhanisamy (2005) in lower Anaicut Reservoirs. The pH of the reservoir was alkaline to neutral without deviating much from the neutral pH value 7. In the present study, the pH values were maximum during summer season (8.46) and minimum value was recorded during monsoon season (7.24). The maximum pH values occurs during the summer season could be uptake of CO2 by the photosynthesizing organisms especially phytoplankton (Murugan, 1990; Gonzalez et al. (2004); Chaterjee and Raziuddin, 2006).

Total alkalinity or acid combined capacity of natural freshwater which is generally caused by carbonates and bicarbonates of calcium and magnesium. Alkalinity and pH are the factors responsible for determining the amenability of water to biological treatment (Manivasakam, 2003). Alkalinity is often related to hardness because the main source of alkalinity is usually from carbonate rocks. If water contains metal carbonates, it is high in alkalinity, conversely if carbonates are associated with sodium of potassium does not contribute to hardness Soft water usually has low alkalinity and little buffering capacity, therefore generally soft water has much more susceptibility to fluctuations in pH from acid rain or acid contamination.The seasonal total alkalinity values in our observations fluctuated from 136.74 – 221.40mg/l indicating that the water is hard. Alkalinity was higher during the summer season (221.40mg/l) followed by steep fall in the monsoon periods (136.74mg/l). The low alkalinity during the monsoon may be due to dilution effect. In the present study, during the study periods, the values are within the permissible limit.

In natural waters, hardness usually ranges from 10mg/l to more than 500 mg/l. value above 500mg/l is relatively uncommon (EPA, 1976). As per the WHO (1984) standards, 500mg/l is the maximum permissible limit of hardness in any water to be used as potable water. Waters with hardness values less than 10mg/l are also not suitable due to their low buffering capacity and more corrosive ability. In the present study the water hardness ranged from 140.68mg/l to 203.34mg/l, from this above point of view the water is suitable for drinking purpose. The variation in the hardness of potable water results in some physiological disorders in human beings due to variations in the osmotic potential of intestinal blood and body fluid (Kakati, 2010). In the present study, the seasonal average of total hardness value is maximum during summer and minimum during monsoon and post-monsoon seasons. During the present study the total hardness values are within the permissible limit. Proper treatment could help in reduction of total hardness (Vatchala, 2007). Human usage of hard water for long time may cause the formation of kidney stone and heart disease (Freeda Gaana Rani *et al.,* 2003).

Calcium, the most important constituent of bio-skeleton, is essential to maintain the integrity of bones to check osteoporosis. It is essential nutrient which plays an important role in biological systems. The chief source of calcium in natural waters is the passage of water through or over the deposits of lime stones, dolomite, gypsum and gypsiteous shale. In natural waters calcium content may range from null to several hundred mg/l. In aquatic environment calcium which serve as one of the micronutrients for most of the organisms. Calcium is an important element influencing flora of an ecosystem, which plays an important role in metabolism and growth.

Magnesium content of water is considered as one of the important qualitative criteria in determining the quality of water for irrigation. Generally calcium and magnesium maintain a state of equilibrium in most waters. More Mg++ in water will adversely affect crop yields as the soils become more alkaline. Magnesium is often associated with calcium primarily due to its similar chemistry. During the study period the magnesium values ranged from 22.14 mg/l to 31.86 mg/l. the maximum permissible limit of magnesium in drinking water 30-50 mg/l (WHO, 1994). In the present study, during the investigation periods all the samples were in permissible limit. Magnesium content above the acceptable limits causes nausea, muscular weakness and paralysis (Purandara*et al.,* 2003).In the present study, the overall mean average of Perumal lake magnesium level was 25.67 mg/l. As per Bureau of Indian Standards (BIS, 1991) 30 mg/l is permissive limit of magnesium in water used as potable water. The present study value indicates the water is suitable for drinking

purpose.Presence of iron in considerable amount in water imparts colourand also develops turbidity, when exposed to air, consequently the water becomes unacceptable for drinking purpose. In the present study, the seasonal values ranged from 0.25 to 1.14mg/l were found below the maximum permissible limits for drinking water. According to the Indian standards, up to 0.3mg/l constitute potable category, between 0.3 to 1.00mg/l represents alternate source category, while the content exceeding 1.00mg/l represents non-potable category. Ammonia is generated for natural sources by bacterial activity and from organic nitrogen containing compounds and hydrolysis of urea. In water bodies, ammonia is produced by the reduction of nitrates under anaerobic conditions. Even at low levels, ammonia is toxic to aquatic organisms. It can affect hatching and growth rates in the early stage of fish and cause tissue changes in the gills, liver and kidney during development. Ammonia becomes more toxic at higher pH level, lower dissolved oxygen level and warm water temperature.

Nitrogen occupies very important role in aquatic production as it is an essential constituent for protein. Zutshi and Khan (1998)stated that, the domestic sewage is mainly responsible for greater concentration of nitrates in fresh water bodies. Occurrence of is mainly due to aerobic decomposition of nitrogen from organic matter. Nitrogen is essential for the synthesis of protein, hence it is a limiting factor along with phosphorus controlling growth of phytoplankton in natural waters (Jhingran, 1991).During the study period the nitrate content of water varied from 1.01 to 3.53mg/l. The presence of nitrate in water is due to domestic activities and agricultural runoff which dissolved in rain water and enter into the lake. During the year 2018, the monsoon and summer seasons the values are higher than in the year 2019 and the are lower in post-monsoon season and pre-monsoon season when compared to 2019. Kumar (1994) pointed out that an appreciable rise of nitrate during April and May (summer season) may be due to excess activity of decomposition in the water bodies. The WHO health based guideline value for nitrate in drinking water is 45mg/l. During the study periods, the values of nitrates in the Perumal Lake water is within the permissible limit.

Chloride is normally the most dominant anion in water, which can cause corrosion and pitting of iron plate or pipes. Chloride occurs in all natural water in widely varyig concentrations. Normal fresh water contains8.3mg of chloride per liter (Vijaya Bhaskar *et al.,* 2009; Swarnalatha and Raj, 1998). The presence of chloride in the lake water was mainly due to domestic sewage and its concentration is an indicator of organic pollution (Kumar, 2002). The present investigation shows the minimum values of 66.14 mg/l were recorded in monsoon season in the year 2018 and maximum value of 88.40 mg/l were recorded in summer season for the year 2018. Similar observation was reported by Karne and Kulkarni (2009) at Maharashtra. The chloride levels of the lake water found to be higher during summer period and low values observed during monsoon season. The increasing value of chloride in summer season may be due to a gradual decrease in the amount of water. Munawar (1970), Saha and Pandi (1986) have reported lower chloride values in unpolluted pond. The chloride content normally increases as the mineral content increases. In the present investigation the overall average chloride concentration was 74.3mg/l. The values fall within the desirable limit of 250mg/l of WHO (1998).

Fluoride is more commonly found in groundwater than the surface waters through weathering of primary silicates and associated accessory minerals (Thakareet al., 2005). The fluoride in drinking water is considered to be a neurotoxin. It contributes to learning disabilities in children, including hyperactivity. In the present study, the maximum value of fluoride recorded during post-monsoon (0.34 mg/l) in the year 2018 Sulphate is one of the major anions occurring in natural waters. It may enter in natural waters through weathering of Sulphate bearing deposits. sulphate is an important constituent of hardness. Excess sulphate has Laxative effect and cause adverse effect on human health (Subramani and Elango, 2005). It also imparts taste to water (Pichammalet al., 2009). Higher values of sulphate may cause gastrointerstinal disorders in human beings (Ramadeviet al., 2009) and produces cathartic effect in human beings (Srinivas et al., 2002).Comparative study of sulphate between the study periods reveals that in all seasons the values are higher in the year 2019 than in the year 2018. The overall mean value of sulphate in Perumal Lake was recorded as 29 mg/l. The maximum permissible limit of sulphate in drinking water is 250mg/l. Sulphate content above the permissible limit may cause diarrhea. Higher values of sulphate may cause gastrointestinal disorders of human beings (Ramadevi*et al.,* 2009).

The present investigation revealed that the dissolved phosphate concentrations in the lake were characterized by low level of phosphate in all the seasons ranged from 0.20 to 0.29mg/l. Verma and Shukla (1968), Kaul et al. (1980), Zutshi and Khan (1998) and also observed similar situations in the water bodies. In the present study, the values were found high during monsoon. This view was supported bySivkumar. (2003) that the planktonic forms utilize phosphate for their multiplication in contaminated waters. There is no variation between the monsoon seasons of the two yearsand during 2018 the phosphate value are higher in pre-monsoon and post-monsoon season than in 2019. But in monsoon season the phosphate value is higher in 2019 than in 2018. The overall mean phosphate of the Perumal lake water was recorded as 0.25 mg/l. Inthe present study, the maximum concentration of phosphate in lake waters was observed during the rainy season (2018). This is probably due to the incoming rainwater, which contains all types of sewage and other rubbish matter including agricultural wastes which empty into the Perumal Lake. The importance of the inflow of phosphate content through the catchment area during the rainy season has been emphasized by Vyas and Kumar (1968) who have reported high concentration of phosphates during the rainy season.

Biological Oxygen Demand (BOD) test is useful in evaluating the self purification capacity of streams, which serves as a measure to assess the quality of waste water which can be safely assimilated by a stream (Trivedy and Goel, 1984). BOD is an important parameter to assess the pollution of waters, where the contamination occurs due to disposal of domestic and industrial effluents. Dissolved oxygen is needed for living organisms to maintain their biological process. The maximum desirable limit of BOD for drinking water is 5 mg/l. In the present investigation, BOD value of water samples varies from 7.02 to 20.64 mg/l. the high BOD values clearly indicate pollution, which may be dumping of domestic waste, human

and animal excreta on the bunds of the lake and attributed to the percolation of wastewater loaded with biodegradable material.

The chemical oxygen demand of water represents the amount of oxygen required to oxidize all of the organic matter, both biodegradable and no-biodegradable by a strong chemical oxidant. The estimation of COD is of great importance for water having unfavorable conditions for the growth of microorganisms such as presence of toxic chemicals (Saxena, 1994). COD is the measure of the oxygen equivalent of the organic matter susceptible to oxidation by chemical oxidant. Thus, COD can be a reliable parameter for judging the pollution of water (Keramatt, 2008). COD estimate the carbonaceous fraction of organic matter. According to Lens et al. (1995) COD values do not differentiate stable and unstable organic pollution; therefore, it is more than BOD. In the present study the COD values ranged from 21.40 mg/l to 31.00 mg/l. A similar finding was reported by Sivakumar et al. (2000) in Pudumund Lake, Ooty. The maximum value observed during summer and pre-monsoon may be due to low water, high temperature, phytoplankton productivity and microbial utilization of oxygen at the time of decomposition (Pillai, 1994).The healthy condition of an aquatic ecosystem depends upon the physico-chemical and biological characteristics, which usually fluctuate with season and degree of pollution. Hence, it is suggested that the water for drinking is pre-treated before consumption that can help prevent outbreak of diseases and occurrence of health hazard associated with aquatic contamination.

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