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Seasonal Variation in Water Quality Parameters of Chaliyar River, Kerala, Southern India

Jithesh M., M. V. Radhakrishnan

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ABSTRACT

The healthy state of an aquatic ecosystem depends upon the physico-chemical characteristics, which usually fluctuate with season and degree of pollution. Recently the river water are often loaded with various organic, inorganic and biological constituents as a result of discharge of untreated waste, dumping of industrial effluent and run-off from agricultural fields. Industrial growth, urbanization and the increasing use of synthetic organic substances have serious and adverse impacts on freshwater bodies. Almost all the major cities and towns of Kerala are facing very serious environmental problems because of the lack of scientific waste removal mechanisms. Chaliyar is the only main stream in Malabar which brings in considerable portion of waters from the crest of the Ghat mountain ridge. Total length of the river is nearly 152 km four different stations were selected on the river namely:Sampling station 1 (S_1) is Chungathara, station 2 (S_2) is Edavanna, station 3 (S_3) is Vazhakkad and station 4 (S_4) is Beypore. The present investigation was carried out to assess the seasonal variations in physico-chemical factors, nutrients, planktonic population and distribution of metals in Chaliyar River water Kerala State. The physical parameters such as temperature, pH, electrical conductivity, total dissolved solids, total suspended solids were analyzed. The parameters showed an increasing trend in summer season and decrease in monsoon season. An increase in 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 effect of dilution by rain water. The chemical parameters analyzed include dissolved oxygen, total alkalinity, total hardness, calcium, magnesium, iron, manganese, nitrate, nitrite, chloride, fluoride, sulfate, phosphate, BOD and COD. The chemical parameters in general 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 2016 values. Fluctuation of seasonal values indicate that, the physico-chemical characteristics of water bodies are influenced by seasonal variations.

Keywords Chaliyar, Water quality, Physico-chemical parameters.

Jithesh M.
Research & Development Center, Bharathiar University, Coimbatore 641046, Tamilnadu, India

M. V. Radhakrishnan*
PG & Research Department of Zoology, Chikkanna Government Arts College, Tirupur 641602, Tamilnadu, India
Email : mvrkrishnan44@yahoo.com
*Corresponding author

INTRODUCTION

The physico-chemical parameters play a vital role in

determining the distribution pattern and quantitative abundance of organisms inhabiting particular aquatic ecosystems (Kumar et al. 2009).Water has the ability to dissolve solids and to absorb gases and other liquids. Because of this solvent power, all natural water contains minerals and other substance which have been picked up from the air, soil and rock over which it possess and any change in water quality will affects aquatic life (Pawar and Pandarkar 2011). Therefore, the continuous and periodical monitoring of water bodies for water quality is necessary. Hence in the present study efforts have been made to analyze the physico-chemical parameters of Chaliyar River from January 2016 to December 2018 (two years).

MATERIALS AND METHODS

Study area

Chaliyar is the fourth largest river in Kerala and drains a very extensive tract of the Wynad ghats and Nilgiri mountains. This is the only main stream in Malabar which brings in considerable portion of waters from the crest of the Ghat mountain ridge. Its two main branches viz., Punnapuzha and Chola River rise respectively in the Kunda mountains on the Nilgiri plateau and on the lower ranges of the South-East Wynad.The two streams after receiving many large feeders (Korapuzha, Kalakkupuzha) unite in the midst of the Nilambur Government Teak plantations and then flow on, receiving several important feeders from the North and South, to their outlet into the sea at Beypore.Total length of the river is nearly 152 km four different stations were selected on the river namely: Sampling station 1 (S_1) is Chungathara, station 2 (S_2) is Edavanna, station 3 (S_3) is Vazhakkad and station 4 (S_4) is Beypore.

Physico-chemical analysis of water

Water samples were collected between 7.00 am and 9.00 am every month from January 2016 to December 2018 (two years). The months were divided into different seasons such as Summer (January, February and March); Pre-monsoon (April, May and June); Monsoon (July, August and September) and Post-monsoon (October, November and December). The average of monthly data were taken for representing the seasonal data. From each station, samples were collected for the analysis of the physical as well as chemical parameters of water such such as electrical conductivity, total dissolved solids, total suspended solids, dissolved oxygen, alkalinity, total hardness, calcium, magnesium, iron, manganese, nitrate, nitrite,

Table 1. Seasonal variation in physico-chemical parameters of Chaliyar River from January 2016 to December 2018. Values are expressed as mean ±SE; Number of sample per season (n=15) ; *p < 0.05.

Parameters	Summer	Pre-monsoon	Monsoon	Post-monsoon	F value
Temperature (^{0}C)	24.0 ± 0.11	26.0 ± 0.18	19.0 ± 0.14	22.0 ± 0.75	146.10
pH	6.9 ± 0.14	7.0 ± 0.12	6.8 ± 0.10*	7.2 ± 0.92*	61.56
Electrical conductivity (µmol/cm)	244.0 ± 22.80	284.0 ± 10.20*	145.0 ± 6.75*	214.0 ± 15.00*	73.15
Total dissolved solids (mg/l)	92.0 ± 1.68	110.0 ± 6.14*	74.0 ± 1165*	86.0 ± 2.20	56.39
Total suspended solids (mg/l)	137.0 ± 6.50	125.5 ± 2.10*	242.32 ± 8.37*	282.10 ± 4.16*	73.46
Dissolved oxygen (mg/l)	6.8 ± 0.14	6.8 ± 0.08	6.8 ± 0.06	7.9 ± 0.75*	44.16
Alkalinity (mg/l)	37.0 ± 2.18	25.0 ±2.75*	36.0 ± 1.96	39.0 ± 2.15	74.15
Total hardness (mg/l)	32.5 ± 1.25	32.0 ± 1.18	23.0 ± 0.98*	25.0 ± 1.24*	39.16
Calcium (mg/l)	13 ± 0.95	12 ± 0.35	7.6 ± 0.08*	5.9 ± 0.89*	57.14
Magnesium (mg/l)	4.0 ± 0.10	3.5 ± 0.00*	4.5 ± 0.60	4.0 ± 0.16*	16.08
Iron (mg/l)	0.16 ± 0.02	0.16 ± 0.02	0.31 ± 0.06*	0.25 ± 0.01*	8.46
Manganese (mg/l)	4.8 ± 0.10	4.6 ± 0.14	1.33 ± 0.04*	1.78 ± 0.06*	46.10
Nitrate (mg/l)	1.8 ± 0.01*	5.3 ± 0.16	2.42 ± 0.10*	2.65 ± 0.08*	8.12
Nitrite (mg/l)	0.16 ± 0.02*	0.24 ± 0.01	0.19 ± 0.00	0.16 ± 0.08*	26.29
Chloride (mg/l)	31.0 ± 0.56	26.7 ± 1.18*	17.0 ± 1.00*	13.0 ± 1.41*	54.76
Fluoride (mg/l)	0.20 ± 0.00	0.16 ± 0.08*	0.29 ± 0.04*	0.16 ± 0.02*	82.38
Sulfate (mg/l)	11.0 ± 1.14	12.68 ± 1.24*	9.0 ± 1.06*	7.5 ± 1.15*	24.12
Phosphate (mg/l)	0.3 ± 0.00	0.3 ± 0.02*	0.2 ± 0.00*	0.7 ± 0.01*	1.36
Biochemical oxygen demand (mg/l)	13.0 ± 0.25	18.0 ± 1.16	11.0 ± 0.99*	14.0 ± 0.55*	28.00
Chemical oxygen demand (mg/l)	18.0 ±0.12	16.0 ± 0.80*	20.0 ± 0.52	22.0 ± 1.06*	29.19

chloride, fluoride, sulfate, phosphate, biochemical oxygen demand as well as chemical oxygen demand using standard protocols (APHA 2008). Temperature and pH were recorded immediately at study site itself.

RESULTS AND DISCUSSION

The mean variations of physico-chemical characteristics of water in four stations of Chaliyar River at different seasons of Summer, Pre-monsoon, Monsoon and Post-monsoon for a period of two years were Presented in Table 1.

Temperature

Temperature plays an important role in limnological studies and is one among the factors that influence the geochemical aspects and eco-biology of ecosystems. Hence, it has been investigated by almost all the limnologists. Most of the aquatic organisms have a fairly narrow temperature range in which they are able to effectively function and survive. So, lowering and raising the temperature may also affect, the organisms' ability to survive (Gupta et al. 2013) . The result of the present study reveals that the temperature increased gradually in all the stations during post-monsoon, summer and in pre-monsoon periods. The overall variation is almost similar during all the stations in all the seasons. The gradual increase of temperature during the summer and subsequently decrease in the monsoon season might be due to the low water, 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(Shastri and Pendse 2001). During the present study period, the mean temperature ranged between 19^0C to 26^0C. In both the years temperature varied according to the seasonal fluctuations with maximum during summer and minimum during monsoon as reported by Gupta et al. (2013).

pH

The acidity or alkalinity nature of water is important in determining the distribution of aquatic organisms and the microbiological integrity of water (Gupta et al. 2013). The pH of the Chaliyar River water during the study period was between 6.0 to 7.2. A similar observation was reported by Gupta et al. (2013). The pH of the river water was acidic to neutral to alkaline without deviating much from the neutral pH value 7. The maximum pH values observed in the present study could be due to the uptake of CO_2 by the photosynthetic organisms especially phytoplankton (Gonzalez et al. 2004, chatterjee and Raziuddin 2006). The range of desirable ph of water prescribed for drinking purpose by WHO (2011) is 6.5 to 9.5. In Chaliyar River water the observed values were within the permissible limit.

Electrical conductivity (EC)

The conductivity measurement provides an indication of ionic concentration and depends on the amount of dissolved solids in water, temperature, types and concentration of ions present (Kumar et al. 2005). The EC values in the present study vary from 98.00 to 284.0 μmho/cm. The EC values were below the WHO (2011) permissible limit (300 μmho/cm). The increased values of EC are due to concentration of ionic salts and nutrients constituents present in the water. An increase or decrease in conductivity of a particular water source will result in similar increase or decrease in quality of othe parameters (Gupta et al. 2013).

Total dissolved solids (TDS)

Total dissolved solids denote the concentration of mineral constituents dissolved in water. TDS of natural waters are mainly composed of carbonates, bicarbonates, chlorides, sulfate, phosphates, silicate, calcium and magnesium (EPA 1976). The results of the present study reveal that the TDS values ranged between 72.00 mg/l and 110 mg/l. Hence, the water can be potable. In the present investigation, the maximum value observed during summer and pre-monsoon periods. A similar result was recorded by Garg et al. (2007), Jothivenkatachalam and Suresh (2008), Chinnaiah and Digamber Rao (2011). During the present study, the higher value of TDS in summer and pre-monsoon seasons may be due to low water levels within the aquifers, high evaporation rate and sediment effect, as evidenced by Jothivenkatachalam and Suresh (2008).

Total suspended solids (TSS)

Total suspended solids (TSS) is a water quality parameter used to assess the quality of water. Indirectly, the suspended solids affect other parameters such as temperature and dissolved oxygen. Because of the greater heat absorbency of the particulate matter, the surface water becomes warmer and this tends to stabilize the stratification (layering) in streams (Jothivenkatachalam and Suresh 2008). This, in turn, interferes with mixing, decreasing the dispersion of oxygen and nutrients to deeper layers. In the present study, in both the years the order of TSS values are pre-monsoon < summer < monsoon < post-monsoon period.

Dissolved oxygen (DO)

The average value of DO in the present study ranged between 6.7 mg/l in nonsoon period and 7.6 mg/l in post-monsoon. The values ranged in the order monsoon < pre-monsoon < summer < post-monsoon in 2016. In 2018 value is 6.8 mg/l for summer, pre-monsoon and monsoon. The post-monsoon value slightly increased as 7.9 ± 0.75 mg/l. Dissolved oxygen concentration was low during the pre-monsoon season but increased during summer and monsoon season. The low dissolved oxygen concentration observed during the pre-monsoon season could be attributed to the lesser volume of water and higher value of dissolved oxygen concentration observed in the monsoon was due to the heavy rainfall (Rajasegar 2003). The decomposition of organic waste and oxidation of inorganic waste may reduce the dissolved oxygen to extremely low levels which may prove harmful to organisms in the aquatic environment. In the present study the amount of DO was within the permissible limit.

Total alkalinity (TA)

Total alkalinity (TA) or acid combined capacity of natural freshwater is generally caused by carbonates and bicarbonates of calcium and magnesium .Alkalinity is often related to hardness because the main source of alkalinity is usually from carbonate rocks, which are mostly $CaCO_3$ (Manimegalai et al. 2010). In the present study the minimum value observed (25 mg/l) during pre-monsoon season and maximum value (39.00 mg/l) during post-monsoon season. Manimegalai et al. (2010) reported that similar findings in the study on Walayar reservoir, Palghat at Kerala. In the present study, during the study periods, the values are within the permissible limit.

Total hardness (TH)

Hardness of water is due to the presence of certain salts of calcium, magnesium and other heavy metals. In the present study, the seasonal average of TH values maximum during pre - monsoon in 2016 and maximum in summer in 2018 and minimum during monsoon and post-monsoon seasons. A similar finding was reported by Dubey and Ujjania (2013). Higher values of hardness were observed during summer, which may be due to low water level and high rate of decomposition and evaporation, that concentrating the salts (Dubey and Ujjania 2013). During the present study the total hardness values within the permissible limit.

Calcium (Ca^{++})

In the present study, calcium values observed maximum in summer in 2016 as 13 mg/l and minimum in post-monsoon as 5.63 in 2018. Increase in summer is due to the decomposition of plants, the shoots of submerged macrophytes as observed by Jothivenkatachalam and Suresh (2008).

Magnesium (Mg^{++})

Magnesium content of water is considered as one of the important qualitative criteria in determining the quality of water for irrigation. More Mg^{++} in water will adversely affect crop yields as the soils become more alkaline. In natural waters, the main source of the magnesium is sewage (Kumari and Rani 2008). During the study period the magnesium values ranged from 3 mg/l in pre-monsoon 2016 to 4.5 mg/l in monsoon in 2018. The maximum permissible limit of magnesium in drinking water 30-50 mg/l (APHA 2008). In the present study, during the investigation periods all the samples were in permissible limit.

Iron (Fe^{++})

In the present study, the seasonal values ranged from 0.14 to 0.33 mg/l were found below the maximum permissible limits for drinking water. A similar finding was observed by Pazhanisamy (2005) in Lower Anaicut Reservoir. Iron gets bioaccumulated in living beings and leads to enhanced respiratory rate, pulse rate, coagulation of blood vessels, hypertension and drowsiness (Raijak 2009). Beyond and permissible concentration iron alters the aesthetic quality of water and also cause haemosiderosis (Raijak 2009).

Nitrate (NO_3^+)

Biological oxidation of organic nitrogenous substances present in the domestic and industrial sewage and nitrifying bacteria add nitrates to water body (Pejavar and Gurav 2008). Nitrate is basically non-toxic but when ingested with food and water, it is reduced by bacterial action to nitrate and then to ammonia, which are toxic. During the study period the nitrate content of water varied from 1.37 to 4.41 mg/l in 2016 from 1.8 to 5.3 mg/l in 2018.

Chloride (Cl)

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 varying concentrations. Normal freshwater contains 8.3 mg of chloride per liter (Vijaya Bhaskar et al. 2009). In the present investigation, the chloride values ranged between 14.00 mg/l to 31.0 mg/l in 2017 and 13.00 to 31.00 mg/l in 2018. High chloride values may be due to organic wastes of animal origin and domestic wastes. However, no adverse health effects on humans have been reported from intake of waters containing even higher concentration of chloride (Pejaver and Gurav 2008).

Fluoride (F)

Fluoride is more commonly found in groundwater than the surface waters through weathering of primary silicates and associated accessory minerals (Thakare et al. 2005, Palanisamy et al. 2007). Long term consumption of water containing 1 mg of fluoride per liter leads to dental fluorosis, white and yellow glistening patches on teeth are seen, which may slowly turn brown. The yellow and white patches when turned brown present itself as horizontal streaks (Ayoob and Gupta 2006). Also it adversely affects kidney at the consumption of 12 mg/day, liver damage at 23 mg/day and chromosomal damage and interference with the DNA repair (Basavaraddi et al. 2012). In the present study it ranged from 0.15 mg/l to 0.34 mg/l. The analysis results of the present study indicate that all the samples are potable (Janardhana Raju et al. 2009).

Sulfate (SO_4)

Sulfate is one of the major anions and may enter natural waters through weathering of sulfate bearing deposits (Pichammal et al 2009, Ramadevi et al. 2009). In the present study sulfate ranged from 5.6 to 10.5 mg/l in 2017 and 7.5 to 12.68 mg/l in 2018.

Phosphate (PO_4)

The present investigation revealed that the dissolved phosphate concentrations in the river as (0.2 ±0.00) in monsoon to 0.7 ± 0.01 in post-monsoon in 2018 and 0.25 mg/l to 0.50 mg/l in post-monsoon in 2016. The dissolved phosphates present in aquatic ecosystem have origin in natural and artificial sources. Most of the detergents and washing powders containing phosphates, which are used to soften the water among other things, which affect the health of all forms of life in the water (Ammons 1996). Phosphate exhibited its inverse relation with the growth rate of planktonic organisms indicating its consumption to some extent and the results are in harmony with findings of Chowdhury and Mazumder (2007).

Biological oxygen demand (BOD)

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). Since BOD is a measure of biodegradable material in water, increase matter causes an increase in the BOD level. Greater the BOD values, the more rapidly oxygen is depleted in the water. Higher BOD value of water sample

clearly indicates pollution and may be attributed to the perculation of waste water loaded with biodegradable compounds (Pitchammal et al. 2009). In the present investigation, BOD value of water samples varies from 11.0 to 18.0 mg/l in 2017 and 11.5 to 14.5 in 2016. The high BOD values clearly indicate pollution, which may be dumping of domestic waste, human and animal excreta on the bunds of the river and attributed to the percolation of waste water loaded with biodegradable material.

Chemical oxygen demand (COD)

The chemical oxygen demand of water represents the amount of oxygen required to oxidize all of the organic matter including biodegradable and non-biodegradable by a strong chemical oxidant. 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). In the present study the COD values ranged from 19.5 mg/l to 22.0 in 2016 and 16.0 mg/l to 22.00 mg/l in 2018. 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 (Pitchammal et al. 2009).

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