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Studies on Seasonal Variation of Physico-Chemical Parameters of Water Samples Collected from Puliyanthangal and Maniyambattu Lakes of Ranipet District, Tamilnadu

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Abstract: The present study was aimed to see the seasonal variation of Physico-chemical parameters of water samples collected from Puliyanthangal and Maniyambattu lakes located in the Ranipet district influenced by tannery effluent discharge. For the present study, water samples were collected from both the lakes' mouth and middle regions for one year from 2015-2016. Standard methodology was analyzed to determine various physicochemical parameters like as temperature, pH, turbidity, EC, TDS, total hardness, Ca, Mg, Fe, NH3, NO3, NO2, Cl, F, and SO4 for seasonality (APHA, 2000). The result showed that the contents of turbidity, EC, total hardness, and NH3 in Puliyanthangaland Maniyambattu lakes were higher in the mouth and middle region of water samples during pre-monsoon, monsoon and post-monsoon seasons except for TH in the monsoon (S_4) season. In both the lakes, values of most of the physicochemical parameters like pH, TDS, Ca, Mg, Cl, Fe, SO_4 NO_3, NO_2 and Fwere found within the permissible limit following the World Health Organization (WHO). However, higher values of specific Physico-chemical parameters indicate that the lake water has become slowly polluted, and it may be due to the influence of tannery effluents in the lake by direct and indirect means. It is suggested that the lake in the Ranipet district should be maintained without much dilution of untreated tannery effluent discharge to sustain and safeguard the lake ecosystem for the survival of living things in the biotope

Keywords: Irrigation, Tannery Effluent, Water Quality

Introduction

Increased water quality degradation due to human activity has become a major source of worry in the current population growth environment. Industrialization and diversity of human activities have resulted in an exponential increase in the uses and abuses of this crucial natural resource. The degradation of water quality may be viewed as an unavoidable side effect of fast industrialization and modernization, which aims to increase output and consumption to raise materialistic standards of living. As a result, it must be examined in the context of the growing need for water quality and quantity for beneficial purposes. The hydrosphere is larger than the lithosphere and is separated into lakes, rivers, estuaries, and oceans. Metals are found in the hydrosphere in the form of dissolved and suspended matter and deposited sediments. Sediments in rivers, lakes, estuaries, and seas are the hydrosphere's primary sinks for heavy metals.The majority of rivers in India have been indiscriminately utilized to dispose of trash that exceeds their capacity for assimilation and have poorly become polluted. The primary sources of river contamination have been identified as industry and household trash. Industrial effluents include contaminants that negatively influence receiving waterways and on human health and aquatic biota. Numerous investigators worldwide have studied the works relating to water and land pollution by various sources, most notably tannery effluents emitted by tanneries. Khan (2001) found out that the River of Rajasthan, India, has been affected by industrial effluent discharge into the riverbed. The effluent water in the river is the primary source of contamination of groundwater. Due to the effect of industrial effluent concentration of sodium and chloride was higher with a proportional increase in Total Dissolved Solids (TDS) and Electrical Conductivity (EC) value. Therefore, soil and land have become hard, compact and saline.Das et al. (2003) examined effluents discharged from various sources and soil/groundwater properties closer to the source of pollution. The results indicated that wastewater discharge into land successfully decreases pollutants by adsorption/chemical reaction in the soil media. Thus, to avoid groundwater pollution, septic effluents should be disposed of through a well-managed subterranean drainage system, and the treatment plant's efficiency should be sufficient to remove the contaminants. Amathussalam

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and Gnanaganesan (2004) studied physicochemical and bacteriological analyses of tannery effluent polluted groundwater in Tiruchirappalli and found out that the groundwater appears to be of poor quality not suitable for drinking purpose. This wastewater (effluent), when discharged into surrounding agricultural fields, disturbs the ecological balance by deteriorating the environmental conditions, micro soil flora and contributes to groundwater pollution through percolation into the soil. Gagnetene*t al.* (2006) reported that heavy metal pollution and eutrophication in the lower Salado River basin (Argentina) found changes in metal concentrations in sediments and water than the control sampling site. Heavy metals, particularly chromium, copper, and lead, appear to be a significant source of pollution in these freshwater ecosystems.

Jothivenkatachalam et al. (2010) studied Correlation analysis of drinking water quality in and around perur block of Coimbatore district, Tamil Nadu, India and reported that correlation and regression analysis reported a significant linear association between several pairs of water quality measures. ShashwatKatiyar (2011) studied the impact of tannery effluent with particular reference to a seasonal variation on Physico-chemical characteristics of river water at Kanpur (U.P), India.He reported that chromium levels were increased (52.1215.52 mg/L) in almost all sampling points with seasonal variation, indicating that tanneries' effluent had a highly detrimental effect on the Ganges river. Sankpal and Naikwade (2012) studied the physicochemical analysis of effluent discharge of fish processing industries in Ratnagiri, India. They asserted that the samples were contaminated and detected values that exceeded the permissible limits. Several remedial actions should be taken to avoid water pollution.

AkhandPratap Singh and DevendraPratap Rao (2013) Assessment of tannery effluent: a case study of Kanpur in India and observed that the analysis of various physical and chemical characteristics of tannery effluents showed variations according to month and results reveals that there are certain relationships between Physico-chemical characteristics of effluents both positive and negative. Ambiga and AnnaDurai (2013) reported that the Groundwater Pollution Potential in and Around Ranipet Area, Vellore District, Tamilnadu is findings that value of few parameters are TDS, Total hardness, Calcium, Magnesium, Sulphate, Chloride, Fluoride and Nitrate fall out of the permissible range regarding BIS. Drinking standards. Hence, suggested taking proper care to avoid contamination of groundwater pollution through periodic monitoring of the water quality. Vinay Kumar Singh (2014) studied the modulatory Effect of Tannery Effluents on the Physicochemical Quality of River Water and reported that tannery wastewater is added continuously in river water; a few years from now, severe water quality deterioration could take place, which will be serious threat to aquatic and human life. Tamilarasi et al. (2015)studied groundwater Quality Monitoring in Walajah Block, in Palar river basin at Vellore District, Tamilnadu, India and reported that the groundwater in Walajah block, situated at Palar basin in Vellore district is deteriorated by the parameters such as total dissolved solids, total alkalinity, total hardness, nitrate and chromium. ArasappanSugasini and KalyanaramanRajagopal (2015) studied the Characterization of Physicochemical Parameters and heavy metal Analysis of Tannery Effluent. They reported that higher amounts were recorded in the untreated effluent, which indicates that it may become a significant source of water pollution, affecting flora and fauna inhabiting such environments. Sekar and Suriyakala (2016) conducted studies on the seasonal variation of heavy metal contamination of groundwater in and around the Udaiyarpalyam taluk in the Ariyalur district of Tamil Nadu.They observed that some heavy metals in several groundwater samples refer to heavy metal affected by water sources. According to the result shows that most of the groundwater deteriorates less than the permissible limit of WHO.

The leather industry is India's fourth-largest commercial activity. The Tamil Nadu tanneries account for around 80% of the total leather export production, with most of them in small and medium-sized factories along the coast. Many tanneries discharge color and bleach-based liquid waste as well as chromium, which are both hazardous. Tanyards also have significant levels of organic matter. A substantial portion of developed countries have phased out or substantially reduced the usage of tanneries due to environmental concerns. This is because the bulk of tanneries are situated in nations with weak or nonexistent environmental rules. The government has asked the Chennai-based Central Leather Research Institute to develop solutions to the worrisome effects of tannery waste. To better manage pollution from tanning companies, the institution has been doing tests on how to regulate pollution and it has also been providing industrial consultation services on pollution control programs. A full-scale demonstration wastewater treatment facility has been in operation at Ranipettai since 1977, a joint effort with industry. Several wastewater treatment systems for various enterprises in Chennai, Ranipettai, and Vaniyambadi have been developed since then.

AREA OF STUDY

Ranipet, often spelled Ranipettai, is the industrial center of Tamil Nadu in southern India. It is a medium-sized community located approximately 20 kilometers north of Vellore. Ranipet is India's fourth-biggest urban area. It is a large industrial town located on National Highway 4 between Chennai and Bangalore. Ranipet, Tamil Nadu, India, is located at a latitude of 12.932063 and 79.333466. The Ranipet region is a chronically polluted area, with 240 tannery industrial units located in and around the town and other businesses such as ceramics, refractory, boiler auxiliaries, and chromium compounds. This settlement on the Palar river's northern bank. Ranipettai was home to 50,764 people. Numerous big and medium-sized leather businesses produce finished leather and leather goods for export, such as shoes and clothes. Other small-scale businesses exist in Ranipet, particularly in the chemical, leather, and tool manufacturing industries. These industries are critical to the town's survival. Additionally, Ranipet has over 500 small and large-scale engineering units that mainly serve BHEL. Ranipet is India's second-largest manufacturing cluster.

COLLECTION OF WATER SAMPLES

The water samples were collected from the mouth and middle region of Puliyanthagal Lake (PS1) and Maniyambattulake (MS1) of Ranipet district, Tamilnadu. The study was carried out from 2015 – 2016. At each sampling site, the sampling bottles were rinsed with distilled water at least three times before sampling was done. All samples were correctly labeled—water samples were collected during the morning (9 am to 10.30 am). Water samples were filtered through Whatman filters to separate suspended particulate matter. Samples bottles were transferred immediately to the laboratory. The methods followed for all the Physico-chemical parameters were done according to the procedures given in APHA (2000). The period was divided into three seasons, respectively: pre-monsoon, monsoon and post-monsoon.

ANALYTICAL METHODS

The water samples were collected from the mouth and middle region of Puliyanthagal Lake (PS1) and Maniyambattulake (MS1) of Ranipet district, Tamilnadu pre-monsoon, monsoon and post-monsoon season, respectively. The selected water quality parameters are pH, turbidity, electrical conductivity (EC), Total Dissolved solids (TDS), Total Hardness, Calcium, Magnesium, Chlorides, Sulphates, iron, Nitrite, Nitrate, ammonia and Fluoride. All the Physico-chemical parameters were done according to the procedures and the standard protocols of the American Public Health Organization (APHA).

On-site analysis

A pH meter was used to determine the pH of the water samples. The pH meter was calibrated by testing three standard solutions: pH 4.0, 7.0, and 10.0. After dipping the pH meter into the water sample and holding it for two minutes, the sample's value was recorded. Electrical conductivity was measured using a EC meter (model HANNA HI 98303). Turbidity was detected in water samples with a turbidity meter. The samples were put into the sample container and left there for a few minutes. The reading stability was then recorded.

Laboratory analysis

The TDS of the water samples was determined by the gravimetric method. Total Hardness, Calcium, Magnesium, chlorides were determined by the titration method. Sulphate and ammonia content was measured by the spectrometric method. Fluoride of the water samples was determined by the alizarin visual method. Nitrate and nitrite were determined by the ultraviolet spectrophotometric screening method.

STATISTICAL ANALYSIS

It was conducted to determine the difference in metal concentration between the season and mouth and middle region of both lakes. Two-way ANOVA and t-test were employed to evaluate the variability of the Physico-chemical parameters for different seasons and places, using the software Minitab. The analyzed data were expressed as mean ± standard deviation (SD), standard error (SE). A $p < 0.05$ was considered significant.

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SELECTION OF SAMPLING POINTS

Sampling points were selected based on the population density, industrial activities like manufacturing sodium chromate, chromium salt, essential chromium sulphate tanning powder used in the leather industry, and groundwater used by the residents for drinking domestic irrigation purposes. The current study areas of Puliyanthangal and Maniyambattu lakes are directly or indirectly receiving partially treated and untreated wastes from nearby industries and untreated domestic wastes from the surrounding villages. Conventional wastewater, including organic and inorganic pollutants, has the potential to create significant complications. Therefore, water samples were taken during the pre-monsoon, monsoon, and post-monsoon seasons from the mouth and middle region of Puliyanthagal Lake (PS1) and Maniyambattulake (MS1) in Ranipet, Tamilnadu, respectively.

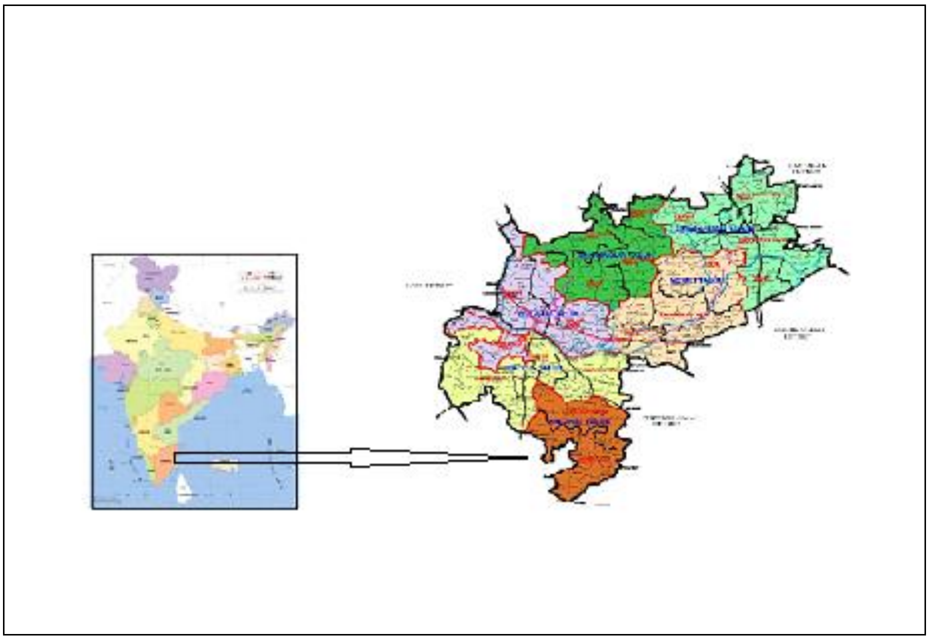

Fig.1.The map of the location is Ranpet district, Tamilnadu, India.

RESULT AND DISCUSSION
WATER PARAMETERS

For the present study, the water samples were collected from the mouth (S_1) and middle (S_2) region of Puliyanthagal Lake (PS1) and mouth (S_1) and middle (S_2) region of Maniyambattu lake (MS1) of Ranipetdistrict, Tamilnadu were analyzed for physicochemical parameters such as turbidity, EC, TDS, TH, pH, Ca, Mg, Fe, NH_3, NO_2, NO_3, NH_3, Cl, SO_4, and F and their results are depicted in table 1.1 an 1.2.

Turbidity

The Turbidity content of the mouth region of Puliyanthanthngal lake (S_1), the middle region of puliyanthangal lake (S_2), mouth region of Maniyambattu lake (S_1) and middle region of Maniyambattu lake (S_2) ranged from 32±4.32 to 38.5±11.47, 28.2±4.99 to 33.25±4.99, 33±2.16 to 39±19.35 and 27±3.82 to 31.7±5.90 during pre-monsoon, monsoon and post-monsoon, respectively. The seasonal mean values of turbidity content was above the permissible limit of 10 given by WHO (1984) for drinking purpose. Turbidity content showed that significant seasonal variation in puliyanthangal lake (PS1) ($F=3.66$ and $p=0.046$) and Maniyambattu lake (MS1) ($F=3.32$ and $p=0.059$) at $p > 0.05$. Insignificant variation of turbidity content was observed among the mouth and middle region at PS1 ($F=0.85$, $p=0.370$) and MS1 ($F=1.64$, $p=0.217$) at $P > 0.05$. The highest value was recorded in the mouth region of the pre-monsoon season at PS1 (38.5±11.47) and post-monsoon season at MS1 (39±19.35). The level of turbidity varied significantly between the sites (t-value = 0.43, $p=0.026$) at $p < 0.05$.

In puliyanthangal lake (PS1) and Maniyambattulake (MS1), the turbidity content of the mouth region (S_1) seemed to be higher level compared to the middle region (S_2). They showed the order Premonsoon> post-monsoon> monsoon in S1 at PS1 and S2 at MS1, pre-monsoon> monsoon > post-monsoon in S2 at PS1 and post-monsoon> pre-monsoon in S1 at MS1 among the seasons. The result showed that turbidity values were higher in all the samples than the permissible limit of 10 from the mouth and middle region of Puliyanthangallake (PS1) and Maniyambattu lake (MS1). Turbidity is clearly indicated. During the pre-monsoon, the content of the mouth region in S1 at PS1 and MS1 was greatly increased, while the content of the middle region in S2 at PS1 and MS1 gradually decreased. Monsoon and post-monsoon season, respectively. Thus, it is predicted that the content of turbidity is likely to be decreased or increased according to the dilution level of tannery effluent into the lake water.

It is significantly noticed that the turbidity content was found to be increased in the pre-monsoon season followed by post-monsoon and monsoon at PS1 and MS1. The high presence of this content may be due to tannery sludge carrying a high load of organic and inorganic components. Furthermore, it is stated that tannery effluent tends to increase the turbidity of lake water, resulting from the death of fish and other aquatic species.. Turbidity is a measure of the ability of water to absorb light and is caused by small particles.Turbidity is produced by suspended particles in water, including mud, sediments, finely divided organic and inorganic matter, absorbable color organic compounds, plankton, and other microscopic organisms. Due to increased turbidity in the water, a loss of primary production, a decrease in O2 and an increased in CO2, biomass will occur, includes fish and other aquatic species (Akan et al., 2009). Due to increased turbidity content in the water, lack of primary productivity, reduction of O_2 and increase of CO_2, biomass, including fish and other aquatic organisms, will occur (Akan *et al*., 2009).

Electrical conductivity

Electrical conductivity is a useful tool for assessing water purity. It is the property of water caused by the presence of various ionic species. The average of EC values ranges from 1085.7±184.9 to 2240.7±959.8 in S_1, 892.5±94.29 to 1593.5±543.7 in S_2 at PS1 and 1211.5±376.4 to 1630±353.03 in S_1 and 1073.7±488.1 to 1102.7±562.6 in S_2 at MS1, during pre-monsoon, monsoon and post-monsoon, respectively. The WHO recommended a conductivity of 600 (S/cm) for drinking water. Our observed seasonal mean values from Puliyanthangal and Maniyambattu lakes were above the permissible limit during the pre-monsoon, monsoon, and post-monsoon periods. Electrical conductivity values at PS1 ($F=7.17$, $p=0.005$) and MS1 ($F=5.01$, $p=0.038$) reported significant seasonal variation ($F=7.17$, $p=0.005$) and between places (mouth and middle region) ($F=5.01$, $p=0.038$).Electrical conductivity varied insignificantly between the mouth and middle region at PS1 ($F=0.01$, $p=0.910$) and between seasons (premonsoon, monsoon, and postmonsoon) at MS1 ($F=0.55$, $p=0.585$) at $P > 0.05$.The highest electrical conductivity value was recorded in the mouth region of the pre-monsoon season at PS1 (2240.75±959.8) and MS1 (1630±353.03). The level of EC varied statistically significant between the lakes (t-value =0.65, $p=0.031$) at $p < 0.05$. They showed the order Premonsoon>Postmonsoon> Monsoon in S1 and S2 at PS1 and MS1 for the season-wise EC level.

However, the fluctuation of values was due to the tannery treated water and its dilution into the mouth and middle region of lake water, and the levels of EC appeared to be higher than the permissible limit of 600 for drinking purposes. High electrical conductivity indicated the accumulation of total dissolved solids and ionic constituents. Electrical conductivity is a helpful parameter of water quality for indicating salinity hazards. In the study, the EC was significantly higher during the pre-monsoon season, followed by the post-monsoon and monsoon seasons at both lakes. Among both lakes' mouth and middle region, the mouth region has a higher content of EC than the middle region. EC was likely to be increased according to the dilution of tannery effluent into the lake water. In puliyanthagal lake water (PS1), the EC level seemed to be high compared to the Maniyambattu lake water sample (MS2).

Total dissolved solids

Total dissolved solids are one of the important measures of water quality. Waters with high solid content are of low palatability and may induce an unfavorable physiological reaction in the transient consumer. The acceptable limit of TDS is 500-2000 (WHO, 1984).The seasonal mean of TDS values ranges from 1541.7±551.2 to 2063.5±1894.05 in S_1, 823.5±106.2 to 1230.2±312.2 in S_2 at PS1 and 1323.7±174.7 to 1612±1241.8 in S_1 and 702.5±279.3 to 1276.5±517.3 in S_2 at MS1, respectively. The seasonal mean values of TDS were within the permissible limit except pre-monsoon season in S_1 at PS1 given by WHO (1984) for drinking purposes. The highest value was recorded in the mouth region of the pre-monsoon season at PS1 (2063.5±1894.05) and MS1 (1612±1241.8). TDS value showed a significant difference between the place (mouth and middle region) at PS1 (F=4.48, p=0.048) and MS1(F=4.58, p=0.046). The level of TDS were varied statistically significant between the lakes (t-value =0.77, p=0.044) at p< 0.05. Insignificant seasonal variation of TDS was observed at PS1(F=0.01, p=0.992) and MS1 (F=0.79, p=0.468) at P>0.05. It is significantly noticed that the pre-monsoon season of mouth region (S_1) at puliyanthangal lake water had a high content of TDS up to the level 2063.5±1894.05 compared with other samples. A high content of TDS may render unfit for agriculture and drinking purpose once it is released into the canal and land area with uncontrolled measure.

Among the season-wise TDS level, they showed the order Premonsoon> post-monsoon>monsoon in S_1 at PS1, S_1 and S_2 at MS1and Premonsoon>monsoon> post-monsoon in S_2 at PS1. Among the mouth and middle region of both lakes, compared the mouth region has a high content of TDS than the middle region. In Puliyanthagal lake water (PS1), the TDS level is higher than the Maniyambattu lake water sample (MS1). TDS reflect the increasing extent of industrial and domestic discharge in aquatic habitats (Welcomme, 1985). According to Manivasakam (1984), a high amount of total dissolved solids recorded in tannery effluent could be attributed to processes like soaking, liming, dehairing, defleshing and deliming.

pH

pH is a term used universally to express the intensity of a solution's acid or alkaline condition. The pH value of the water is an essential indication of its quality and it is dependent on the carbon dioxide, carbonate and bicarbonate equilibrium. The average of pH values ranges from 6.9±0.12 to 7.2±0.19 in S_1, 7±0.29 to 7.2±0.05 in S_2 at PS1 and 8±0.93 to 8.3 ±0.86 in S_1 ,7±0.57 to 7.2 ±0.12 in S_2 at MS1 respectively. The seasonal mean value within the permissible limit from Puliyanthangal Lake and Maniyambattu lake is given by WHO (1984) during pre-monsoon, monsoon and post-monsoon.

The pH of the present study was fluctuated from 6.9±0.12 to 8.3 ±0.86 in all the water samples from Puliyanthangal Lake and Maniyambattulake during pre-monsoon, monsoon and post-monsoon, respectively. There was a slightly alkaline from S_1 and S_2 at PS1except for the mouth region of the monsoon was slightly acidic and the middle region of the monsoon was neutral. pH was slightly alkaline at MS1 from S_1 and $S_{2,}$ except the middle region of the monsoon was neutral. The seasonal mean value of pH showed statistically significant between the place (mouth and middle region) at PS1 (F=11.04, p=0.004) and MS1 (F=13.28, p=0.002) at p>0.05. The variation of pH was statistically significant between the sampling lakes (Puliyanthangal lake and Maniyambattu lake) at$p$<0.05 (T-value=-0.46, p=0.025). Insignificant seasonal variation was observed at PS1 (F=0.56, p=0.581) and MS1 (F=0.42, p=0.662) at p>0.05.The discharge of wastewater into water bodies may cause a drop or increase in their pH, affecting the size and activities of microbial populations therein. Other workers also reported acidic (Pathe*et al.*, 1995, Dilkshit and Shukla 1989, and Saravanan*et al.*, 1999) and alkaline tannery wastewaters (Shukla and Shukla 1994, Kadam 1990, Sastry 1986, Sakthivel and Sampath 1990).

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Total hardness

Ions, especially calcium, sulphate, magnesium and sodium, impart hardness to the water. Though the World Health Organization (1984) has fixed the level of 500 ppm as the tolerance limit of hardness, the water is classified as very hard if the value exceeds 200 ppm. The total hardness is an essential water quality parameter whether it is to be used for domestic, industrial, or agricultural purposes. The amount of total hardness in both sampling sites water samples in pre-monsoon, monsoon and post-monsoon season were ranged between of 719.7±81.8 to 1683.7±591.7 in S_1, 708.7±88.3 to 805±153.5 in S_2 at PS1 and 610.5±311.3 to 1474.2±702.2 in S_1 and 427.5±60.7 to 957.2±768.1 in S_2 at MS1, respectively. The seasonal mean values of TH were above the permissible limit given by WHO (1984) for drinking purposes.

TH content showed that statistically significant between the season (F=5.58, *p*=0.013), place (mouth and middle region) (F=10.27, *p*=0.005) at PS1 and between the period (F=4.97, *p*=0.019) at MS1. Insignificant variation was observed that between the place in MS1 (F=1.40, *p*=0.251). The highest value was recorded in the mouth region of the pre-monsoon season at PS1 (1683.7±591.7) and MS1 (1474.2±702.2). The variation of TH concentration between the lakes (Puliyanthangal lake and Maniyambattu lake) were statistically significant at (t-value=1.07, *p*=0.020) at p<0.05. Season-wise, Total hardness showed the order of Premonsoon> post-monsoon>monsoon in S_1, S_2 at PS1 and MS1. Among both sites' mouth and middle region, the mouth region has a higher TH than the middle region. In puliyanthagal lake water (PS1), the TDS level is higher than the Maniyambattu lake water sample (MS1). Hardness is advantageous in certain conditions. It prevents corrosion in the pipes by forming a thin layer of scales and reducing heavy metals' entry from the pipes to the water (Praharaj*et al.*, 2002).

Calcium

The seasonal mean of Ca values ranges from 87.2±17.03 to 188.5±59.4 in S_1, 81.7±16.8 to 152.5±115.6 at S_2 at PS1 and 72±37.9 to 151.7±59.3 at S_1, 71±45.3 to 148.7±85.2 at S_2 at MS1. The seasonal mean value of Ca was within the permissible limit from Puliyanthangal Lake and Maniyambattu lake during pre-monsoon, monsoon and post-monsoon. The content of Ca was observed a significant difference between the season in PS1(F=5.25, *p*=0.016) and MS1 (F=4.87, *p*=0.020) at p>0.05. Insignificant variation of Calcium was observed that between the place(mouth and middle region) in PS1(F=0.58 ,p=0.457) and MS1 (F=0.00,p=0.988) at p>0.05. The variation of Ca level in between the lakes (Puliyanthangal lake and Maniyambattu lake) were statistically significant at (T-value=0.16, *p*=0.032) p<0.05. The highest value was recorded in the mouth region of the pre-monsoon season at PS1(188.5±59.4) and MS1 (151.7±59.3).

Season wise the calcium level showed the order of Premonsoon> post-monsoon>monsoon in S_1, S_2 at PS1 and S_1, S_2 at MS1. Among both lake's mouth and middle region, the mouth region has a high Ca level than the middle region. In puliyanthagal lake water (PS1), the Ca is higher than the Maniyambattu lake water sample (MS1). The pre-monsoon season's highest value Ca content was found, followed by post-monsoon season and monsoon season from Puliyanthangal Lake and Mniyampattulake. The low calcium content in drinking water may cause rickets and defective teeth; it is essential for the nervous system, cardiac function, and blood coagulation. Being an essential contributor to hardness in water reduces the utility of water for domestic use (Purohit and Saxena, 1990).

Magnesium

The acceptable limit of magnesium is 30-150. The seasonal mean of Mg values ranges from 45±6 to 67.5±13.3 in S_1, 41.5±5.74 to 62.5±16.2 in S_2 at PS1 and 51.5±16.36 to 76.7±20.7 in S_1 and 44.2±3.86 to 59±8.4 in S_2 at MS1 during pre-monsoon, monsoon and post-monsoon. The level of Mg concentration was within the permissible limit of WHO for drinking purposes. Magnesium content showed that significant seasonal variation at PS1(F=8.19, *p*=0.003) and MS1 (F=4.14, *p*=0.033). The highest value was recorded in the middle region of the pre-monsoon season at PS1 (67.5±13.3) and the mouth region of MS1 (76.7±20.7). The variation of Mg level in between the sites was statistically significant at (T-value=--0.37, *p*= 0.012) at p<0.05. Statistically insignificant variation was observed between the place at PS1 (F=0.35, p=563) and MS1 (F=1.50, p=0.237) at p>0.05.

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Season-wise, the magnesium level showed Premonsoon> post-monsoon>monsoon in S_1, S_2 at PS1and S_1, S_2 at MS1. Among both lakes' mouth and middle region, the mouth region has a high Mg content than the middle region. In Maniyambattu lake water, the Mg level is higher than in the puliyanthangal lake water sample (PS1). The pre-monsoon season's highest value Mg content was found, followed by the post-monsoon season and monsoon season from S_1 to S_2 at PS1 and MS1. Geologically Magnesium-rich minerals are associated with bare and ultra-basic rocks and ultramafic rocks of igneous and metamorphic percentage. The same trend could be noticed from the tannery effluent in Nagpur by Srinivas *et al.* (1984) reported that calcium, magnesium, and bicarbonates in excess make water unfit for irrigation since its application increase problems of soil salinity and its permeability detrimental to crop plants. The present study implies the same trend that the Lake water becomes unfit for drinking purposes.

Iron

The permissible limit of Fe is 0.1 – 1.0. The seasonal mean of Fe values ranges from 0.32±0.2 to 1.5±0.2 in S_1, 0.25±0.2 to, 1.3±0.14 in S_2 at PS1 and 0.3±0.17 to 1.3±0.46 at S_1, 0.23±0.24 to 1.2±0.25 in S_2 at MS1during the pre-monsoon, monsoon and post-monsoon season, respectively. Fe concentration was found within the acceptable limit except for pre-monsoon in the mouth and the middle region at PS1 and MS1 given by WHO for drinking purposes. Fe content showed that highly significant seasonal variation in PS1 ($F=26.32$, $p=0.000$) and significant variation in MS1 ($F=6.38$, $p=0.008$) at $p > 0.05$. The highest value was recorded in the mouth region of the pre-monsoon season at PS1 (1.5±0.2) and the mouth region of the pre-monsoon at MS1 (1.3±0.46). There was an insignificant difference between the place in PS1 ($F=0.16$, $p=0.692$) and MS1 ($F= 1.87$, $p=0.188$) at $p > 0.05$. The variation of Fe level in between the lakes (Puliyanthangal lake and Maniyambattu lake) was not statistically significant at (T-value=0.29, $p=0.773$) at $p > 0.05$.

Seasonally, Fe from Puliyanthangal Lake and Maniyambattu lake was shown in the following order: pre-monsoon> post-monsoon> monsoon.Among both sites' mouth and middle region, the mouth region has a higher content of Fe than the middle region. The Fe level in puliyanthagal lake water (PS1) appeared higher than in Maniyambattu lake water (MS1). Fe content's highest value was found in the pre-monsoon season, followed by the post-monsoon season and monsoon season from Puliyanthangal Lake and Maniyambattulake. The concentration of Fe above the safe limit could lead to liver, lung, kidney, brain, heart, muscle and respiratory disorders (Lark *et al*., 2002). In the current study, high content of Fe was found in the mouth region of the pre-monsoon season at PS1 and the mouth region of the pre-monsoon at MS1, indicating that it is harmful to aquatic organisms.

Chloride

In the present study, chloride concentration was found to be 220.7±98.39 to 512±280.07 at S_1, 212.5±98.75 to 557.5±390.9 at S_2 at PS1 and 416.5±169.4 to 614±193.2 at S_1 and 291.5±290.59 to 389.25±60.17 at S_2 at MS1 during pre-monsoon, monsoon and post-monsoon. The seasonal mean values of Cl were within the acceptable limit of 200-1000 given by WHO (1984) for drinking purposes. At $p > 0.05$, there was a significant difference in chloride content between seasons in PS1 ($F=4.76$, $p=0.022$) and places (mouth and middle region) in MS1 ($F=1.89$, $p=0.018$).The highest values were recorded in the mouth region of the pre-monsoon season at PS1 (512±280.07) and MS1 (614±193.2) at $p > 0.05$. The variation of Cl level in between the sites (Puliyanthangal lake and Maniyambattu lake) was statistically significant at (T-value=-1.03, $p=0.030$)$p < 0.05$. At $p > 0.05$, there was statistically insignificant variation between the place (mouth and middle region) in PS1 ($F=0.000$, $p=0.999$) and the season in MS1 ($F=0.07$, $p=0.934$).

Seasonally, the level of Cl was shown in the following order: pre-monsoon> post-monsoon> monsoon in S1 and S2 at PS1 and MS1. Among both sites' mouth and middle region, the mouth region has a higher content of chloride than the middle region. In Maniyambattu lake water (MS1), the chloride level seemed to be higher than the puliyanthangal lake water sample (PS1). The highest value of chloride content was found in the pre-monsoon season, followed by the post-monsoon season and monsoon season from puliyanthangal lake and Maniyambattu lake. Other workers found that the chloride level of tannery effluents was significantly higher (4070 mg/l) (Dilkshit and Shukla, 1989, Sakthivel and Sampath, 1990).

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Sulfate (SO_4)

The seasonal mean of Sulphate values ranges from 139.5±53.02 to 300±116.6 in S_1, 128.2±61.9 to 203.7±54.5 in S_2 at PS1 and 110±50.6 to 177±39.5 in S_1, 105.2±44.04 to 170±38.7 in S_2 at MS1 during pre-monsoon, monsoon and post-monsoon. The level of SO_4 concentration was within the acceptable limit of 200-400 given by WHO (1984) for drinking purposes. The mean value of sulfate was statistically significant between the season in PS1 (F=8.71, *p*=0.002) and MS1 (F=6.78, *p*=0.006) at p > 0.05. The variation of sulphate was statistically insignificant between the place (mouth and middle region) in PS1 (F=1.15, p=0.297) and MS1 (F=0.01, p=0.922) at p > 0.05. The highest values were recorded in the mouth region of the pre-monsoon season at PS1 (300±116.6) and MS1 (177±39.5). The variation in SO4 levels between sites was statistically significant at (T-value=2.28, p=0

.029) at p > 0.05.

Seasonally, the level of SO4 showed to be in the following order: pre-monsoon> post-monsoon> monsoon in S1 and S2 at PS1 and MS1. The mouth region of both lakes has a higher content of sulfate than the middle region. The chloride level in puliyanthangal lake water (PS1) appeared higher than in Maniyambattu lake water (MS1). The highest value of sulphate content was found in the pre-monsoon season, followed by the post-monsoon season and monsoon season from puliyanthangal lake and Maniyambattu lake. Many researchers have discussed the presence of high sulphate content in saltwater, sewage effluent and ceramic industry. (Saxena, 1987; Kaur et al., 1996; Srinivas et al., 2002).

Nitrate (No_3)

The average of NO_3 values ranges from 3±0 to 3.5±0.57 in S_1, 3±0 to 3.25±0.5 in S_2 at PS1 and 3±0 to 3.37 ± 0.94 in S1, 3±0 to 3.25±0.5 in S_2 during pre-monsoon, monsoon and post-monsoon season, respectively. The NO3 concentration was within the WHO (1984) acceptable limit of 45-100 for drinking purposes. Nitrate concentration was statistically significant between the places (mouth and middle region) in PS1 (F=2.45, *p=0.013).* The variation of NO_3 level in between the lakes was not statistically significant at (t-value= 0.33, *p*= 0.743) p > 0.05. Statistically insignificant variation of nitrate in between the seasons in PS1 (F=0.27, p=0.764), between the places (F=0.00, p= 1.000) and between the seasons (F=0.56, p=0.582) in MS1 at p > 0.05.

Seasonal nitrate levels were shown in the order of Premonsoon=postmonsoon> monsoon in S1 and Premonsoon>postmonsoon=monsoon in S2 at PS1. Season-wise, they showed Premonsoon>Postmonsoon> Monsoon in S1 and S2 in Maniyambattu lake. Among both lakes' mouth and middle region, the mouth region has a higher content of nitrate than the middle region. The nitrate level in puliyanthangal lake water (PS1) appeared higher than in Maniyambattu lake water (MS1). The highest value of nitrate content was found in the pre-monsoon season, followed by the post-monsoon season and monsoon season from Pulyanthangallake and Maniyambattu lake. Nitrate is one of the several inorganic pollutants contributed by nitrogenous fertilizers, human and animal waste and industrial effluents through the biochemical activities of microorganisms (Agarwal, 2005). However, the water samples for the present study contained only a low level of NO_3 and thereby, it is exempted from nitrate poisoning.

Nitrate NO_2

The average of NO_2 values ranges from 0.05±0.01 to 0.2±0.18 in S_1, 0.028±0.007 to 0.06±0.059 in S_2 at PS1 and 0.025±0.01 to 0.25±0.17 in S_1, 0.021±0.0025 to 0.025±0.01 in S_2 at MS1 during pre-monsoon, monsoon and post-monsoon season, respectively. The level of NO_2 was significantly different between the places in PS1 (F=6.47, *p*=0.020) and MS1 (F=8.50, *p*=0.009) at p > 0.05. The variation of NO_2 level in between the lakes was statistically significant (T-value= 0.43, p=0.048) at p > 0.05. At p > 0.05, statistically insignificant variation in NO2 was observed between seasons in PS1 (F=1.62, p=0.226) and MS1 (F=2.46, p=0.114).Seasonal nitrate levels were shown to be in the order of Premonsoon=postmonsoon> monsoon in S1 and Premonsoon>postmonsoon=monsoon in S2 on PS1. In S1 and S2, the season-wise order in Maniyambattu lake was Premonsoon>Postmonsoon> Monsoon. Among both lakes' mouth and middle region, the mouth region has a higher content of nitrate than the middle region. The nitrate level in puliyanthangal lake water (PS1) appeared higher than in Maniyambattu lake water (MS1). The highest value of nitrate content was found in the pre-monsoon season, followed by the post-monsoon season and monsoon season from Puliyanthangallake and Maniyambattu lake.

Ammonia (NH_3)

The average of NH_3 values ranges from 3.37±0.75 to 4.75±2.32 in S_1, 2.25±0.37 to 2.62±0.47 in S_2 at PS1 and 3±1.15 to 5.17±2.09 in S1, 2.37±0.75 to 3.62±0.47 in S_2 at MS1 during the pre-monsoon, monsoon and post-monsoon season, respectively. The NH3 concentration was higher than the WHO (1984) acceptable limit of 0.1 for drinking. The level NH_3 was statistically significant between the place (mouth and middle region) in PS1 (F=6.61, p=0.019) and between the season in MS1 (F=4.99, p=0.019) at p > 0.05. The variation of NH_3 level in between the lakes was statistically significant at (T-value=-0.30, p=0.017) at p > 0.05. The highest value was recorded in the mouth region of the pre-monsoon season at PS1 (4.75±2.32) and the middle region of the pre-monsoon season at MS1 (5.17±2.09).

At PS1, seasonal ammonia concentrations were assessed to be Premonsoon>Postmonsoon> Monsoon in S1, Premonsoon=Postmonsoon> Monsoon in S2 and Premonsoon>Postmonsoon> Monsoon was the sequence of the seasons in Maniyambattu lake as seen in S1 and S2. The mouth region of both lakes contains more ammonia than the middle region. Ammonia levels appeared to be higher in Maniyambattu lake water (MS1) than in puliyanthangal lake water (PS1). The pre-monsoon season had the highest NH3 content, followed by the post-monsoon and monsoon seasons in Puliyanthangal and Maniyambattu lakes. According to Wetzel (1983), heterotrophic microbes create ammonia as a primary end product of organic matter degradation, either directly from proteins or organic molecules.

Fluoride

Fluoride is also an important chemical constituent of water. It is generally present in small quantities. Its occurrence in higher amounts in the order of 1mg/l is safe and effective in reducing dental decay. The average of F values ranges from 1.47±0.34 to 2.71±1.19 in S_1, 1.4±0.14 to 1.5±0.057 in S_2 at PS1 and 1.5±0.62 to 2.82±1.27 in S_1 and 1.15±0.17 to 1.47± 0.70 in S_2 at MS1 during the pre-monsoon, monsoon and post-monsoon season, respectively. The recommended permissible limit of F is 1.0-1.5. Except for S1 in pre-monsoon and S2 in pre-monsoon and post-monsoon seasons at PS1, the level of F concentration was within WHO's the acceptable limit for drinking purposes.The content of fluoride showed a significant difference between the place (F=5.06, p=0.037) and between the season (F=3.98, p=0.037) in PS1 and between the place in MS1 (F=6.11, p=0.024) at p > 0.05. The variation of F level in between the lakes was statistically significant at (T-value=-0.44, p > 0.024) at p > 0.05.

Fluoride is frequently described as a double-edged sword. Fluoride is vital for the proper development of teeth. Fluoride concentrations of more than 1.5mg/l, on the other hand, induce dental and skeletal fluorosis, decalcification, mineralization of tissues, and digestive and neurological system diseases (Udhayakumar et al., 2006). According to a Tamil Nadu government assessment, a water system's headwork has been mostly abandoned due to excessive pollution levels from tannery effluents. In and around Ranipet, Vaniyambadi, Ambur, Walajapet, and Dindigul, the water quality is deplorable. The importance of seriously addressing tannery effluents has been addressed at various times.

According to DhulasiBirundha and Saradha (1993), the sewage released by a tannery following the treatment of one-tonne hide is similar to the sewage produced by a small town of 5,000 inhabitants. The impact of the leather tanning business on open water bodies is far more prominent and frequently highly damaging. The presence of sodium sulphate, chromium, and some tanning chemicals depletes the oxygen in water, imparting an unpleasant odour, and effectively halting the self-purification process in bodies of water by destroying the biota. The tanning sector is a significant source of pollution. Allowing untreated sewage water to stagnate, as

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is now practiced, has been proven to generate an annoyance and an ugly look, in addition to damaging ground and surface water.

Ramaswamy and Sridharan (1998) conducted a study on the groundwater quality in Tamil Nadu near tanneries and discovered that total hardness, chlorides, calcium, and magnesium levels were 3 to 28 times higher than the WHO's permitted limit for drinking water (1993). The tannery effluent is affluent in metallic ions such as chromium, potassium, sodium, and magnesium, as well as organic contaminants such as oil, grease, tannin, and lignin (Manonmani et al., 1991). Khwaja et al. (2001) discussed the effect of wastes on the physicochemical characteristics of Ganga water and sediments about tannery pollution in Kanpur (India). They concluded that increased values of BOD, COD, chlorine, and total solids could be attributed to domestic wastes and tannery wastes. However, chromium is one characteristic that can be predominantly traced back to tanneries.

Sponza (2003) observed that waste (industrial effluents) pollutes soil and groundwater and has several harmful consequences for agricultural products, animals, and the health of residents in surrounding regions, due to the presence of waste compounds and toxic heavy metals. A massive increase in pollution caused by industrial units discharging effluents into rivers and lakes is a cause for worry in developing countries. Developed countries, which face water pollution issues resulting from industrial expansion and modernization of agricultural methods, are increasingly addressing the issues through enhanced wastewater treatment procedures. However, developing nations still face difficulties due to a lack of professional expertise, ineffective implementation of environmental legislation, and limited financial resources.

DISCUSSION

The present study showed that Physico-chemical parameters such as turbidity, EC, TH, and ammonia are highest in S_1 and S_2 at PS1 and MS1except TH in the monsoon (S_4) season. These readings are higher than that of the acceptable limit prescribed by WHO (1984). If it is diluted in lakes, rivers or released into the land area uncontrollably, it may negatively impact lentic waters, wells, and bore water. The level of turbidity, electrical conductivity, TH and ammonia were high in the mouth region compared to the middle region at both lakes in the pre-monsoon season, followed by post-monsoon and monsoon season, respectively. Among the lakes from the mouth and middle region, the pre-monsoon season had a higher content of Physico-chemical parameters than that of its acceptable limit post-monsoon and monsoon season. Despite the treated tannery water released from common effluent treatment plants, it is claimed to be unfit for drinking and agriculture purposes and thereby, it is rendered unfit for drinking and agriculture purposes. Fe content was higher in the pre-monsoon season than that of the acceptable limit of post-monsoon and monsoon season from S_1 and S_2 at PS1 and MS1. Fluoride content was higher in the mouth region at both lakes than within the middle region's limit except pre-monsoon season in the middle region of Puliyanthangallake.

The current study found that seasonal variations in physicochemical parameters such as turbidity, EC, TH, Ca, Mg, Cl, Fe and turbidity, EC, TDS, TH, Ca, Mg, Cl, Fe, SO4, NO3, NO2, NH3 and F from the mouth and middle region at puliyanthangal lake and Maniyambattu lake are highest in the pre-monsoon season, followed by the postmonsoonThus, it is predicted that the content of all the parameters is likely to be increased or decreased according to the dilution of effluent into the lake water. According to a Tamil Nadu government report, due to high pollution levels from tannery effluents, a water system head-work must be virtually abandoned. The water quality in and around Ranipet, Vaniyambadi, Ambur, Walajapet and Dindigul leaves much to be desired. The need to address tannery effluents on a severe basis has been raised on several occasions (Tamil Nadu Leather Corporation, 1986). According to DhulasiBirundha and Saradha (1993), the sewage discharged by a tannery after treating one-ton hide is equivalent to the public sewage of a small town of 5,000 people.

The leather tanning industry's effect on the open water bodies is much more significant, often quite detrimental. The presence of sodium sulphate, chromium, and some tanning agents removes oxygen from water, giving it an unpleasant odour and ultimately stopping the water bodies' self-purification process by killing the biota. The tannin industry is a potential polluting industry of considerable importance. It has been discovered that allowing untreated wastewater to stagnate, as is commonly done now, causes odour nuisance and an unsightly appearance, in addition to polluting groundwater and surface water. Ramaswamy and Sridharan (1998) studied the groundwater quality of Tamil Nadu in the premises of tanneries and observed that the total hardness, chlorides, Calcium and Magnesium were 3 to 28 times higher than the drinking water permissible limit prescribed by WHO (1993). The tannery effluent contains a high concentration of metallic ions like chromium, potassium, sodium, magnesium, and organic pollutants like oil, grease, tannin, and lignin (Manonmani*et al*., 1991). Khwaja*et al.* (2001) discussed the influence of wastes on the physicochemical characteristics of the Ganga water and sediments in tannery pollution at Kanpur (India). They concluded that high concentrations of parameters like as BOD, COD, chlorine, and total solids might be attributed to both residential and tannery wastes. However, chromium is one parameter it can mostly be directly attributed to tanneries. Sponza (2003) stated that waste (industrial effluents) causes soil and groundwater pollution besides causing some adverse effects on agricultural produce, animals, and people's health in the neighboring areas since it contains waste chemicals and toxic heavy metals discharge of effluents from industrial units into rivers and lakes have resulted in a massive increase in pollution, which is a significant source of concern in developing countries. Developed countries with water pollution problems due to industrial proliferation and modernization of agricultural technologies are now combating the problems through improved wastewater treatment techniques. But developing countries with a lack of technical knowledge, weak implementation of environmental policies, and limited financial resources are still facing problems.

CONCLUSION

The study concludes that the elevated levels of Physico-chemical parameters in the water samples might result from tannery effluent discharge into the water. Additionally, it may result in unfavorable circumstances for drinking water and aquatic life survival. It is consequently recommended that industrial waste be processed to the desired quality before dumping into water bodies and that a standard of effluent quality be established for pollution abatement in the interest of public health and fishing prosperity.

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Table.1.1 Seasonal variation of Physico-chemical parameters of Puliyanthangal Lake, Ranipet district

	Premonsoon		Monsoon		Postmonsoon	
Parameters	Mouth	Middle	Mouth	Middle	Mouth	Middle
pH	7.2±0.19	7.2±0.05	6.9±0.12	7±0.29	7.2±0.19	7.1±0.53
Turbidity	38.5±11.47	33.25±4.99	32±4.32	32.2±4.03	36.5±13.89	28.2±4.99
EC	2240.7±959.8	1593.5±543.7	1085.7±184.9	892.5±94.29	1393±476.3	1010±186.7
TDS	2063.5±1894.05	1230.2±312.2	1541.75±551.2	889.75±238.4	1914.7±1351.6	823.5±106.26
TH	1683.7±591.7	805±153.5	719.7±81.8	708.7±88.3	984±101.3	770.5±238.3
Ca	188.5±59.4	152.5±115.6	87.2±17.03	81.7±16.8	106.5±23.2	95.5±31.8
Mg	67.5±13.3	62.5±16.2	45±6	41.5±5.74	59±11.6	58.5±9.57
Cl	512±280.07	557.5±390.9	220.7±98.39	212.5±98.75	362.5±67.01	325±59.16
Fe	1.5±0.2	1.3±0.14	0.32±0.2	0.25±0.2	0.55±0.5	0.47±0.48
So4	300±116.6	203.7±54.5	139.5±53.02	128.2±61.9	145±15.18	142.5±12.7
No3	3.5±0.57	3.25±0.5	3±0	3±0	3.5±0.57	3±0
No2	0.2±0.18	0.06±0.059	0.05±0.01	0.028±0.007	0.2±0.21	0.028±0.008
NH3	4.75±2.32	2.62±0.47	3.37±0.75	2.25±0.37	3.9±2.44	2.62±0.47
F	2.71±1.19	1.5±0.057	1.47±0.34	1.4±0.14	1.5±0.14	1.4±0.18

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Table.2 .Seasonal variation of Physico-chemical parameters of ofManiyambattulake, Ranipet district.

	Premonsoon		Monsoon		Postmonsoon	
Parameters	Mouth	Middle	Mouth	Middle	Mouth	Middle
pH	8.3±0.86	7.2±0.12	8±0.93	7±0.57	8.2±0.91	7.2±0.27
Turbidity	36.5±5.06	31.7±5.90	33±2.16	27±3.82	39±19.35	31.5±2.51
EC	1630±353.03	1102.7±562.6	1211.5±376.46	1073.7±488.1	1493.5±225.6	1099.5±153.8
TDS	1612±1241.8	1276.5±517.3	1323.75±174.7	702.5±279.3	1529.25±297.8	911±400.48
TH	1474.2±702.2	957.2±768.1	610.5±311.3	427.5±60.7	661.2±342.01	639.2±88.3
Ca	151.7±59.3	148.7±85.2	72±37.9	71±45.3	127±31.7	124.5±27.2
Mg	76.7±20.7	59±8.4	51.5±16.3	44.25±3.86	58.2±14.1	53.7±11.89
Cl	614±193.2	389.25±60.17	416.5±169.4	291.5±290.59	536.25±149.5	341.25±296.26
Fe	1.3±0.46	1.2±0.25	0.3±0.17	0.23±0.24	0.71±0.68	0.3±0.18
So4	177±39.5	170±38.7	110±50.6	105.2±44.04	117.2±29.1	114.7±26.2
No3	3.37±0.94	3.25±0.5	3±0	3±0	3.25±0.5	3.1±0.25
No2	0.25±0.17	0.025±0.01	0.025±0.01	0.021±0.0025	0.165±0.186	0.022±0.005
NH3	5.17±2.09	3.62±0.47	3±1.15	2.37±0.75	3.25±0.95	2.87±0.25
F	2.82±1.27	1.15±0.17	1.5±0.62	1.47±0.70	2.3±1.39	1.32±0.43

Table.1.1 Turbidity

Site 1	DF	SS	MS	F	P
Place	1	26673	26673	0.85	0.370
Period	2	231011	115505	3.66	0.046
Interaction	2	57030	28515	0.90	0.422
Error	18	567380	31521		
Total	23	882094			
Site 2	DF	SS	MS	F	P
Place	1	30459	30459.4	1.64	0.217
Period	2	123684	61842.0	3.32	0.059
Interaction	2	47131	23565.4	1.27	0.306
Error	18	334845	18602.5		
Total	23	536119			

Turbidity	DF	T-value	P-value
Between the sites	46	0.43	0.026

Table.1.2 EC

Site 1	DF	SS	MS	F	P
Place	1	3361	3361	0.01	0.910
Period	2	3638009	1819005	7.17	0.005
Interaction	2	1346981	673491	2.66	0.098
Error	18	4565618	253645		

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Total	23	9553969			
Site 2	DF	SS	MS	F	P
Place	1	747654	747654	5.01	0.038
Period	2	164784	82392	0.55	0.585
Interaction	2	201633	100817	0.68	0.521
Error	18	2687319	149295		
Total	23	3801390			

EC	DF	T-value	P-value
Between the sites	38	0.65	0.031

Table.1.3 PH

Site 1	DF	SS	MS	F	P
Place	1	4.5067	4.50667	11.04	0.004
Period	2	0.4564	0.22822	0.56	0.581
Interaction	2	1.1704	0.58522	1.43	0.264
Error	18	7.3494	0.40830		
Total	23	13.4830			
Site 2	DF	SS	MS	F	P
Place	1	6.2730	6.27304	13.28	0.002
Period	2	0.3981	0.19903	0.42	0.662
Interaction	2	0.0240	0.01201	0.03	0.975
Error	18	8.5018	0.47232		
Total	23	15.1969			

PH	DF	T-value	P-value
Between the sites	46	-0.46	0.025

Table.1.4 Total dissolved solid(TDS)

Site 1	DF	SS	MS	F	P
Place	1	4394704	439704	4.48	0.048
Period	2	16536	8268	0.01	0.992
Interaction	2	931332	465666	0.47	0.630
Error	18	17651723	980651		
Total	23	22994296			
Site 2	DF	SS	MS	F	P
Place	1	1653750	1653750	4.58	0.046
Period	2	572479	286240	0.79	0.468
Interaction	2	279127	139563	0.39	0.685
Error	18	6502446	361247		
Total	23	9007801			

TDS	DF	T-value	P-value
Between the sites	38	0.77	0.044

Table.1.5 Total hardness (TH)

Site 1	DF	SS	MS	F	P
Place	1	779401	779401	10.27	0.005
Period	2	847211	423606	5.58	0.013
Interaction	2	1188884	594442	7.83	0.004
Error	18	1366163	75898		
Total	23	4181659			
Site 2	DF	SS	MS	F	P
Place	1	306456	306456	1.40	0.251
Period	2	2166392	1083196	4.97	0.019
Interaction	2	322949	161475	0.74	0.491
Error	18	3926283	218127		
Total	23	6722080			

TH	DF	T-value	P-value
Between the sites	46	1.07	0.020

Table.1.6 Ca

Site 1	DF	SS	MS	F	P
Place	1	1837.5	1837.5	0.58	0.457
Period	2	33329.3	16664.7	5.25	0.016
Interaction	2	1057.0	528.5	0.17	0.848
Error	18	57149.5	3175.0		
Total	23	93373.3			
Site 2	DF	SS	MS	F	P
Place	1	0.7	0.7	0.00	0.988
Period	2	26026.3	13013.2	4.87	0.020
Interaction	2	37.3	18.7	0.01	0.993
Error	18	48137.5	2674.3		
Total	23	74201.8			

Ca	DF	T-value	P-value
Between the sites	46	0.16	0.032

Table.1.7 Magnesium (Mg)

Site 1	DF	SS	MS	F	P
Place	1	42.67	42.67	0.35	0.563
Period	2	2006.33	1003.17	8.19	0.003
Interaction	2	32.33	16.17	0.13	0.877
Error	18	2206.00	122.56		
Total	23	4287.33			
Site 2	DF	SS	MS	F	P
Place	1	280.17	280.167	1.50	0.237
Period	2	1549.75	774.875	4.14	0.033
Interaction	2	564.58	282.292	1.51	0.248
Error	18	3368.00	187.111		
Total	23	5762.50			

Mg	DF	T-value	P-value

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Between the sites	46	-0.37	0.012

Table.1.8 Chloride

Site 1	DF	SS	MS	F	P
Place	1	0	0	0.00	0.999
Period	2	410254	205127	4.76	0.022
Interaction	2	7089	3545	0.08	0.921
Error	18	776080	43116		
Total	23	1193432			
Site 2	DF	SS	MS	F	P
Place	1	91143	91143.4	1.89	0.018
Period	2	6580	3290.2	0.07	0.934
Interaction	2	30837	15418.5	0.32	0.731
Error	18	869706	48317.0		
Total	23	998267			

Cl	DF	T-value	P-value
Between the sites	46	-1.03	0.030

Table.1.9 SO_4

Site 1	DF	SS	MS	F	P
Place	1	4538	4537.5	1.15	0.297
Period	2	68567	34283.4	8.71	0.002
Interaction	2	14256	7128.1	1.81	0.192
Error	18	70876	3937.5		
Total	23	158236			
Site 2	DF	SS	MS	F	P
Place	1	15.0	15.0	0.01	0.922
Period	2	20575.8	10287.9	6.78	0.006
Interaction	2	140.6	70.3	0.05	0.955
Error	18	273220.3	1517.8		
Total	23	48051.6			

SO_4	DF	T-value	P-value
Between the sites	35	2.28	0.029

Table.1.10 Iron (Fe)

Site 1	DF	SS	MS	F	P
Place	1	0.01760	0.01760	0.16	0.692
Period	2	5.73771	2.86885	26.32	0.000
Interaction	2	0.05771	0.02885	0.26	0.770
Error	18	1.96188	0.10899		
Total	23	7.77490			
Site 2	DF	SS	MS	F	P
Place	1	0.27094	0.27094	1.87	0.188

Period	2	1.84567	0.92284	6.38	0.008
Interaction	2	2.78688	1.39344	9.63	0.001
Error	18	2.60398	0.14467		
Total	23	7.50746			

Fe	DF	T-value	P-value
Between the sites	46	0.29	0.773

Table.1.11 NO_3

Site 1	DF	SS	MS	F	P
Place	1	0.37500	0.375000	2.45	0.013
Period	2	0.08333	0.041667	0.27	0.764
Interaction	2	0.75000	0.375000	2.45	0.114
Error	18	2.75000	0.152778		
Total	23	3.95833			
Site 2	DF	SS	MS	F	P
Place	1	0.00000	0.000000	0.00	1.000
Period	2	0.27083	0.135417	0.56	0.582
Interaction	2	0.18750	0.093750	0.39	0.685
Error	18	4.37500	0.243056		
Total	23	4.83333			

NO_3	DF	T-value	P-value
Between the sites	46	0.33	0.743

Table.1.12 NO_2

Site 1	DF	SS	MS	F	P
Place	1	0.92628	0.0926284	6.47	0.020
Period	2	0.046334	0.0231670	1.62	0.226
Interaction	2	0.029228	0.0146141	1.02	0.380
Error	18	0.257807	0.0143226		
Total	23	0.425998			
Site 2	DF	SS	MS	F	P
Place	1	0.094627	0.0946270	8.50	0.009
Period	2	0.054762	0.0273808	2.46	0.114
Interaction	2	0.052802	0.0264008	2.37	0.122
Error	18	0.200325	0.0111292		
Total	23	0.402515			

NO_2	DF	T-value	P-value
Between the sites	46	0.43	0.048

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Table.1.13 NH_3

Source	DF	SS	MS	F	P
Place	1	13.8017	13.8017	6.61	0.019
Period	2	2.2408	1.1204	0.54	0.594
Interaction	2	1.9658	0.9829	0.47	0.632
Error	18	37.6100	2.0894		
Total	23	55.6183			
Source	DF	SS	MS	F	P
Place	1	4.3350	4.33500	3.47	0.079
Period	2	12.4658	6.23292	4.99	0.019
Interaction	2	2.0325	1.01625	0.81	0.459
Error	18	22.4800	1.24889		
Total	23	41.3133			

NH_3	DF	T-value	P-value
Between the sites	46	-0.30	0.017

Table.1.14F

Site 1	DF	SS	MS	F	P
Place	1	1.3728	1.37282	5.06	0.037
Period	2	2.1596	1.07982	3.98	0.037
Interaction	2	1.8336	0.91682	3.38	0.057
Error	18	4.8857	0.27143		
Total	23	10.2518			
Site 2	DF	SS	MS	F	P
Place	1	4.7704	4.77042	6.11	0.024
Period	2	1.0300	0.51500	0.66	0.529
Interaction	2	2.7433	1.37167	1.76	0.201
Error	18	14.0525	0.78069		
Total	23	22.5963			

F	DF	T-value	P-value
Between the sites	46	-0.44	0.024

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Figure 1.Mouth region of puliyanthangal Lake

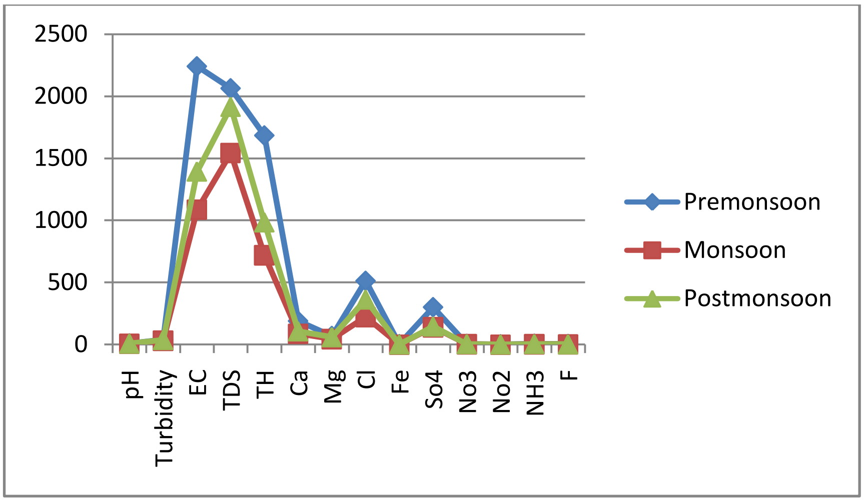

Figure 2. Middle region of Puliyathangal Lake

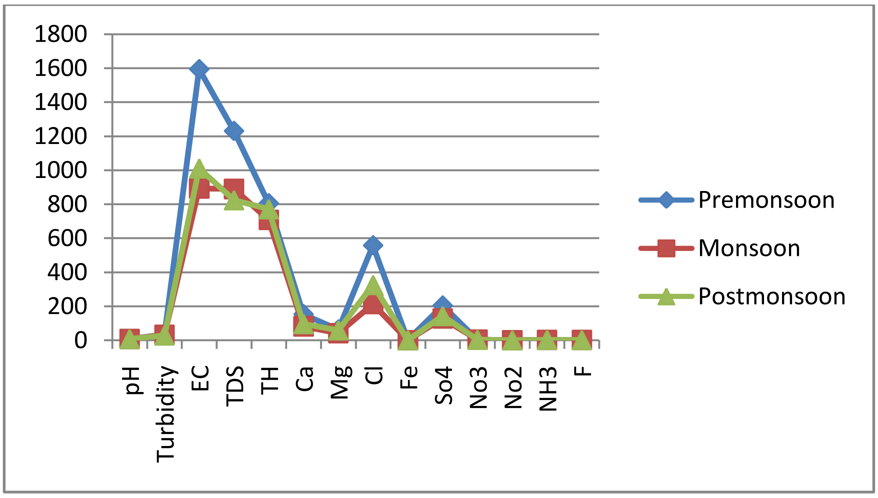

Figure 4.Mouth region of Maniyambattulake

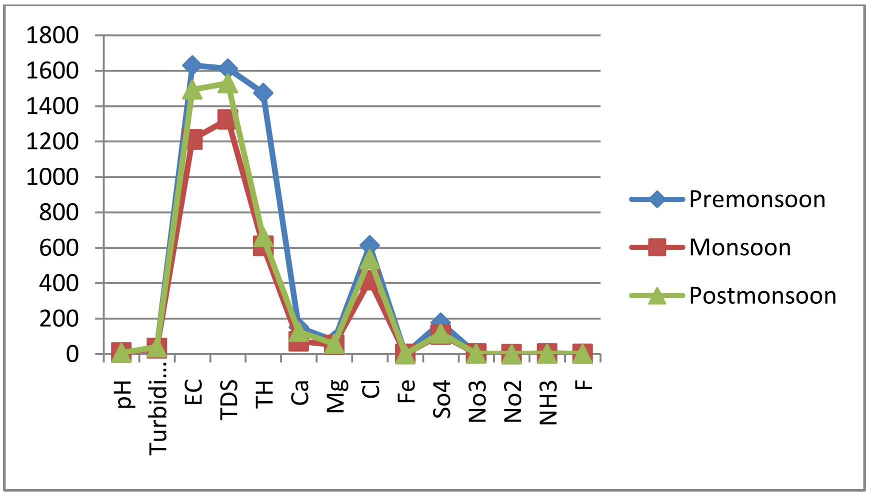

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Figure 5.Middle region of Maniyambattulake