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CENTRAL WATER COMMISSION

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A STUDY ON THE STATUS OF WATER QUALITY AT AMBARAMPALAYAM SITE OF ALIYAR RIVER WITH CHANGE IN SEASON AND ASSESSING ITS SUITABILITY FOR HUMAN CONSUMPTION BASED ON INDIAN STANDARDS 10500:2012

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ABSTRACT

In the current study, the water samples were collected from Ambarampalayam site near Pollachi, for one year from June 2018 to May 2019 for carrying out physico-chemical analysis. The water samples were preserved at low temperature to carryout analysis of various parameters whose values won't change within certain time limit. The parameters chosen for evaluating water quality include Temperature, pH, Electrical conductivity, Total dissolved solids, Alkalinity, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Fluoride, Total Hardness, Chloride, Nitrate and Iron. The methods employed for analysis are as per standard methods recommended by APHA. The results obtained were compared with Indian Standards and any variation may be influenced by sample locations, time of sampling and activities carried out around the site of the river. Hence, it is recommended that the water can be used for drinking purposes with proper treatment and regular water quality monitoring.

Introduction

Water forms the basis and essential for all living organisms existing in the Universe. Water acts as a medium in organisms in which complex metabolic processes which are necessary for life take place. Organisms simply cannot function without water and if deprived will rapidly die. Organism not only needs water but also needs the clean water. Human beings are affected by the most subtle variations in water chemistry and supply. According to World Health Organization (WHO) an estimate mentioned that 1200 million people lack a satisfactory or safe water supply [1]. Water quality is the measure of the suitability of water for a particular use based on specific physical, chemical, and biological characteristics. Assessment of the quality of a water body, whether surface water or groundwater, can help us answer questions about whether the water is acceptable for drinking, bathing, or irrigation to name a few applications. It also allows scientists to determine whether the water in a particular system is improving or worsening and why. We can use the results of water quality assessments to compare the quality of water from one water body to another in a region, State, or across the whole country.

The uses of water include (i) domestic (i.e., drinking, cooking, washing, bathing and gardening etc. (ii) public purposes (cleaning streets, recreational purposes like swimming pools, public fountains and ornamental ponds, fire protection and public parks), (iii) industrial purposes (processing, cooling and heating), (iv) agricultural purposes(irrigation) and (v) Power production (hydro power and steam power).

India has long tradition of managing water, but increasing demands and abuse due to population, industrial growth and agricultural development poses new challenge. Surface waters available in rivers, lakes, ponds and dams are used for drinking, irrigation and other purposes. Dams are constructed for different purposes like water needs for urban population, irrigation and industrial use.

Determining water quality requires the measurement and analysis of specific characteristics which

include such parameters as temperature, dissolved mineral content, and bacteria. These characteristics are often compared with standards set by regulatory agencies to determine if the water is suitable for a particular use. Some water quality parameters can be determined "in-situ" meaning that they are measured directly in the stream or well. These include temperature, pH, dissolved oxygen, conductivity, and turbidity. Other chemical and biological parameters are analyzed in a laboratory from samples collected in the water body of interest.

Water quality available for specific uses will decline with pollution. For example with progressive quality deterioration, water uses may successively shift from drinking to bathing water, water for livestock, agriculture and industrial uses and so on.

It has been defined as water that is free from pathogenic agents, free from harmful chemical substances, pleasant to taste i.e., free from colour and odour is usable for domestic purposes. If it does not fulfill these criteria, water is said to be polluted or contaminated. Water pollution occurs when water body is adversely affected due to the addition of undesirable materials to the water. When it is unfit for its intended use, water is considered polluted. Water quality basically refers to the physical, chemical and biological characteristics of water. The physico-chemical methods are used to detect the effects of pollution on the water quality.

Changes in the water quality are reflected in the biotic community structure. To protect public health, regulations on pathogen contamination have been developed for water bodies. Presence of fecal coliform is typically used as an indicator for the presence of pathogen. The coliform bacteria group consists of several genera of bacteria belonging to the family enterobacteriaceae. These mostly harmless bacteria live in soil, water, and the digestive system of animals. Fecal coliform bacteria, which belong to this group, are present in large numbers in the feces and intestinal tracts of humans and other warm-blooded animals, and can enter water bodies from human and animal waste. If a large number of fecal coliform bacteria (over 200 colonies/100 milliliters (ml) of water sample) are found in water, it is possible that pathogenic (disease- or illness-causing) organisms are also present in the water. Fecal coliform by themselves are usually not pathogenic. They are indicator organisms, which means they may indicate the presence of other pathogenic bacteria. Pathogens are typically present in such small amounts it is impractical monitor them directly.

Swimming in waters with high levels of fecal coliform bacteria increases the chance of developing illness (fever, nausea or stomach cramps) from pathogens entering the body through the mouth, nose, ears, or cuts in the skin. Diseases and illnesses that can be contracted in water with high fecal coliform counts include typhoid fever, hepatitis, gastroenteritis, dysentery and ear infections. Fecal coliform, like other bacteria, can usually be killed by boiling water or by treating it with chlorine. Washing thoroughly with soap after contact with contaminated water can also help prevent infections.

Keeping the above facts, an attempt has been made to evaluate the physico chemical quality of water of Aliyar River for change in water quality with seasonal variation and drinking water applications.

METHODS AND MATERIALS

Study area

The study area Ambarampalayam site is located on aliyar river near Pollachi taluk, Coimbatore district, Tamil Nadu. Aliyar river flows in a north-westerly direction for about 37 kms in Tamil Nadu and enters into Kerala and finally confluence in Bharathapuzha. Ambarampalyam site was located at

a latitude of 10°37'49" N and a longitude of 76°56'50"E. Fig.1.Shows the location of the present study area. Ambarampalayam receives rainfall through South West monsoon from June to September, North East Monsoon from October to December, January to February (Post monsoon) and March to May (Pre monsoon).

Sample collection

In this study, the samples were collected from Aliyar River at Ambarampalayam Site. The samples were collected once in every month from June 2018 to May 2019 around 08:00AM to 09:00AM to maintain uniformity. The samples were collected in a clean white polythene container.

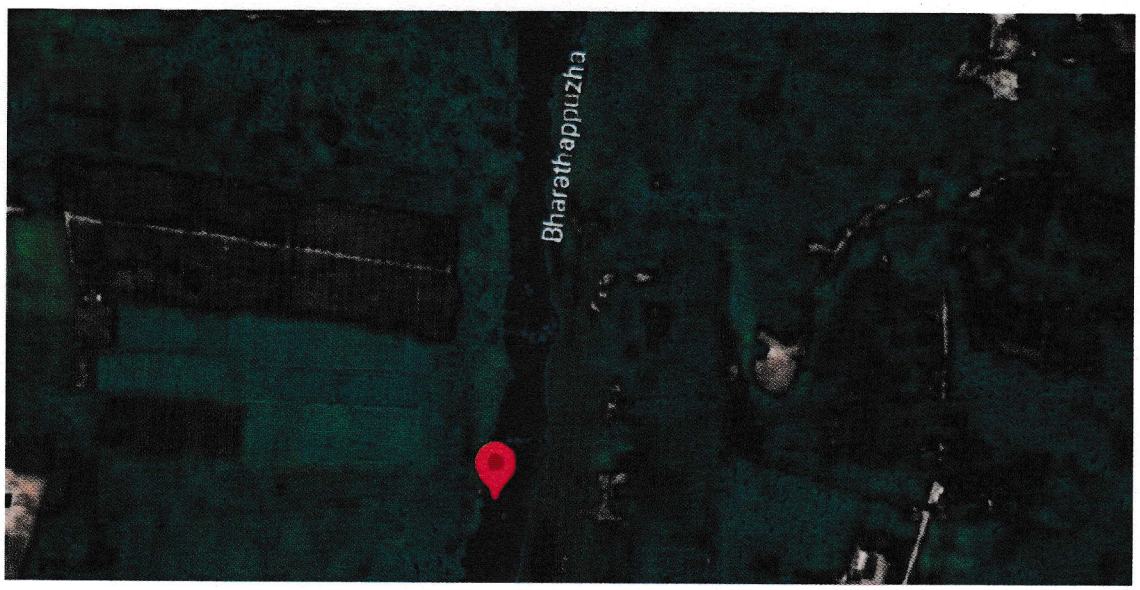

Fig.1. Location of present study area of Aliyar River

Great care was taken in the collection of water samples to secure truly representative samples from different locations of dam and also to prevent any extraneous contamination of the samples at the time of collection. The preservation procedure includes keeping the samples in dark, adding chemicals, lowering the temperature to retard reactions or combination of these. Collected samples were brought to the laboratory and kept in the refrigerator for later analysis.

Table.1. Methods employed for analysis of physico-chemical parameters[2]

S.No	Parameter	Units	Methodology
1	Temperature	°C	Mercury Thermometer
2	pH	-	Potentiometric Method
3	Electrical Conductivity	µmhos/cm	Conductivity cell Potentiometric method
4	Total alkalinity	mg/l	Titrimetric to pH 4.5
5	Biological Oxygen Demand(BOD)	mg/l	Modified Wrinkler's titrimetric method
6	Chemical Oxygen Demand (COD)	mg/l	Liebig Reflux condenser method/Closed Reflux Method
7	Fluoride	mg/l	SPADANS Method/ ISE method

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8	Total Hardness	mg/l	EDTA Titrimetric Method
9	Chlorides	mg/l	Argentometric titration Method
10	Nitrates	mg/l	Ion Selective Electrode Method
11	Iron	mg/l	Phenanthroline spectrophotometric Method
12	Total Coliform	Count/100ml	Most Probable number Method
13	Fecal Coliform	Count/100ml	Most Probable number Method

Table.2.water quality parameters and Indian Standards for various chemical and biological constituents [3]

S.No.	Parameters	Drinking water IS 10500 : 2012		Probable Effects
		Permissible Limit	Maximum Limit	
1	Odor	Agreeable	Agreeable	Aesthetically undesirable.
2	Taste	Agreeable	Agreeable	Aesthetically undesirable.
3	pH	6.5 to 8.5	No relaxation	Affects taste, corrosivity & supply system.
4	TDS (mg/l)	500	2000	May cause gastro-intestinal irritation, corrosion and laxative effect to new users.
5	Hardness (as CaCO3) (mg/l)	200	600	Causes scaling, excessive soap consumption, calcification of arteries.
6	Alkalinity (as CaCO3) (mg/l)	200	600	Imparts unpleasant taste, deleterious to humans in presence of high pH, hardness and TDS
7	Nitrate (mg/l)	45	No relaxation	Causes infant methaemoglobinaemia, at very high concentration causes gastric cancer and effects central nervous& cardiovascular system
8	Sulfate (mg/l)	200	400	Causes gastro-intestinal irritation. Along with Mg or Na can have a cathartic effect. Concentration more than 750 mg/l may have laxative effect
9	Fluoride (mg/l)	1	1.5	Reduces dental carries, very high concentration may cause crippling skeletal fluorosis
10	Chloride (mg/l)	250	1000	May be injurious to heart or kidney patients. Taste, indigestion, corrosion &palatability are affected
11	Turbidity (NTU)	5	10	Indicates pollution/ contamination
12	Total Coliform, Fecal Coliform (cfu)	0	0	Causes water borne diseases like coliform jaundice; Typhoid, Cholera etc. produces infections involving skin mucous membrane of eyes, ears and throat.

Determination of water quality parameters

The analysis of various physico-chemical parameters namely temperature, pH, Electrical conductivity, Total Alkalinity, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Fluoride, Calcium, Chlorides, Nitrates and iron were carried out as per standard methods. The methods employed for analysis of physico-chemical parameters are given in Table.1. A brief description of these parameters have been discussed below [5]

Temperature

Temperature is a physical property of matter that quantitatively expresses hot and cold. It is the manifestation of thermal energy, present in all matter, which is the source of the occurrence of heat, a flow of energy, when a body is in contact with another that is colder. In water ecosystem the temperature controls the rate of all chemical reactions. The temperature of samples were taken at the sample location itself using a mercury -in-glass thermometer which was inserted to the depth of 2 cm for about 3 minutes. The readings were expressed in degree Celsius (°C).

pH

pH is a measure of how acidic/basic water is. The range goes from 0 to 14, with 7 being neutral. pH of less than 7 indicate acidity, whereas a pH of greater than 7 indicates a base. The pH of water is a very important measurement concerning water quality. It is defined as negative log of Hydrogen ion concentration. pH of the samples were determined by using digital pH meter (Make: Elico LI 127 pH meter).

Electrical Conductivity

Conductivity is a measure of water's capability to pass electrical flow. This ability is directly related to the concentration of ions in the water. These conductive ions come from dissolved salts and inorganic materials such as alkalis, chlorides, sulfides and carbonate compounds. Compounds that dissolve into ions are also known as electrolytes. The more ions that are present, the higher the conductivity of water. Likewise, the fewer ions that are in the water, the less conductive it is. Distilled or deionized water can act as an insulator due to its very low (if not negligible) conductivity value. Sea water, on the other hand, has a very high conductivity. Electrical conductivity was measured using Conductivity TDS meter- 308. The electrode of the conductivity meter is dipped into the sample and the readings were noted for stable values in µmhos or Siemens(s).

Total Alkalinity

Alkalinity is the capacity of water to resist changes in pH that would make the water more acidic. It should not be confused with basicity which is an absolute measurement on the pH scale. Alkalinity is the strength of a buffer solution composed of weak acids and their conjugate bases. It is measured by titrating the solution with a monoprotic acid such as HCl/H_2SO_4 until its pH changes abruptly, or it reaches a known endpoint where that happens. Alkalinity is expressed in units of mg/L which corresponds to the amount of monoprotic acid added as a titrant in millimoles per liter. The sample was titrated against 0.1N Sulphuric acid in the presence of phenolphthalein and Bromocresol green indicators.

Total Hardness

Water hardness is the amount of dissolved calcium and magnesium in the water. Hard water is high in dissolved minerals, largely calcium and magnesium. General guidelines for classification of waters are: 0 to 60 mg/L (milligrams per liter) as calcium carbonate is classified as soft; 61 to 120 mg/L as moderately hard; 121 to 180 mg/L as hard; and more than 180 mg/L as very hard

Fluoride

Fluoride at a lower concentration at an average of 1 mg/l is regarded as an important constituent of drinking water [4]. Surface water generally contains less that 0.5 mg/l fluoride. However, when present in much greater concentration, it becomes a pollutant.

Chloride

Chlorides may get into surface water from several sources includes rocks containing chlorides, agricultural runoff, wastewater from industries, oil well wastes, effluent wastewater from wastewater treatment plants, road salting. The estimation of chloride was carried out according to the method mentioned in APHA. Silver nitrate reacts with chloride, a very slightly soluble white precipitate of silver chloride is formed. At the end point when all chloride gets precipitated, free silver ions react with chromate to form silver chromate of reddish brown colour. The sample was titrated against standardized silver nitrate solution using potassium chromate solution in water as indicator.

Nitrates

Nitrate is an inorganic compound that occurs under a variety of conditions in the environment, both naturally and synthetically. Nitrate in drinking water is measured either in terms of the amount of nitrogen present or in terms of both nitrogen and oxygen. The federal standard for nitrate in drinking water is 10 milligrams per liter (10 mg/l) nitrate-N, or 45 mg/l nitrate-NO3. Methemoglobinemia is the most significant health problem associated with nitrate in drinking water.

Iron

Iron is the second most abundant metal in the earth's crust, of which it accounts for about 5%. Elemental iron is rarely found in nature, as the iron ions Fe2+ and Fe3+ readily combine with oxygen- and sulfur-containing compounds to form oxides, hydroxides, carbonates, and sulfides. Iron is most commonly found in nature in the form of its oxides. Kidney stone related problem may develop if calcium and iron contents are high. Iron was estimated using Phenanthroline spectrophotometric method.

Biological Oxygen Demand

Biochemical oxygen demand is a measure of organic material contamination in water expressed in mg/l. BOD is defined as the amount of dissolved oxygen required for biochemical decomposition of organic compounds and the oxidation of certain inorganic materials. The BOD was measured according to modified Wrinkler's Titration method. The principle of the method involves measuring the difference in oxygen concentration of sample before and after incubation for 5 days at 20°C.

Chemical Oxygen Demand

COD is the amount of dissolved oxygen required to cause chemical oxidation of the organic material in water. Both BOD and COD are key indicators of the environmental health of a surface water supply. The sample was analyzed for COD using Liebig reflex condenser method/Open Reflux Method.

Table.3. Water quality analysis result for the period June 2018 – May 2019 at Ambrampalayam site of Aliyar River.

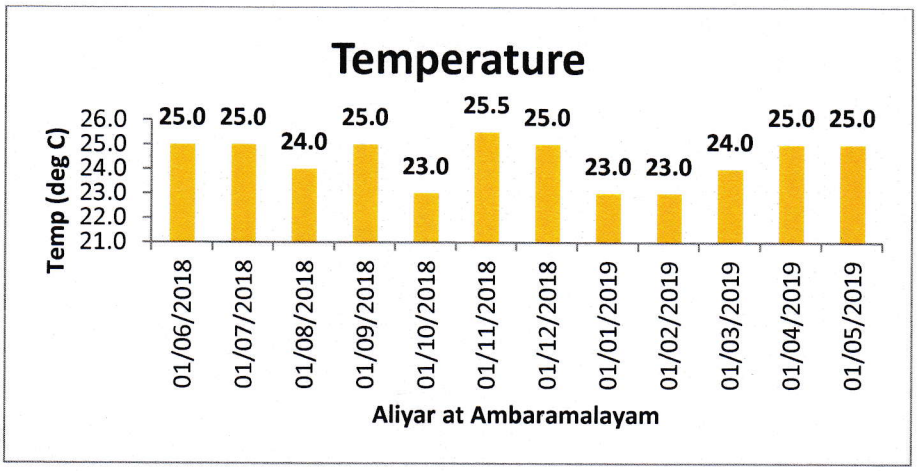
Month	COD (mg/L)	Temp (deg C)	EC_GEN (µmho/cm)	pH GEN (pH units)	ALK-TOT (mgCaCO3/L)	Cl (mg/L)	F (mg/L)	Fe (mg/L)	NO3-N (mgN/L)	BOD (mg/L)	COD (mg/L)	HAR_Total (mgCaCO3/L)	TDS (mg/L)
01/06/2018	2.5	25.0	190	7.8	74	15.5	0.24	0.000	0.10	0.6	2.5	72	105
02/07/2018	3.1	25.0	104	7.4	32	11.7	0.10	0.010	0.23	1.0	3.1	36	59
01/08/2018	9.1	24.0	208	7.6	77	15.5	0.10	0.029	0.45	3.2	9.1	81	116
01/09/2018	3.1	25.0	207	8.0	57	21.4	0.03	0.000	0.18	1.4	3.1	65	116
01/10/2018	7.3	23.0	333	7.9	99	27.2	0.48	0.000	5.28	2.1	7.3	127	186
01/11/2018	10.2	25.5	645	8.2	172	63.9	0.78	0.000	10.10	1.2	10.2	224	361
01/12/2018	8.3	25.0	607	8.2	181	60.2	0.62	0.010	5.38	1.0	8.3	225	340
01/01/2019	3.5	23.0	142	8.0	42	13.6	0.07	0.050	3.04	0.4	3.5	55	80
01/02/2019	10.3	23.0	166	7.9	44	21.2	0.07	0.000	2.50	1.4	10.3	56	93
01/03/2019	12.9	24.0	128	7.5	36	15.5	0.06	0.000	2.10	1.8	12.9	41	72
01/04/2019	2.3	25.0	132	7.4	39	13.7	0.26	0.069	3.93	1.2	2.3	51	74
01/05/2019	7.8	25.0	201	8.0	67	15.7	0.25	0.000	4.56	1.0	7.8	82	115

Results and Discussion

All the water quality parameters were analyzed at Lower Water Quality Laboratory, Southern Rivers Division of Central Water Commission. [6]

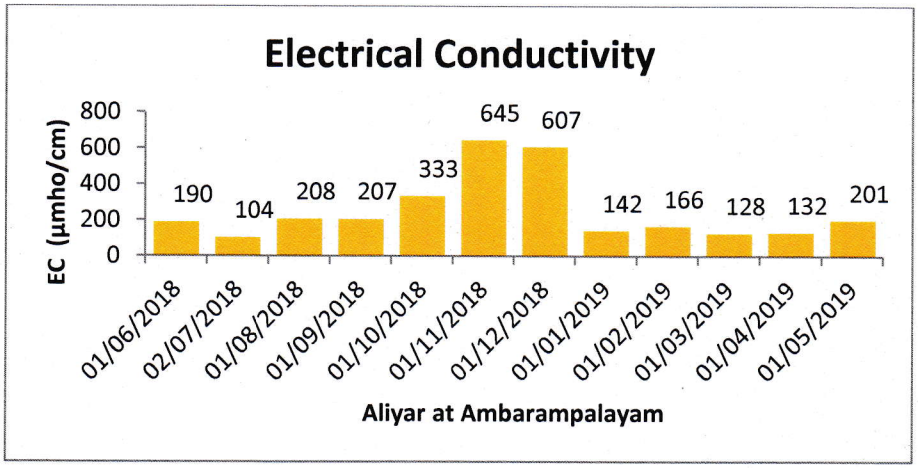
Temperature

Temperature is one of the most important ecological and physical factors which have a profound influence on both living and non living components of environment, thereby affecting organisms and functioning of an ecosystem, though the temperature influences the overall quality water, there are no guideline values recommended for water. The temperature has been ranged from 23^0 C to 25.5^0C.



Electrical Conductivity

The electrical conductivity of the water samples ranges from 104 µmhos/cm in the month of July 2018 to 645 µmhos/cm in the month of November 2018. Electrical Conductivity is usually the measure of ionic concentrations present in a water sample. The conductivity of most freshwaters ranges from 10 to 1000 µS cm-1, but may exceed 1000 µS cm-1, especially in polluted waters, or those receiving large quantities of land run-off.



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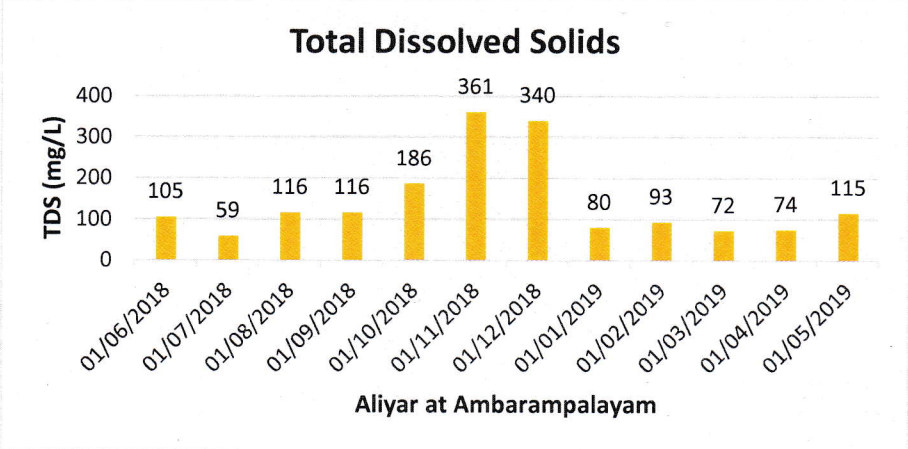
Total Dissolved Solids

Total dissolved solids (TDS) is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. The principal constituents are usually calcium, magnesium, sodium, and potassium cations and carbonate, hydrogen carbonate, chloride, sulfate, and nitrate anions. The presence of dissolved solids in water may affect its taste. The palatability of drinking water has been rated by panels of tasters in relation to its TDS level as follows: excellent, less than 300 mg/litre; good, between 300 and 600 mg/litre; fair, between 600 and 900 mg/litre; poor, between 900 and 1200 mg/litre; and unacceptable, greater than 1200 mg/litre. Water with extremely low concentrations of TDS may also be unacceptable because of its flat, insipid taste. Total dissolved solids (TDS) is usually low for freshwater sources, at less than 500 ppm.In the present study of aliyar river at Ambarampalayam TDS found maximum in November 2018 though in acceptable limit.



pH

The pH of the water samples ranges from 7.4 in the months of July 2018 and April 2019 to 8.2 in the months of November and December 2018. In this present investigation, the values of pH indicate that the water is slightly alkaline in nature and the range of pH for domestic use recommended by BIS is 6.5 to 8.5

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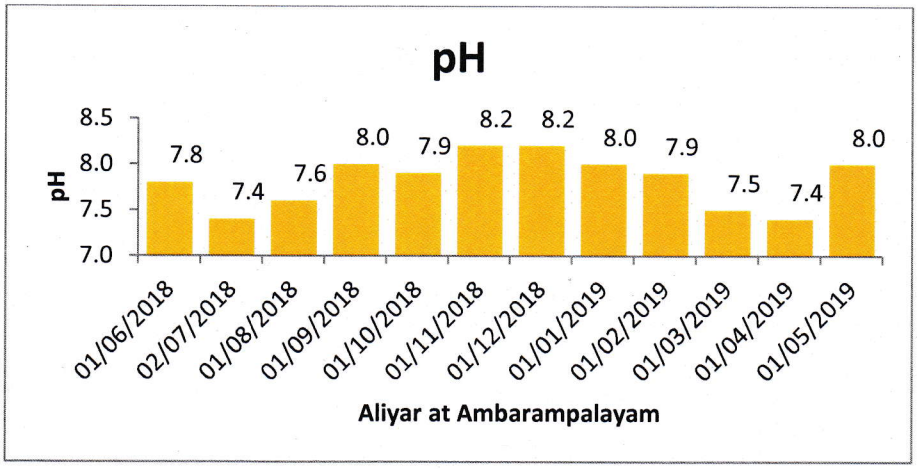
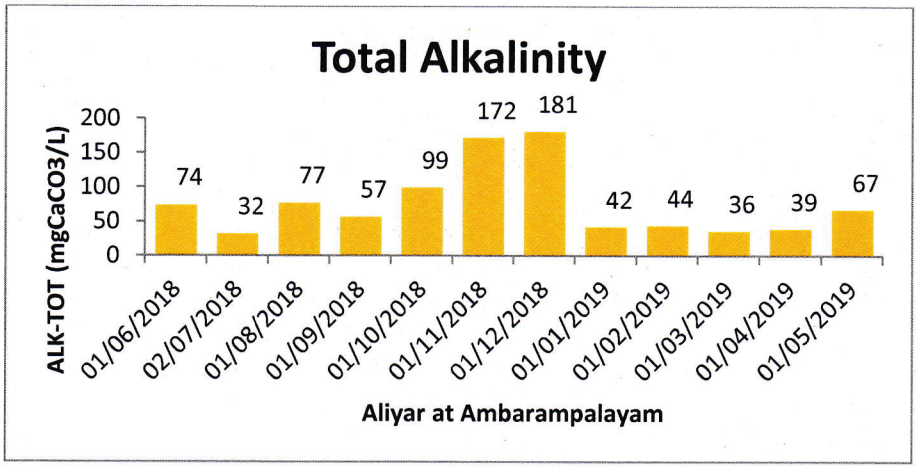


Total alkalinity:

The total alkalinity of the water samples ranges from 32 to 181 mg $CaCO_3$ /L. The maximum and minimum values are recorded in the months of December 2018 and July 2018 respectively. Alkalinity is an estimate of the ability of water to resist change in pH upon addition of acid. Alkalinity of water is measure of its capacity to neutralize acids. This is due to the primarily salts of weak acids or strong bases. Bicarbonates represent the measure form of alkalinity. Bicarbonates are formed in considerable amount from the action of carbon dioxide upon basic materials in soil and other salts of weak acids.



Total Hardness

The sources of Ca and Mg in natural water are various types of rocks, industrial waste and sewage. There is evidence that hard water plays a role in heart diseases. The maximum value of total Hardness in the water sample during this one year period was observed in the month of November-2018 and December-2018.

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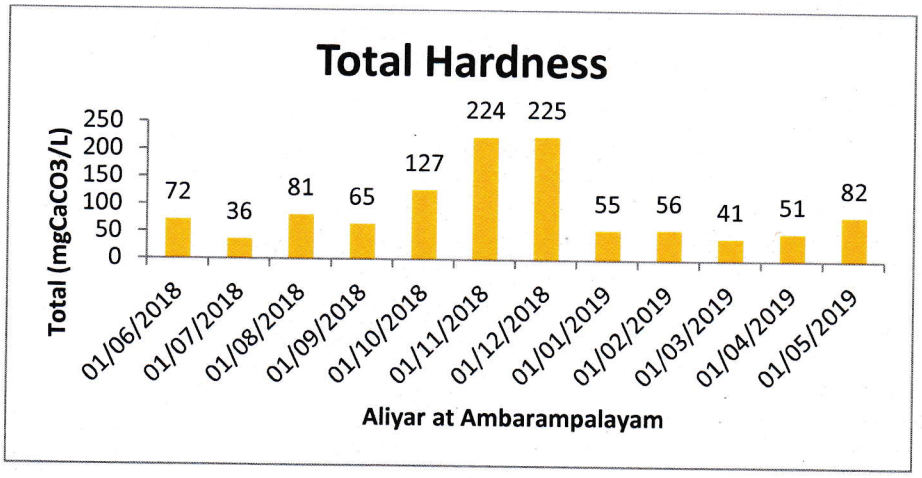
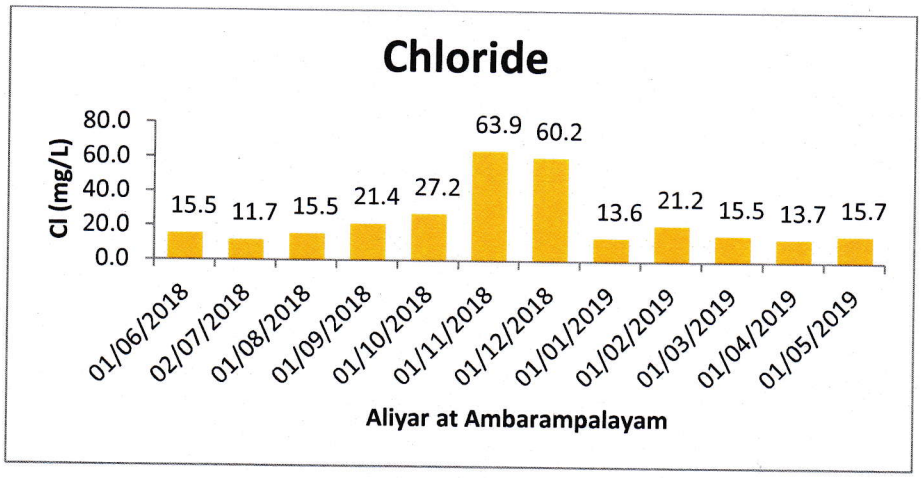


Chloride

A maximum value of 63.9 mg/L and a minimum value of 13.6 mg/L were observed during the months of November-2018 and January-2019 respectively. High chloride ion concentration indicates organic pollution in the water. The chloride concentration on fresh natural water is quite low generally less than that of bicarbonates. Chloride is a natural substance present in all potable water as well as sewage effluents as metallic salt. Many researchers reported that rain1fall add chloride directly. It is low in summer as compared to rainy season and occupying the intermediate position in winter [5].



Nitrate (NO_3-N)

Nitrates are very important nutrient factor in aquatic ecosystems, generally, water bodies polluted by organic matter exhibit higher values of nitrates. The variation in the nitrate content of water samples ranged from 0.10 to 10.10 mg/L. This can be observed from the plot below.

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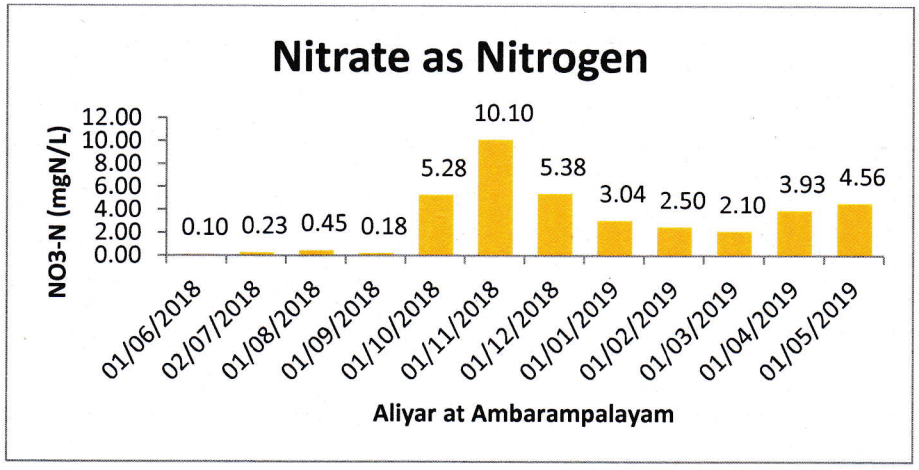
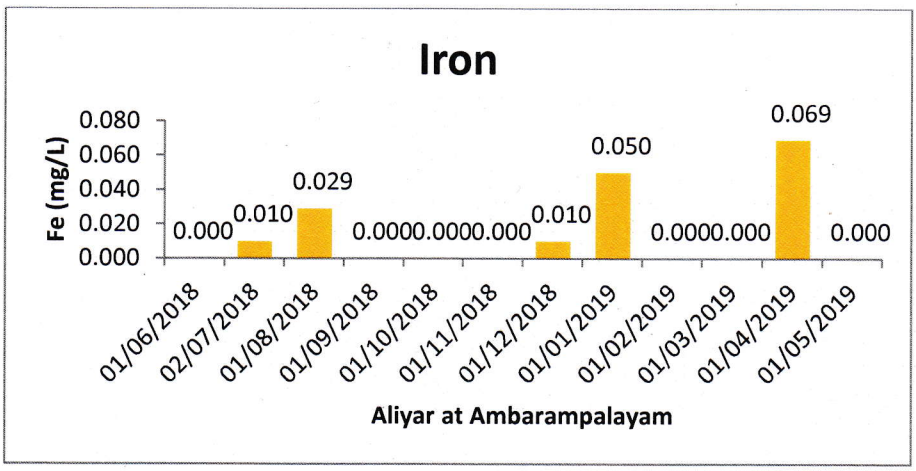


Iron

Iron content varied from zero to 0.069. This is within acceptable limits as per IS 10500:2012. The permissible limit of iron is 0.3 mg/L.



Fluoride

The Fluoride content of the river water samples varied from 0.03 to 0.78 mg/L during this testing period. The Fluoride content is within the permissible limits as per Indian Standards.

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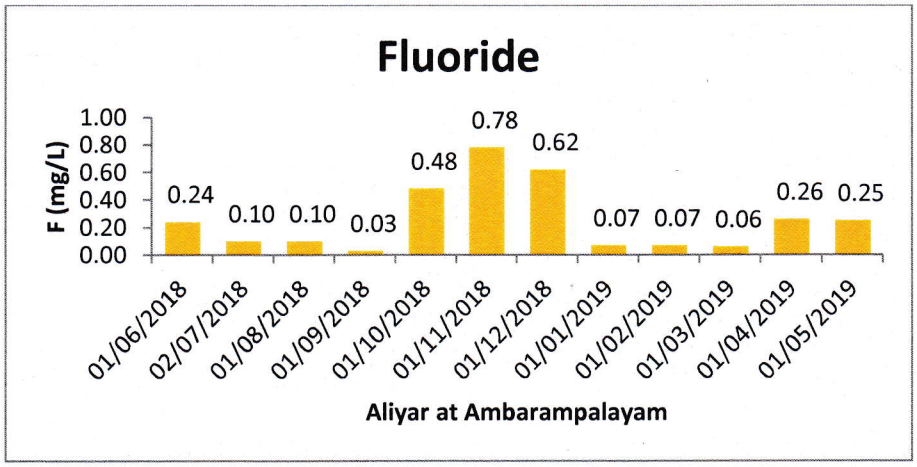
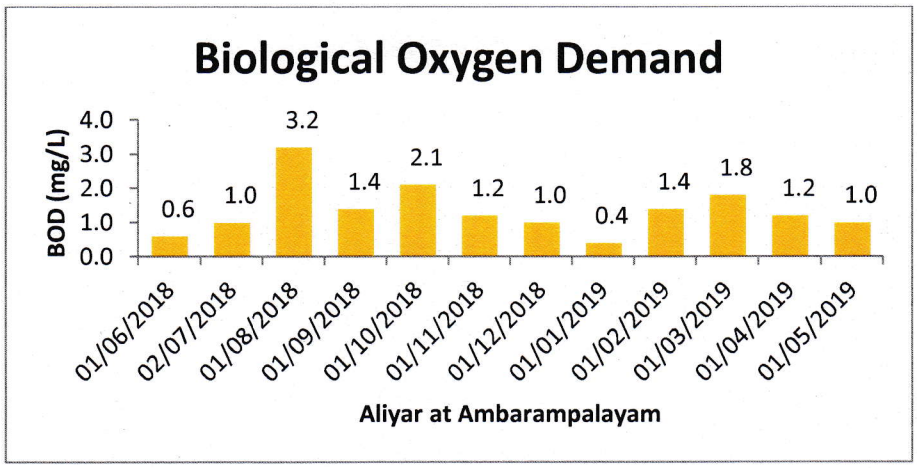


Biological Oxygen Demand

The high value of BOD indicates the presence of domestic, industrial wastes in huge quantities. The level of BOD depends on temperature, density of plankton, concentrations of organic matter and other related factors [20]. Organic matter was indicated by comparatively high BOD level. Water with BOD levels < 4 mg/l are deemed as clean, while those > 10 mg/l are considered polluted and unsafe. BOD was ranged from 0.4 mg/L to 3.2 mg/L [5].



Chemical Oxygen Demand

COD values convey the amount of dissolved oxidizable organic matter including the non-biodegradable matters present in it. The minimum values of COD in sampling station might be due to low organic matter. While the maximum value in stations might be due to high concentration of pollutants and organic matter. COD is one of the useful indicators of organic and inorganic substance of river water by sewage discharge and anthropogenic activities.The minimum COD value was observed during the month of April-2019 and maximum value was observed in the month of March-2019.

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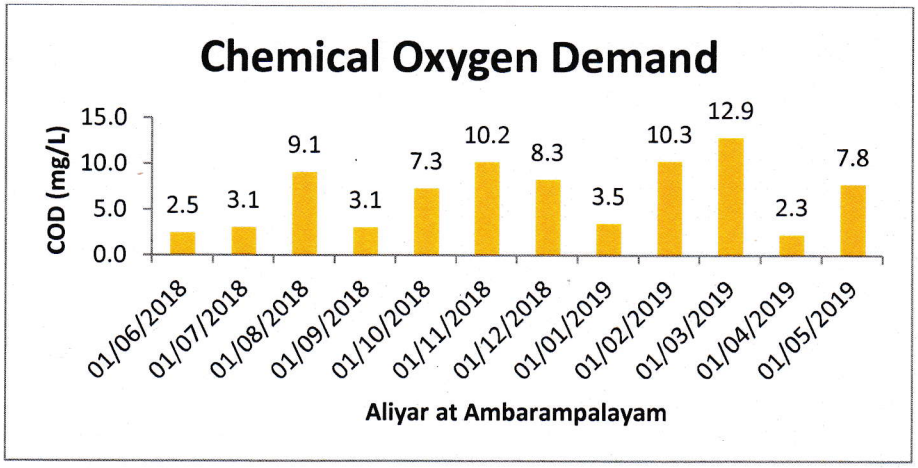
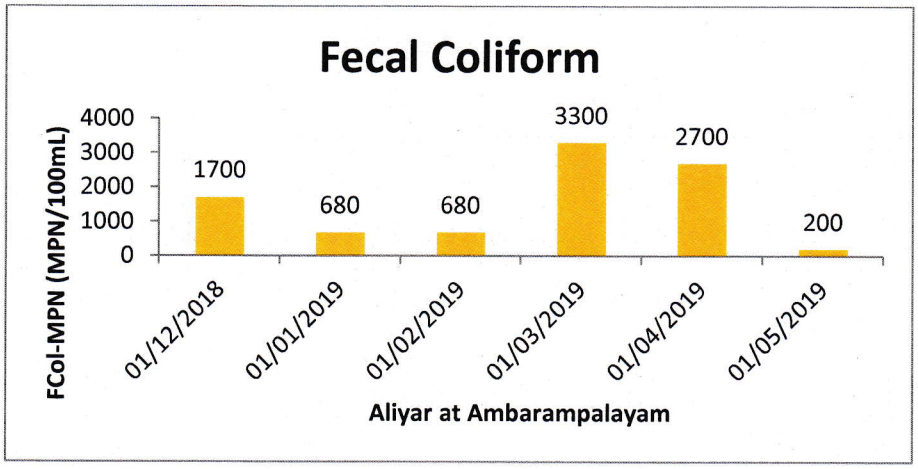
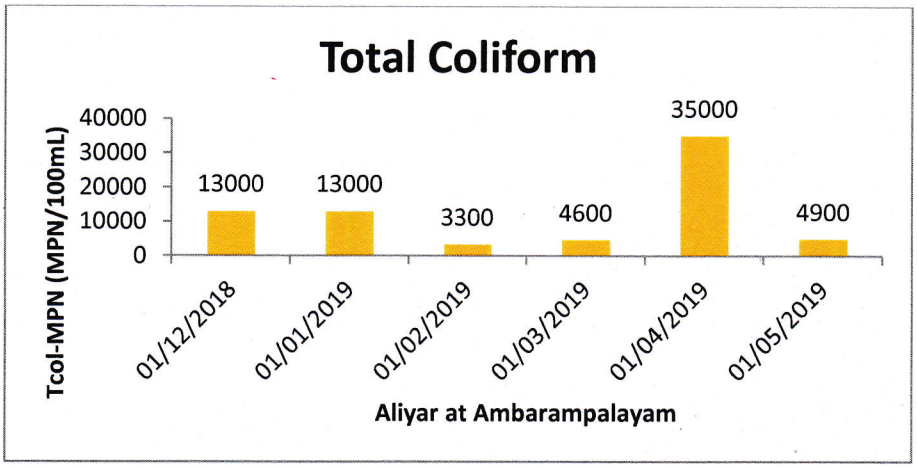


Total Coliform and Fecal Coliform

The Total coliform and Fecal coliform count in water as per IS norms is to be zero for drinking water. But the presence of Fecal Coliform in the water conveys that water is not fit for drinking without proper antimicrobial treatment.





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CONCLUSION

The analysis of water of Aliyar River at Ambarampalayam site shows that the pH, Electrical conductivity Total alkalinity, Calcium, BOD, COD, Fluoride, Iron, Nitrate and chloride are within the permissible limits with some exceptions in few months. The Total Coliform and Fecal Coliform which are regarded as indicator organisms for bacteriological pollution found to be not within in the permissible limits as per IS 10500:2012. Few parameters showed little higher values in the month of November, December 2018 (during North East Monsoon) which might be due to the human activities nearby that area such as laundry, rearing of animals, fishing, sewage mixing, other agricultural inputs around this area of the river and large runoff of water collecting huge quantity of wastes from surrounding into the mainstream of the river. The study reveals that, the water quality of Aliyar River is reasonably good and fit for drinking purposes but needs proper treatment to minimize the contamination before consumption as Fecal Coliform present in the water may cause some diseases.

References

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SEASONAL AND INTRA-ANNUAL VARIATION IN THE WATER QUALITY OF NOYYAL RIVER AT SITE ELUNUTHIMANGALAM

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Abstract

This study investigates the time series measurement of water quality parameters in the Noyyal River at Elunuthimangalam which predicts the present water quality status of the study area, one of the water quality hotspots in India. All the samples were collected thrice in a month at a fixed time in the morning during June 2018 to May 2019. The water samples collected for the analysis of different physico-chemical and biological parameters from Elunuthimangalam site based on standard procedure to study the seasonal and intra-annual variability in the water quality of the Noyyal River during 2018-19. Further, Principal Component Analysis tool, multivariate statistical technique, used to understand the temporal variation and interpretation of water quality datasets. A seasonal river which flows mainly during monsoon, Noyyal River congregate for the rest of the year to sewage and industrial effluents from the textile cities in its basin. Our observations suggests that most of the parameters fails to meet the quality standards specified by the BIS.

1. INTRODUCTION

A river system consists of main river and its tributaries, which carries substantial load of dissolved and particulate matter from natural and anthropogenic sources in one way. There are numerous impacts like climate, lithology, atmospheric and anthropogenic inputs reflects in the quality of a river (Bricker and Jones, 1995). The river water contamination is a matter of great concern all over the world in recent decade (May et al., 2006; Ouyang et al., 2006). Pollution of a river first affects its chemical quality and systematically devastate the aquatic community by distracting the food web (Joshi et al., 2009) and also generates around 80% of all illness across the world (Budhathoki., 2010).

The Noyyal River originates in the Vellingiri hills in the Western Ghats of Tamil Nadu and flows through Coimbatore, Tirupur, Erode and Karur districts of Western Tamil Nadu before its confluence with the Cauvery River at Noyyal hamlet in Karur district. The total length of the river is about 180 km, flowing from west to east encompassing a catchment area of 3510 sq. km. The basin with an average width of about 25 km. is widest in the central part with a width of about 35 km. The cultivable land in the river basin is around 1800 sq. km. The population density in the basin varies from 120 persons/sq. km. in the countryside to 1000 per sq. km. in the cities. The Noyyal River catchment area is characterized by inadequate rainfall. As a result, the Noyyal River Tank system was developed years back in the region to hold the river overflows from the N-E and S-W monsoons. The river forms the southern boundary of the Coimbatore city and acts as a major drainage course carrying the

storm water discharge. The region is familiar for textile production through its textile, bleaching and dyeing industries. Tirupur City alone has more than 6500 hosiery and garment industries and 750 bleaching and dyeing industries. Industrial effluents have compromised agriculture in this basin by polluting both the ground water and the surface water.

For assessing the water quality physico-chemical and biological properties are used (Manjare et al., 2010). With the objective of assessing the quality of water resources, and to check the effectiveness of water treatment and supply by the concerned authorities, a standard IS 10500:2012 was formulated by Bureau of Indian Standards (BIS, 2012). Realizing the water scarcity with shortage of annual rainfall, several check dams, reservoirs and tanks were constructed at various periods. These systems are known to irrigate large piece of agricultural land. While the river Noyyal predominantly runs dry up to Coimbatore city, thereafter a continuous flow of city's drainage and sewage is seen in the river. At Tirupur, effluents from dyeing and bleaching industries and domestic sewage are let into the Noyyal River.

The region which constitutes the Noyyal river Basin depends mainly on ground water for it needs. As a result over the years, there has been lowering of water table in many parts of Noyyal river basin. Ground water recharge in Noyyal river basin is mainly due to rains, infiltration during monsoon and non-monsoon rains, rainfall, seepage from wet cultivation, seepage from water bodies such as tanks, anicuts, canals, and reservoirs. As water storage is monsoon dependent, the water available in the wells in both sides of the banks is good only during the rainy seasons. The ground water usage status predominantly in Noyyal River Basin is as follows: Coimbatore – Over Exploited, Tirupur – Over Exploited, Erode – Semi Critical and Karur – Semi Critical.

CWC recognized Elunuthimangalam is one of the certain water quality 'hotspots' in India, in 2011, in which most of the parameters fails to meet the quality standards specified by the BIS (CWC 2011). Bureau of Indian Standards (BIS) vide its document IS: 10500:2012 has recommended the quality standards for drinking water and these have been used for finding the suitability of river water. On this basis of classification, the natural river water of India has been categorized as desirable, permissible and unfit for human consumption. River water quality is very important for aspect in India. The physico-chemical parameters like pH, electrical conductance (TDS), Chloride, Fluoride, Iron, Nitrate, Sulphate, Total hardness, Calcium and Magnesium are main constituents defining the quality of river water in surface water. Therefore, presence of these parameters in river water beyond the permissible limit in the absence of alternate source has been considered as river water quality hotspots. Several studies has been conducted on water quality analysis of Noyyal River (Govindarajalu 2003; Mohan and Vanalakshmi 2013; Rajkumar 2011; Srinivasan et al. 2014; Marimuthu et al.

2015; Babu et al. 2017 and Adarsh et al. 2019) and the dying industries are responsible for pollution of Noyyal River. Recent studies showed that, the Elunuthimangalam water is not fit for use due to presence of three toxic metals namely Cadmium, Nickel and Lead are shown above acceptable limits according to BIS 10500:2012 (CWC, 2018).

The time series measurement of water quality parameters are multiscaling in characteristics also non-linear and non-stationery (Rao and Hsu., 2008), further it is required the suitable modelling studies with proper datasets in time and space. The of multivariate statistical techniques used for analysis and interpretation of complex data sets in water quality assessment, identification of pollution sources and understanding spatio-temporal variations in water quality for effective river water quality management (Shrestha and Kazama., 2007). In this time series study, multivariate statistical techniques were used to evaluate the seasonal and intra-annual variations in water quality of Noyyal River at Elunuthimanagalam.

2. MATERIALS AND METHODS

2.1 Description of Study Area

The map of the Noyyal river basin and the tree structure of Noyyal river basin as shown in figure 1 and 2 respectively. The site Elunuthimangalam (E Mangalam) situated at (Latitude - 11°01'54", Longitude - 77°53'15") just upstream of the confluence of Noyyal river with Cauvery river. The Noyyal River being a seasonal river, with flows mainly during monsoon, plays a reluctant host for the rest of the year to sewage and industrial effluents mainly from Coimbatore and Tirupur, the two main textile cities in its basin.

On the Noyyal River, two dams were built by Government of Tamil Nadu. These are Orathupalayam dam, about 32 km downstream from Tirupur city and the Aathipalayam Dam in Karur district, commissioned with the objective of irrigating about 20000 acres of land in Tirupur and Karur districts. The river has 23 check dams along its course. Most of them are located between Kooduthurai and Tirupur. The Orathupalayam dam was built in 1992 and it has an ayacut of over 10,000 acres in Tirupur and Karur Districts. The Orathupalayam dam's catchment is 2,245 sq km and includes most of the area in which the bleaching and dyeing units are located. These factories discharge huge quantity of effluent everyday into the Noyyal River which accumulate in the Orathupalayam dam. As of now, Orathupalayam dam stands decommissioned and is acting as an effluent tank for the Tirupur textiles units.

2.2. Sampling

The water samples were collected at site Elunuthimangalam thrice in a month since it is a flux station (if discharge is available) during June 2018 to May 2019 and transported to

lab and stored at 4°C. A total of 30 river water samples were collected during Monsoon (June – October), winter (November – February) and summer (March – May) between June 2018 to May 2019. The southwest monsoon (June-September) in the year 2018 has withdrawn from the entire India by 21st October 2018 (IMD, 2018) and followed by commencement of Northeast Monsoon rains. Water samples for Dissolved Oxygen and Biochemical Oxygen Demand collected in BOD bottles (300 ml) by DO sampler to avoid aeration during sampling. 1000 ml of river water samples were collected for physico-chemical analysis in a cleaned polythene bottles.

2.2. Analytical Methodology for physico-chemical and biological parameters

The samples were analyzed as per the standards methods (Table 1) of APHA (2017). The analysis was carried out for physico chemical and biological parameters including coliforms.

2.3 Analytical Quality Control AQC)

The Quality Control (QC) of the datasets was assessed by the use of replicates, spike samples and intermediate checks of NIST Certified Reference Materials (Merck). Quality Assurance (QA) of physico-chemical parameters were carried out by successful completion of Proficiency Testing by Global PT provider and all the Z values are within the limit. There is no incongruity occurred between the original and measured values. So, this data sets used for the present study is considered acceptable and further no major analytical problem come across during the analysis of these samples.

2.4 Statistical Analysis

A multivariate statistical technique like Principal Component Analysis (PCA) is such a tool, which enables us to understand the relationship among huge number of variables (Andrade et al., 1992; Shrestha and Kazama., 2007). PCA is designed to transform the original variables into new, uncorrelated variables (axes), called the principal components, which are linear combinations of the original variables. The new axes lie along the directions of maximum variance. PCA provides an objective way of finding indices of this type so that the variation in the data can be accounted for as concisely as possible (Sarbu and Pop, 2005). PC provides information on the most meaningful parameters, which describes a whole data set affording data reduction with minimum loss of original information (Helena et al., 2000).

Table 1. Methods adopted for analyzing various physic-chemical and biological parameters

Sl. No.	Parameter	Unit	Method	Reference
1	Electrical Conductivity	µS/cm	Electrometric Method	APHA23rd Edn.2017 -- 2510 B
2	pH		Electrometric Method	APHA23rd Edn.2017 -- 4500H^+ B
3	Total Hardness as $CaCO_3$	mg/L	Titrimetric Method	APHA23rd Edn.2017 -- 2340 C
4	Calcium as Ca	mg/L	Titrimetric Method	APHA23rd Edn.2017 -- 3500Ca - B
5	Magnesium as Mg	mg/L	Calculation Method	APHA23rd Edn.2017 -- 3500Mg - B
6	Total alkalinity as $CaCO_3$	mg/L	Titrimetric Method	APHA23rd Edn.2017 -- 2320 B
7	Chloride as Cl	mg/L	Argentometric Method	APHA23rd Edn.2017 -- 4500Cl^- B
8	Biochemical Oxygen Demand	mg/L	Dilution Method@20°C for 5 days	APHA23rd Edn.2017 -- 5210 B
9	Dissolved Oxygen	mg/L	Azide Modification Method	APHA23rd Edn.2017 -- 4500, O-C
10	Nitrate as NO_3	mg/L	ISE Method	APHA23rd Edn.2017 -- 4500 NO_3^- D
11	Fluoride as F	mg/L	ISE Method	APHA23rd Edn.2017 -- 4500 F^- C
12	Sodium as Na	mg/L	Flame Emission Photometric Method	APHA23rd Edn.2017 -- 3500 Na-B
13	Potassium as K	mg/L	Flame Emission Photometric Method	APHA23rd Edn.2017 -- 3500 K-D

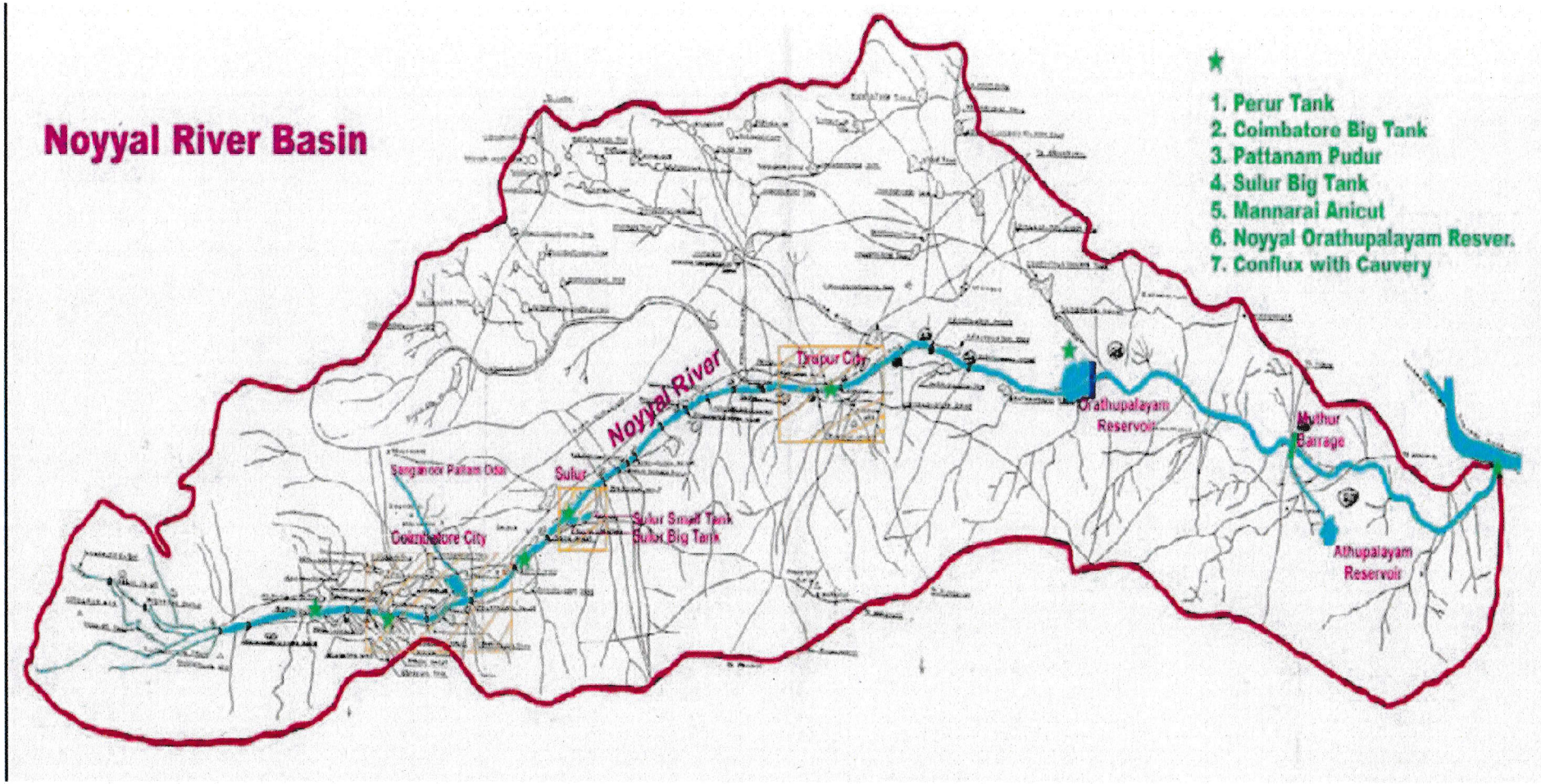


Figure - 1. Noyyal River Basin

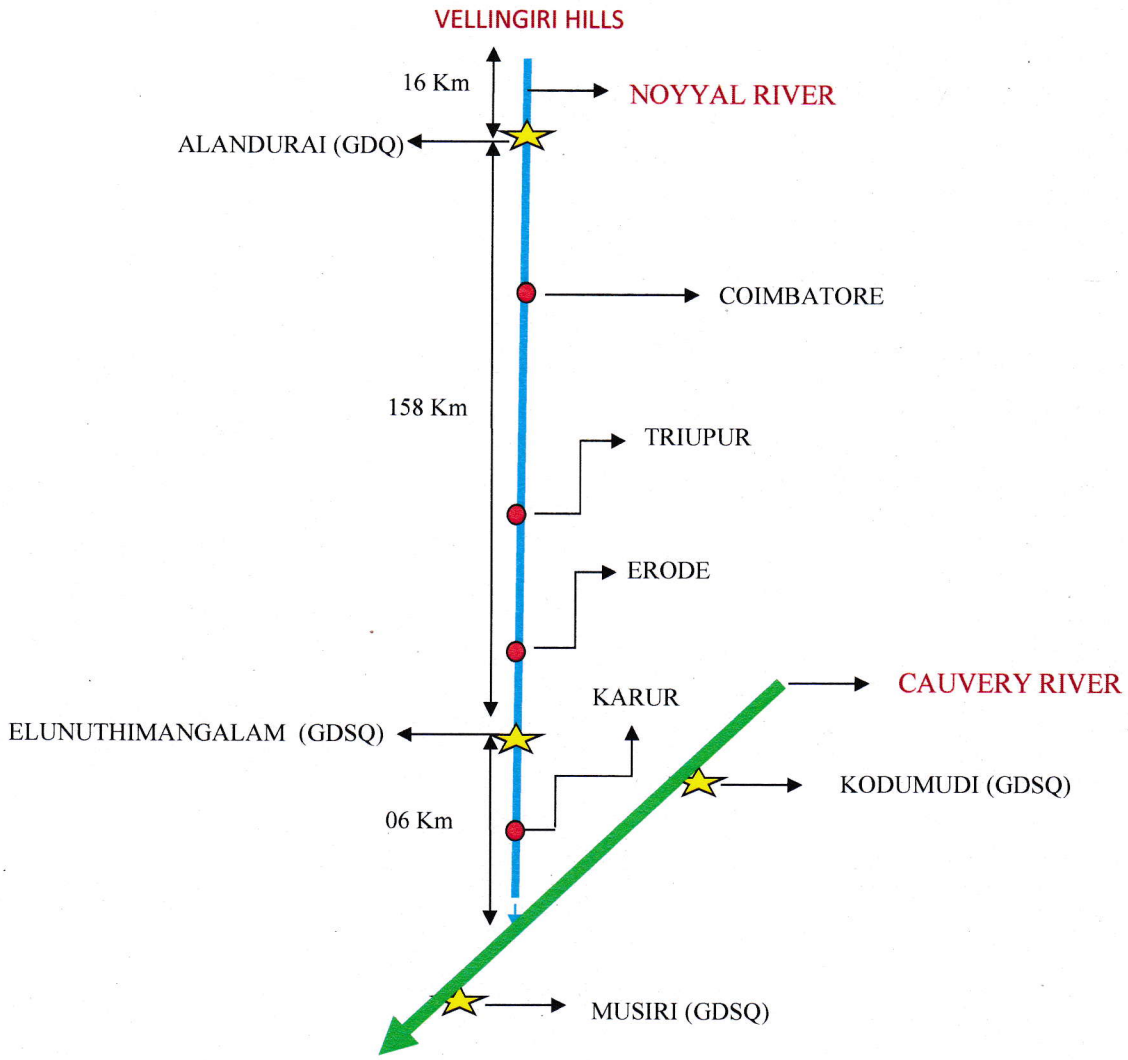


Figure – 2. Tree Structure of Noyyal River Basin

3. RESULTS AND DISCUSSION

3.1. Intra-annual variations in the water quality of Noyyal River

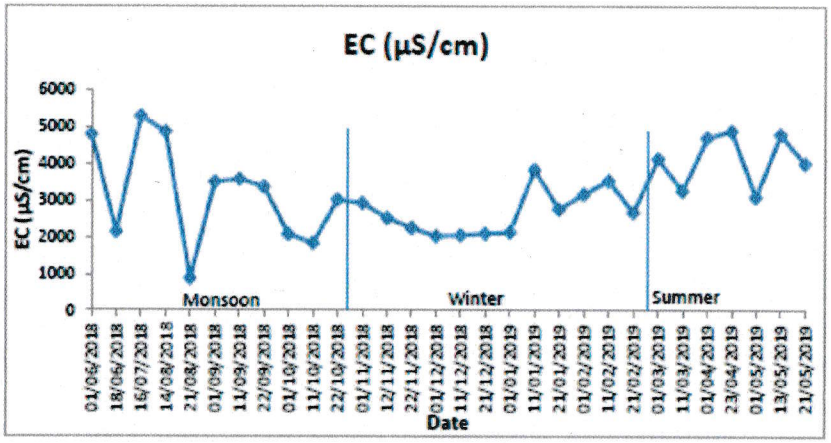
The Electrical conductivity (EC) values varied between 892 – 5311 µS/cm (figure 3). The highest value of EC reported in the month of July 2018 where lower discharge evidenced and lowest value reported on August 2018 where higher discharge (figure 5) evidenced. The values are higher during the months of June 2018 to mid of August 2018 and gradually decreasing up to 11th October 2018. From there values increased and then slightly reduced and more or less similar pattern up to 1st January 2019. From then to May 2019, the values showed higher when compared to previous month observations. The concentration of EC exceeds drastically over the permissible limit (59% for monsoon and 46% for non-monsoon) at Elunuthimangalam (CWC, 2011), which influences other water quality parameters.

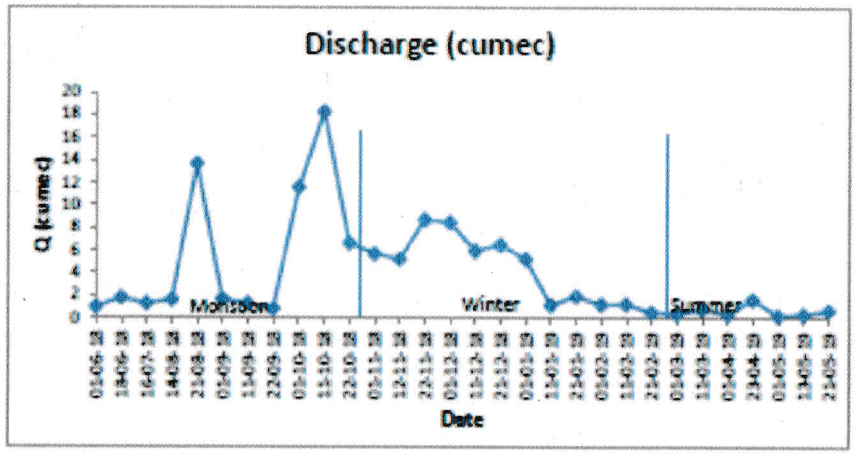
The total concentration of soluble salts in water is indicated by the value of high Electrical Conductivity. The high Electrical Conductivity of the river water is due to the usage of the salt (NaCl), bleaching agents in the upstream (Tirupur Textile Industries) of river Noyyal. Further it is supported by the graph plotted between Sodium, Chloride (average values) and the corresponding year. The suitability of water for various purposes as per BIS standards and the river water is not suitable for irrigation purposes because of its high saline nature and contains high Sodium and Chloride content.

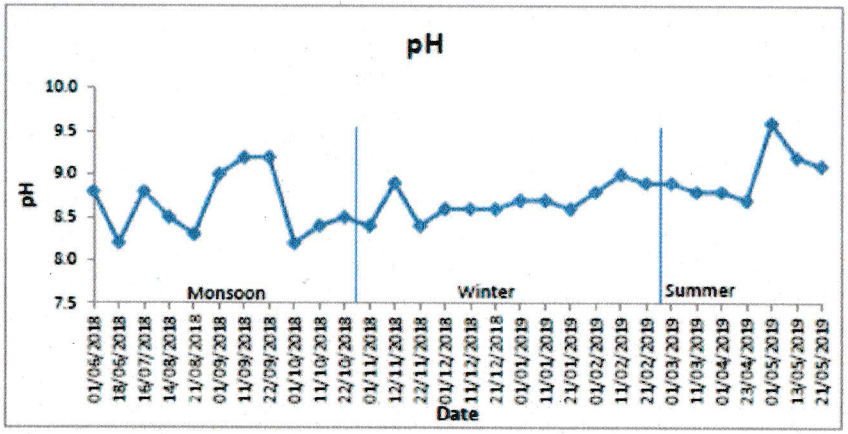
Recent study (Adarsh and Priya., 2020) performed the spectral characterization of time series of six water quality parameters from Noyyal River using Hilbert–Huang Transform (HHT) and examined the association between EC with other water quality parameters based on CWC data. Their HHT analysis successfully captured the anthropogenic interventions at the Noyyal River in the form of frequent pollutant disposals.

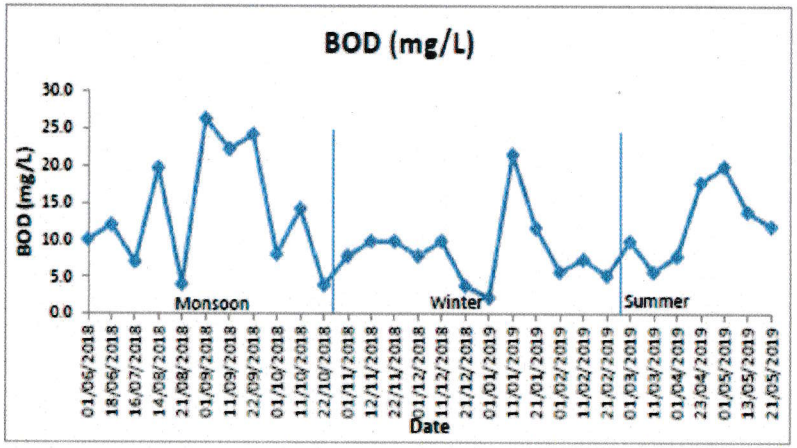
It can be summarized that the water of the Noyyal River is polluted as vital water quality parameters are exceeding the permissible limits. The river water is not suitable for irrigation purposes because of its high saline nature and contains high Sodium and Chloride content.

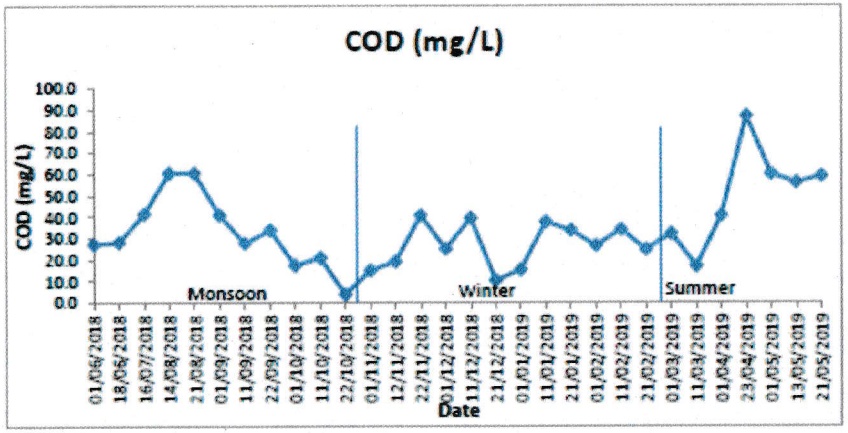
The physico-chemical and biological parameters viz., pH (8.2 to 9.6), BOD (2.2 – 26.3 mg/L), COD (3.9 – 87 mg/L), DO (2.8 – 8.4 mg/L), SAR (3.4 – 15.9), Sodium (109 – 893 mg/L), Potassium (10.2 – 48 mg/L), Calcium (44 – 159 mg/L), Magnesium (19.5 – 112.7 mg/L), Chloride (143.8 – 1218.2 mg/L), Fluoride (0.13 – 1.39 mg/L), TDS (500 – 3024 mg/L), Temperature (24 – 28 °C), Discharge (0.224 – 18.31 cumec), Sulphate (45.7 – 425.5 mg/L) and Total Hardness (190 – 735 mg CaCO3/L) in the Noyyal River showed that, it is fail to meet the water quality standard.

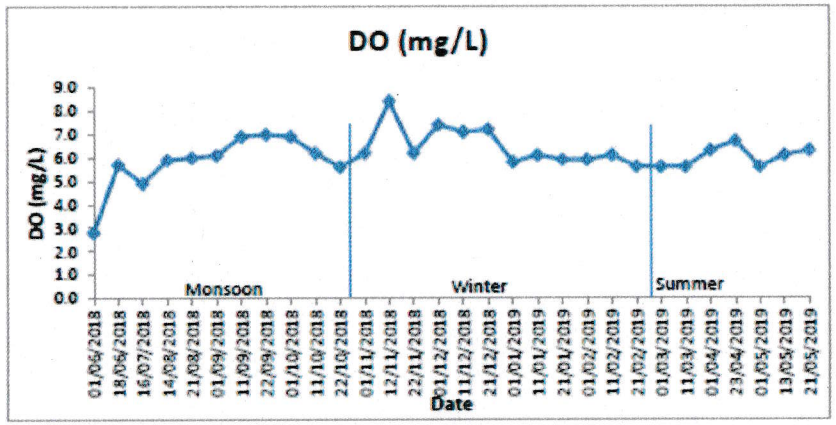

EC (µS/cm)
EC (µS/cm)
6000
5000
4000
3000
2000
1000
0
Monsoon
Winter
Summer
Date

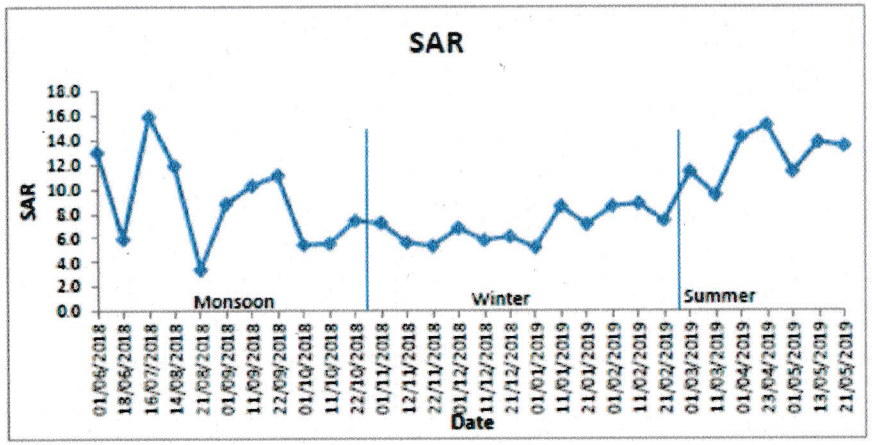

Discharge (cumec)
Q (cumec)
Monsoon
Winter
Summer
Date

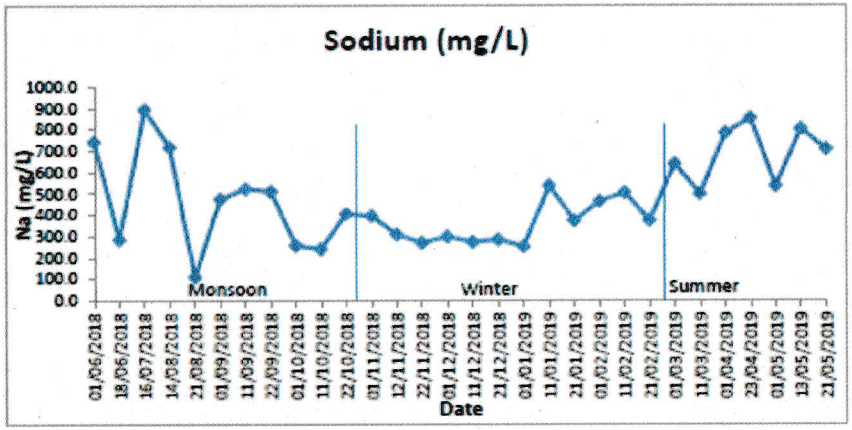

pH
pH
10.0
9.5
9.0
8.5
8.0
7.5
Monsoon
Winter
Summer
Date

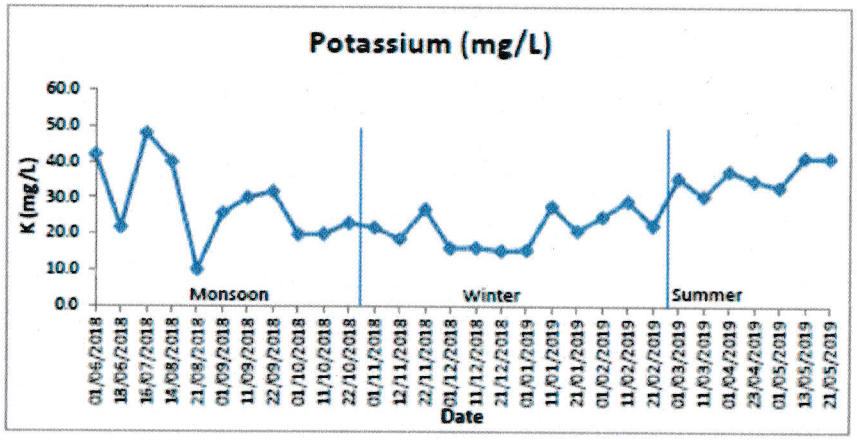

BOD (mg/L)
BOD (mg/L)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Monsoon
Winter
Summer
Date

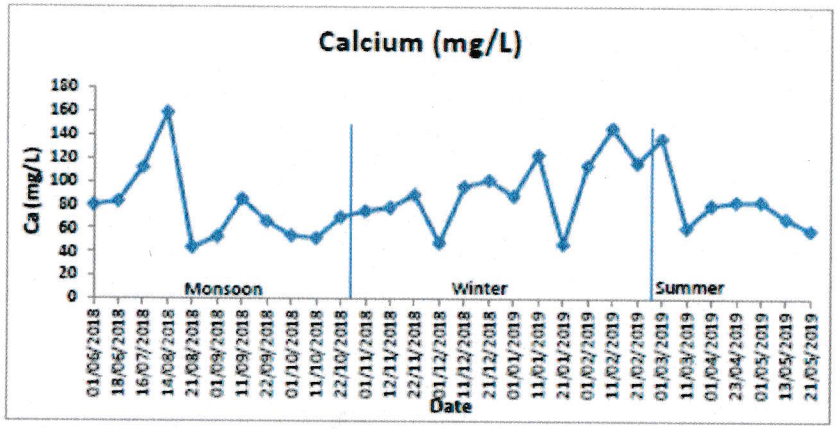

COD (mg/L)
COD (mg/L)
Monsoon
Winter
Summer
Date


DO (mg/L)
DO (mg/L)
Monsoon
Winter
Summer
Date


SAR
SAR
Monsoon
Winter
Summer
Date


Sodium (mg/L)
Na (mg/L)
Monsoon
Winter
Summer
Date


Potassium (mg/L)
K (mg/L)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Monsoon
Winter
Summer
01/06/2018
18/06/2018
16/07/2018
14/08/2018
21/08/2018
01/09/2018
11/09/2018
22/09/2018
01/10/2018
11/10/2018
22/10/2018
01/11/2018
12/11/2018
22/11/2018
01/12/2018
11/12/2018
21/12/2018
01/01/2019
11/01/2019
21/01/2019
01/02/2019
11/02/2019
21/02/2019
01/03/2019
11/03/2019
01/04/2019
23/04/2019
01/05/2019
13/05/2019
21/05/2019
Date


Calcium (mg/L)
Ca (mg/L)
180
160
140
120
100
80
60
40
20
0
Monsoon
Winter
Summer
01/06/2018
18/06/2018
16/07/2018
14/08/2018
21/08/2018
01/09/2018
11/09/2018
22/09/2018
01/10/2018
11/10/2018
22/10/2018
01/11/2018
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22/11/2018
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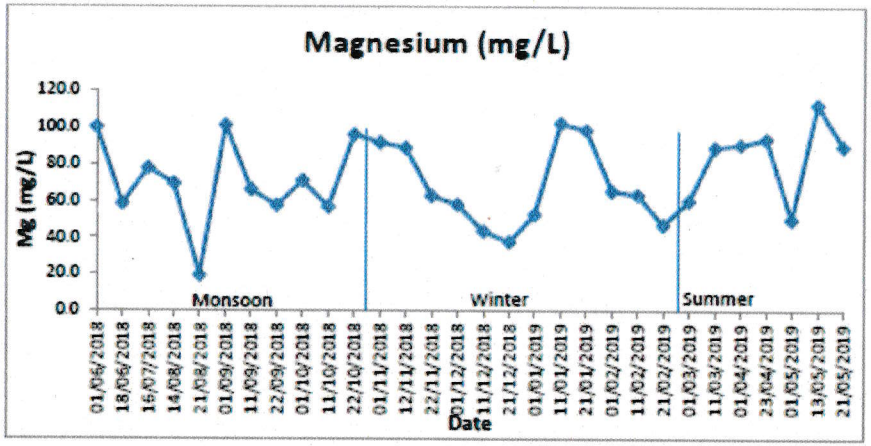
11/01/2019
21/01/2019
01/02/2019
11/02/2019
21/02/2019
01/03/2019
11/03/2019
01/04/2019
23/04/2019
01/05/2019
13/05/2019
21/05/2019
Date


Magnesium (mg/L)
Mg (mg/L)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Monsoon
Winter
Summer
01/06/2018
18/06/2018
16/07/2018
14/08/2018
21/08/2018
01/09/2018
11/09/2018
22/09/2018
01/10/2018
11/10/2018
22/10/2018
01/11/2018
12/11/2018
22/11/2018
01/12/2018
11/12/2018
21/12/2018
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11/02/2019
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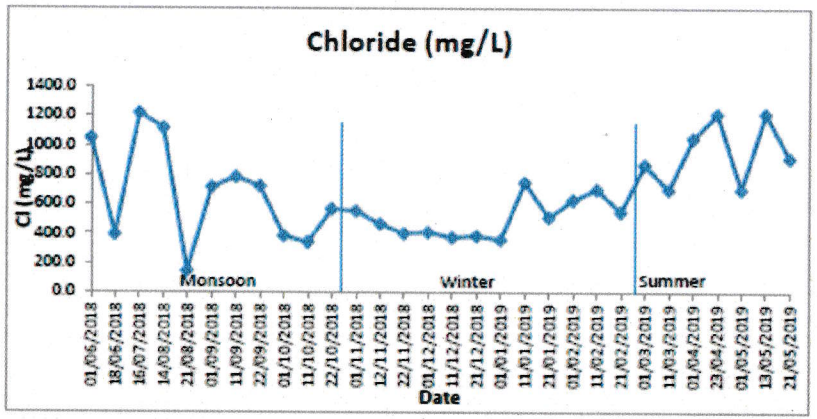
01/04/2019
23/04/2019
01/05/2019
13/05/2019
21/05/2019
Date


Chloride (mg/L)
Cl (mg/L)
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
Monsoon
Winter
Summer
01/06/2018
18/06/2018
16/07/2018
14/08/2018
21/08/2018
01/09/2018
11/09/2018
22/09/2018
01/10/2018
11/10/2018
22/10/2018
01/11/2018
12/11/2018
22/11/2018
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01/01/2019
11/01/2019
21/01/2019
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23/04/2019
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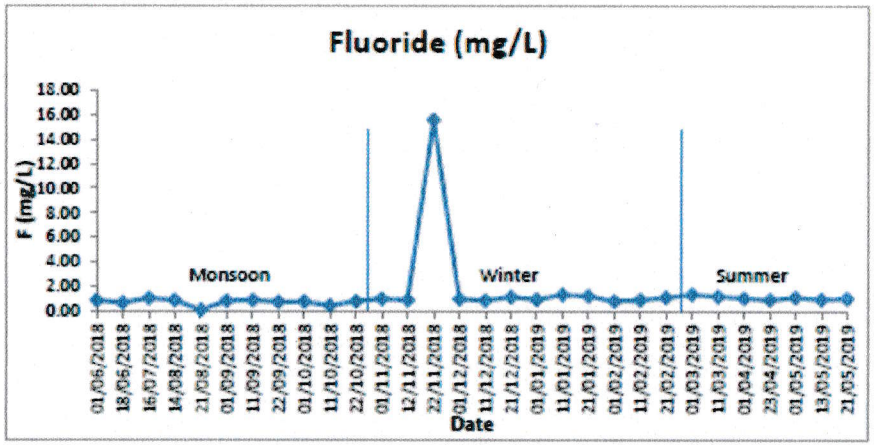
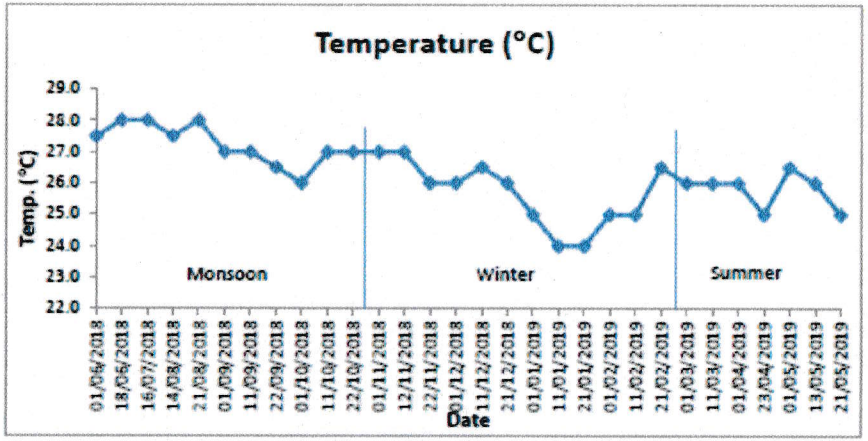
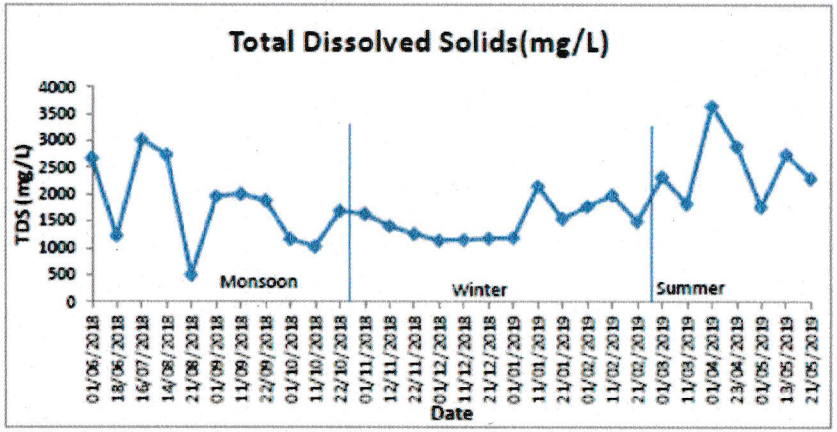
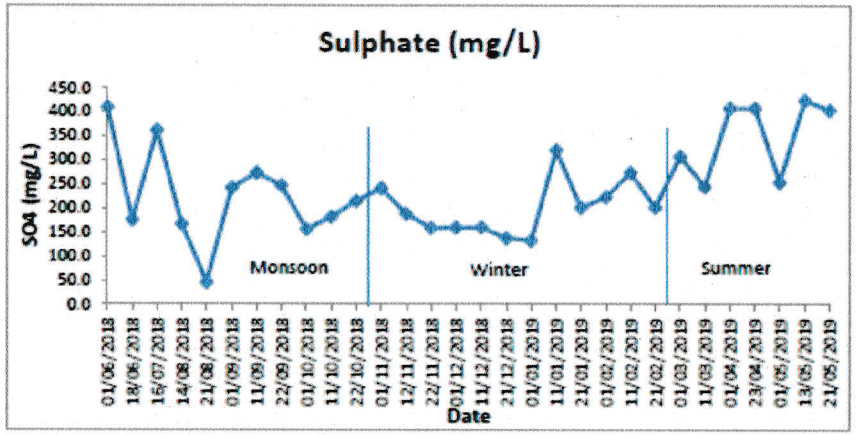
13/05/2019
21/05/2019
Date


Fluoride (mg/L)
F (mg/L)
Monsoon
Winter
Summer
Date


Temperature (°C)
Temp. (°C)
Monsoon
Winter
Summer
Date


Total Dissolved Solids(mg/L)
TDS (mg/L)
Monsoon
Winter
Summer
Date


Sulphate (mg/L)
SO4 (mg/L)
Monsoon
Winter
Summer
Date

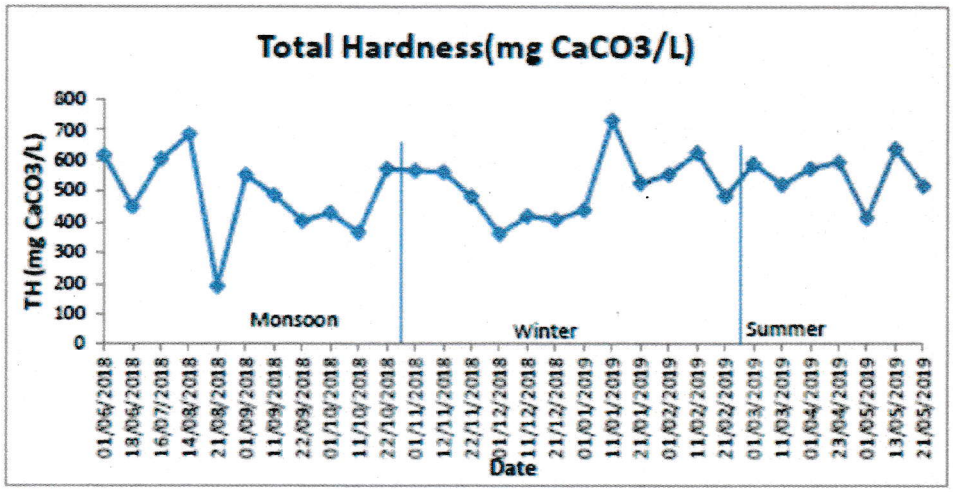


Figure 3. Seasonal and Intra-annual variability of various water quality parametrs

3.2 Seasonal Variations in the water quality of Noyyal River

The Electrical conductivity (EC) values shows clear seasonality. Based on the discharge values, the EC values are reversely changing. Starting month of monsoon the EC values are much higher where discharge values are very less. Gradually the water flow stabilized and it is clearly showed in the winter season where the stabilization of the EC values occurred. In the fag end of winter season the discharge values reduced and EC values are increasing and clear summer characteristics observed.

The Biological Oxygen Demand (BOD) values are high during the non-monsoon period when compared to monsoon. This indicates that the contamination is taking place during non-monsoon period continuously which reduces/dilutes with the onset of monsoon.

3.3 Principal Component Analysis

5 Major PCs were extracted with % of variance greater than 5% from all the 33 water quality parameters which accounted 76.9%. There are numerous criterions to identify the number of PCs to be retained in order to understand the elementary data composition and a scree plot (Figure 4) is used here. It showed change of slope after fifth components. The PCA loadings obtained after PCA biplot from the data are given in Table 2.

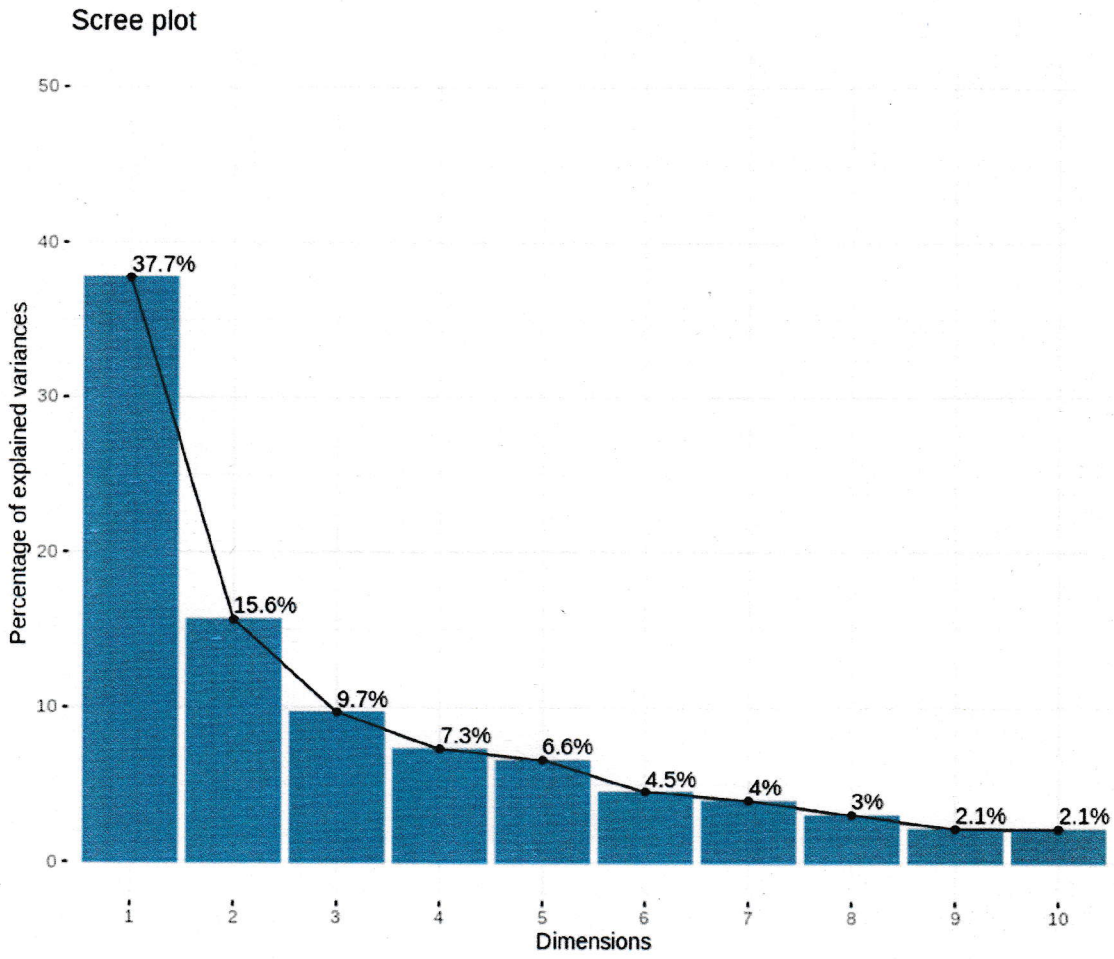


Figure 4 Scree plots of % of variance of PCA

The degree of association between each variable showed the respective factor for each component. PC1 elucidate 37.7% of total variance. PC1 has strong positive loading on EC, Na, Cl, SAR, TDS, K, SO4, Na%, TH and TA, and moderate positive loading on PA and CO3, and a strong negative loading on Q (Table 2 and 3).

PC2 represented for 15.6% of variance and dominated positively by SiO2, B, NO3 and NO2+NO3. PC3 accounted for 9.7% of total variance with high absolute positive loading on DO, NO2+NO3, NO3, Fe and DO SAT. PC4 explained for 7.3% of variance and high positive loading on PA and CO3. PC5 did not contain distinctive variance due to not having the loading value greater than 0.50. So, they are not taken into consideration in water quality.

Table 2 Principal Component Analysis of water quality parameters

Variables	PC1	PC2	PC3	PC4	PC5
Q	-0.801	-0.054	-0.046	-0.063	0.173
EC	0.968	0.001	-0.109	-0.136	0.022
pH	0.589	-0.360	0.395	0.248	-0.152
TDS	0.931	-0.012	-0.031	-0.143	0.072
Temp	-0.172	-0.379	-0.667	0.096	-0.026
PA	0.664	-0.041	0.289	0.579	0.148
TA	0.743	0.484	-0.260	0.081	-0.169
B	0.172	0.697	0.206	0.060	0.068
Ca	0.436	0.512	-0.212	0.372	-0.562
Cl	0.955	-0.108	-0.079	-0.127	0.030
CO3	0.664	-0.042	0.289	0.579	0.147
F	0.514	0.466	0.332	-0.031	-0.046
Fe	0.239	-0.220	0.528	0.134	-0.023
HCO3	0.302	0.568	-0.514	-0.364	-0.302
K	0.930	-0.146	-0.136	-0.032	0.062
Mg	0.564	0.195	0.079	-0.568	0.414
Na	0.967	-0.113	-0.044	-0.091	0.062
NH3	0.241	0.332	0.191	-0.375	-0.023
NO2.NO3	-0.112	0.690	0.537	-0.121	0.177
NO2	0.049	-0.078	0.140	-0.221	-0.458
NO3	-0.113	0.690	0.532	-0.114	0.189
PO4	-0.443	0.541	-0.367	-0.157	0.221
SiO2	-0.037	0.786	-0.057	0.248	0.050
SO4	0.877	-0.126	0.110	-0.152	0.255
BOD	0.329	-0.384	0.040	-0.533	-0.447
COD	0.455	-0.410	0.119	-0.121	-0.191
DO	-0.409	-0.066	0.596	-0.210	-0.459
DO_SAT	-0.456	-0.109	0.514	-0.197	-0.458
CaH	0.435	0.513	-0.215	0.369	-0.562
TH	0.767	0.508	-0.078	-0.232	-0.026
Na%	0.862	-0.395	0.044	0.005	0.035
RSC	0.000	0.000	0.000	0.000	0.000
SAR	0.940	-0.248	0.006	-0.050	0.061
Eigen Values	12.066	4.999	3.090	2.332	2.098
% of variance	37.7	15.6	9.7	7.3	6.6
Cumulative %	37.7	53.3	63	70.3	76.9

High negative variations in river discharge can be attributed to the high seasonality in various water quality parameters. An Eigenvalue gives a measure of the significance of the factor: the factors having the highest Eigenvalues are the most significant. Eigenvalues of 1.0 or greater are considered significant (Kim and Mueller, 1987).

Table 3 PCs and loading factors

PCs	Loading Factors
PC1	EC, Na, Cl, SAR, TDS, K, SO4, Na%, TH, TA, PA, CO3, Q
PC2	SiO2, B, NO3, NO2+NO3
PC3	DO, NO2+NO3, NO3, Fe, DO SAT,
PC4	PA, CO3
PC5	Nil

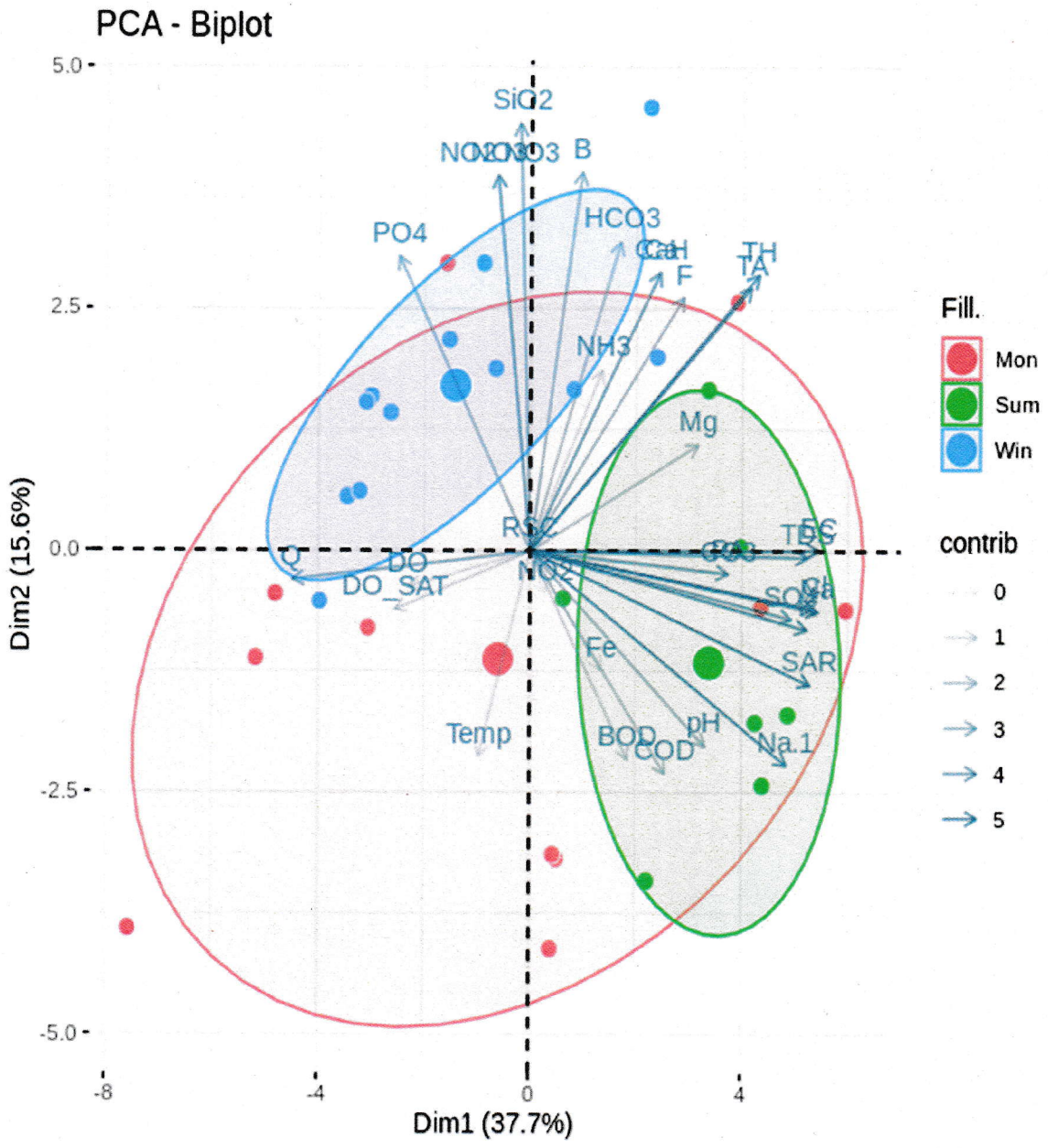


Figure 5 Biplot of first two PCs.

4.0 CONCLUSION

The quality of the surface water gradually deteriorates due to contamination by domestic effluents from the towns located along the river. The TDS level of the river water is in the range of 500 mg/L to 3024 mg/L and at times even higher. The Electrical Conductivity is high, in the range of 892 µS/cm and 5311 µS/cm which has been reported in earlier studies.

Pressure from the civil society and judicial interventions over the last two decades led the Tamil Nadu Pollution Control Board to insist on effluent treatment facilities in Tirupur. Many units were ordered closed on the river until zero liquid discharge status was achieved. As a result several dyeing units have constructed Effluent Treatment Plants (ETP) and many others are now connected to the Common ETPs (CETPs) in Tirupur. These CETPs can handle the industrial waste water with capacities ranging from 1.5 to 10 MLD and discharge the treated waste water into river Noyyal. The quality of water in the river has been improving over the years due to all the above interventions.

The river water is neither suitable for drinking purpose nor is fulfilling the needs of agriculture. Sodium & Potassium, Chloride and Sulfates contribute major portion of E.C. Apart from the above four major parameters, the Noyyal river water exceeds the BIS permissible limits with respect to Total Hardness, pH etc making the water unsuitable for drinking purposes.

In this time series study, multivariate statistical techniques were used to evaluate the seasonal and intra-annual variations in water quality of Noyyal River at Elunuthimanagalam for effective river water quality management. Further it is required the suitable modelling studies with proper datasets in time and space.

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SCIENTIFIC REPORT ON SEASONAL VARIATIONS IN THE WATER QUALITY OF RIVER BHAVANI AT SITE SAVANDAPUR AND THENGUMARAHADA

Alla Srikanth Reddy, L. Priyadharsini

ABSTRACT;

To effectively utilize the resources maintaining the quality of water is very important. The present study focus on the water quality of Bhavani River, Tamilnadu at Savandapur and Moyyar River which is a tributary of Bhavani River at Thengumarahada sites from upstream to downstream. Living organisms including human beings are under great pressure with the change in chemical and biological characteristics due to various reasons like spike in population, rapid industrialization, excessive use of fertilizers and manmade disasters which include nuclear disasters etc. To prevent great number of human population and for safe use of water from various illness and other diseases it is imperial to check the quality at regular interval of time. The collected samples were analyzed for different parameters such as pH, Electrical Conductivity, Total Dissolved Solids, Biological Oxygen Demand, Chemical Oxygen Demand, Calcium, Chlorides, Total Coliform, and Fecal Coliform etc. All the parameters are within the range as per Indian Standards with few exeptions in the Bacteriological parameters. Taken as a whole our study related to water of river Bhavani at Savandapur and Moyyar at Thengumarahada found to be fit for drinking with proper treatment and also can be used for irrigation purposes without any treatment.

Introduction

The Bhavani is a 217-kilometre (135 mi) long perennial river fed mostly by the southwest monsoon and supplemented by the northeast monsoon. Its watershed drains an area of 0.62 million hectares (2,400 sq mi) spread over Tamil Nadu (87%), Kerala (9%) and Karnataka (4%). The main river courses majorly through Coimbatore district and Erode district in Tamil Nadu. About 90 per cent of the river's water is used for agriculture irrigation. The river joins the Cauvery at the Kooduthurai holy site near Bhavani [1].

Water is the precious gift of nature for human beings, is being polluted day by day with increasing urbanization. Although three-fourth of the earth is being surrounded by water, a little portion of it can be used for drinking purpose. Water pollution is a phenomenon that is characterized by the deterioration of its quality as result of various human activities. Virtually almost all the surface water in India is unfit for direct consumption. In spite of the fact that the municipal water supply in most of the cities is through treated surface water, due to over contamination, more stringent treatments would be required to make the

surface water potable. All living organisms on the earth need water for their survival and growth. Good quality of water is essential for living organisms. Water is most indispensable requirement for all living organisms and any alterations

According to the latest estimates, more than half of Indian rivers and other surface water bodies are now significantly polluted. River pollution is a growing problem and cause of concern in India. In developing countries, as much as 70 percent of industrial waste and 80 percent of domestic waste is said to flow untreated into rivers. In a number of industrialized countries, as well as some countries in transition, it has become common practice to base limits for discharges of hazardous substances on the best available technology. In order to reduce inputs of phosphorus, nitrogen and pesticides from non-point sources (particularly agricultural sources) to water bodies, environmental and agricultural authorities in an increasing number of countries are stipulating the need to use best environmental practices [2].

Industrial, municipal and agricultural pollution of the river results in poor water quality and negative impacts on the health of people, plants and animals dependent on the river water. For surface water determination of water quality index becomes essential and pre-requisite. Analysis of some physico-chemical characteristics like water Temperature, Electrical Conductivity, transparency, Total Dissolved Solids, pH, BOD (biological Oxygen Demand), SAR (Sodium Adsorption Ratio), Total Hardness etc. has been done during the investigation period of June 2018 to May 2019.

Bacteriological water analysis is a method of analyzing water to estimate the numbers of bacteria present and, if needed, to find out what sort of bacteria they are. It represents one aspect of water quality. It is a microbiological analytical procedure which uses samples of water and from these samples determines the concentration of bacteria. It is then possible to draw inferences about the suitability of the water for use from these concentrations. This process is used, for example, to routinely confirm that water is safe for human consumption or that bathing and recreational waters are safe to use.

The interpretation and the action trigger levels for different waters vary depending on the use made of the water. Whilst very stringent levels apply to drinking water, more relaxed levels apply to marine bathing waters, where much lower volumes of water are expected to be ingested by users.

The present investigation has been more focused on the stud related to the seasonal variations of water quality of River Bhavani at Savandapur And its tributary Moyyar River at Thengumarahada.

All the parameters were analyzed based on the methods recommended by 23rd Edition of APHA (American Public Health Association) .

Table.1. Methods employed for analysis of physico-chemical parameters [3]

S.No	Parameter	Units	Methodology
1	Temperature	°C	Mercury Thermometer
2	pH	-	Potentiometric Method
3	Electrical Conductivity	µmhos/cm	Conductivity cell Potentiometric method
4	Total alkalinity	mg/l	Titrimetric to pH 4.5
5	Biological Oxygen Demand (BOD)	mg/l	Modified Wrinkler's titrimetric method
6	Chemical Oxygen Demand (COD)	mg/l	Liebig Reflux condenser method/Closed Reflux Method
7	Fluoride	mg/l	SPADANS Method/ ISE method
8	Calcium	mg/l	EDTA Titrimetric Method
9	Chlorides	mg/l	Argentometric titration Method
10	Nitrates	mg/l	Ion Selective Electrode Method
11	Iron	mg/l	Phenanthroline spectrophotometric Method
12	Total Coliform	Count/100ml	Most Probable number Method
13	Fecal Coliform	Count/100ml	Most Probable number Method

Table.2.water quality parameters and Indian Standards for various chemical and biological constituents [4]

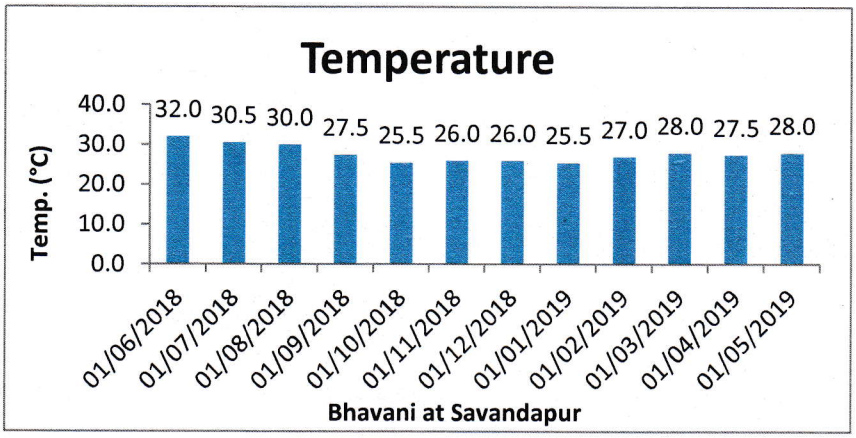
S.No.	Parameters	Drinking water IS 10500 : 2012	
		Permissible Limit	Maximum Limit
1	Odor	Agreeable	Agreeable
2	Taste	Agreeable	Agreeable
3	pH	6.5 to 8.5	No relaxation
4	TDS (mg/l)	500	2000
5	Hardness (as CaCO3) (mg/l)	200	600
6	Alkalinity (as CaCO3) (mg/l)	200	600
7	Nitrate (mg/l)	45	No relaxation
8	Sulfate (mg/l)	200	400
9	Fluoride (mg/l)	1	1.5
10	Chloride (mg/l)	250	1000

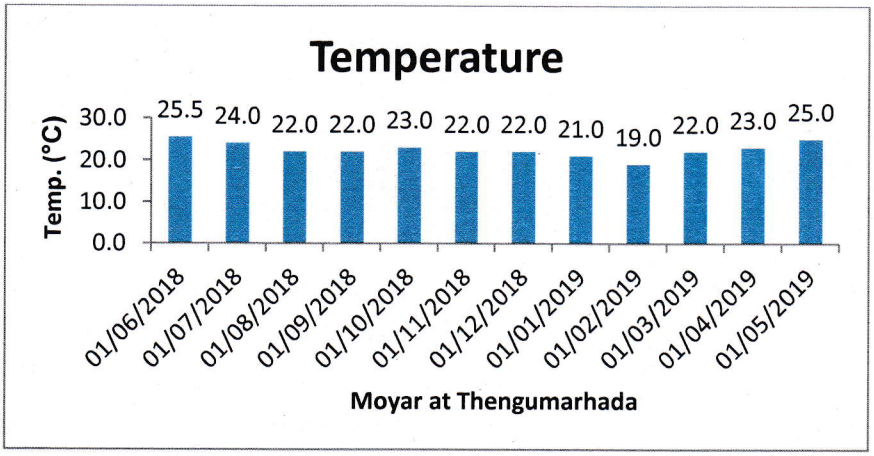
11	Turbidity (NTU)	5	10
12	Arsenic (mg/l)	0.01	0.05
13	Copper (mg/l)	0.05	1.5
14	Cadmium (mg/l)	0.003	No relaxation
15	Chromium (mg/l)	0.05	No relaxation
16	Lead (mg/l)	0.01	No relaxation
17	Iron (mg/l)	0.3	No relaxation
18	Zinc (mg/l)	5	15
19	Fecal Coliform (cfu)	0	0
20	E. Coli (cfu)	0	0

Results and Discussion

The following physico-chemical parameters namely Temperature, Electrical Conductivity, pH, Biological Oxygen Demand(B.O.D), Chemical Oxygen Demand(C.O.D), Calcium, Chloride, Total Alkalinity, Nitrate as Nitrogen, Fluoride were carried out as per standard methods given in Table 1. The water samples were collected at sites Savandapur located at a latitude of 11°31'17" N and a longitude of 77°30'36" E. and Thengumarhada located at a latitude of 11°34'22" N and a longitude of 76°55'09" E during June 2018 to May 2019 during Monsoon (June – October), winter (November – February) and summer (March – May) between June 2018 to May 2019 [5].

Temperature

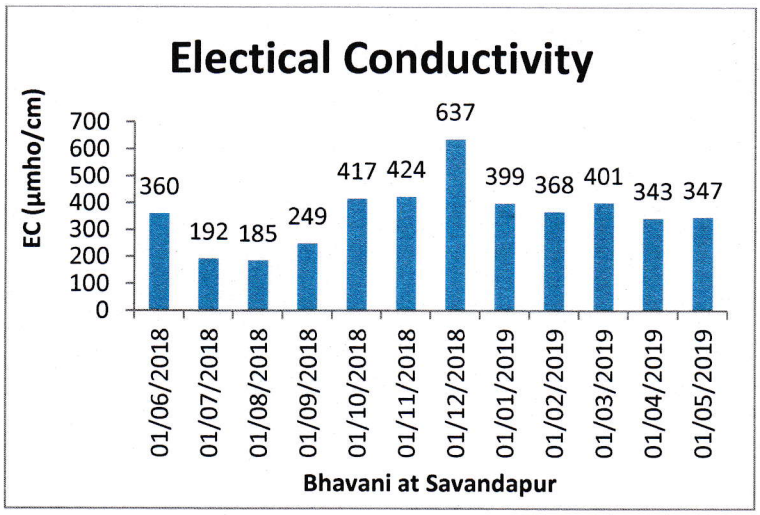


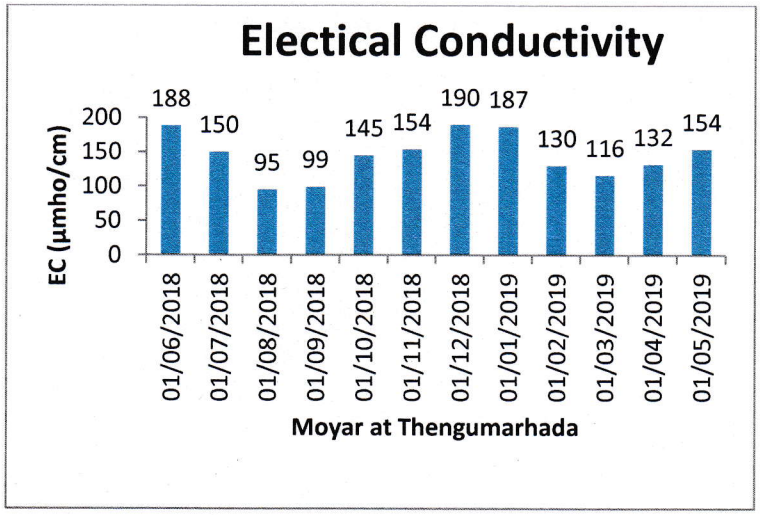


Temperature is a critical water quality and environmental parameter because it controls the kinds and types of aquatic life, regulates maximum DO concentration of water and influences the rate of chemical and biological reactions. Seasonal variations in stream temperature may be caused by number of factors and a change in temperature affects aquatic life.

The Temperature values in the Savandapur ranging from 25.5^0C to 32.0^0C and in the Thengumarhada values ranging from 19.0^0C to 25.5^0C. The average Temperature values higher in the Savandapur when compared to Thengumarhada.

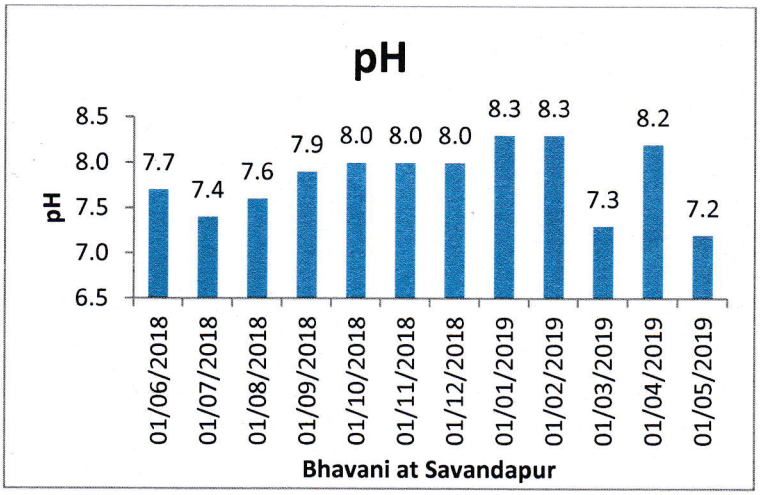
Electrical conductivity

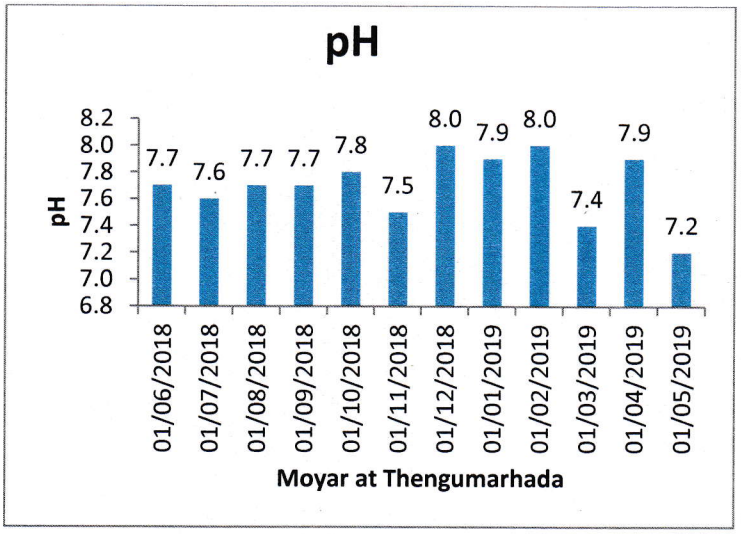




Electrical conductivity usually used for indicating the total concentration of ionized constituents of water. The electrical conductivity has been increased from 190 (maximum) at thengumarahada to 637 (maximum value) at Savandapur.

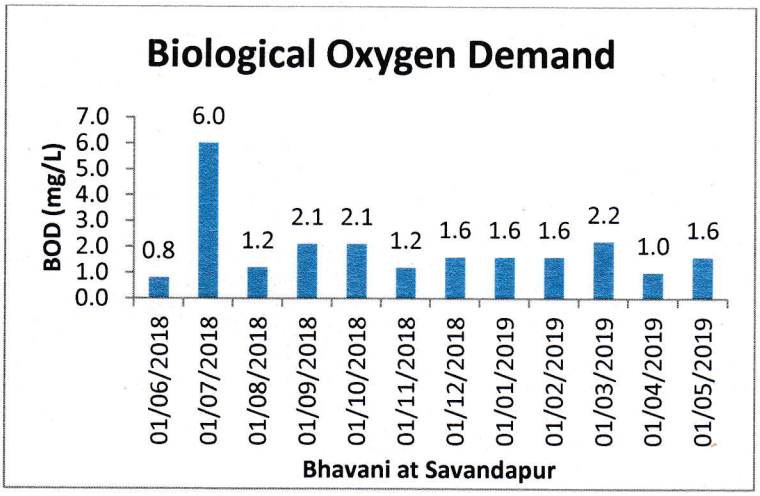
pH

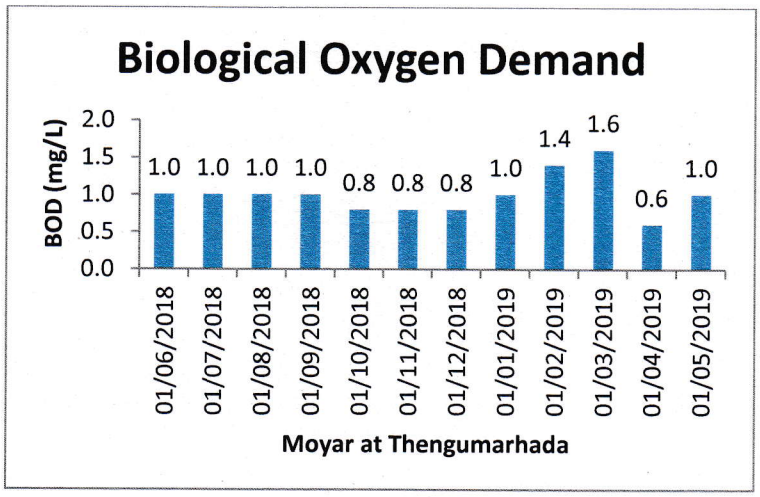




The pH values of the samples ranged from 7.2 to 8.3,at Savandapur and Thengumarahada sites where most of the water samples tested in the study were found to be in the permissible range of pH value recommended by several health and pollution control organizations e.g. WHO, CPCB, BIS i.e. 6.5-8.5.

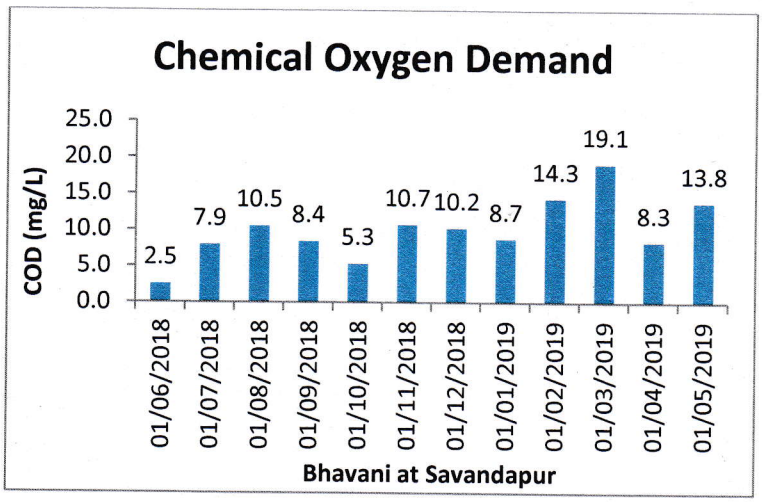
Biological Oxygen Demand

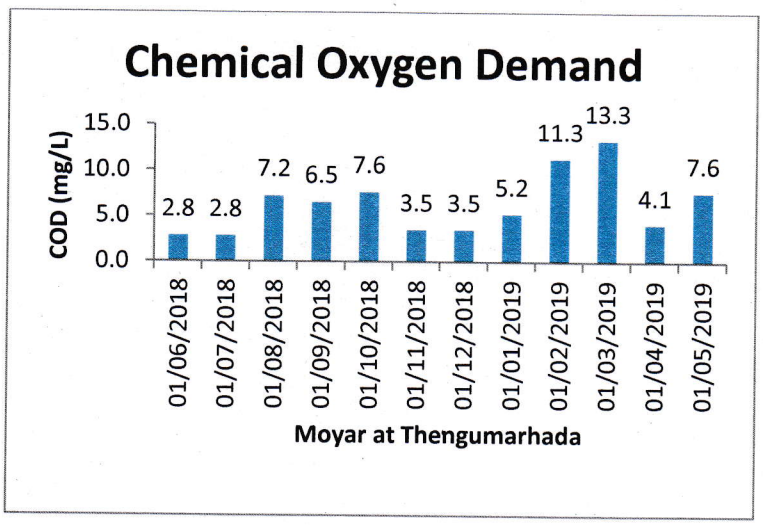




Biological oxygen demand is a measure of the oxygen in the water that is required by the aerobic organisms. The biodegradation of organic materials exerts oxygen tension in the water and increases the biochemical oxygen demand. BOD5 is the amount of oxygen required by the living organisms engaged in the utilization and ultimate destruction or stabilization of organic water. The maximum BOD of 6.0 was observed at Savandapur site whereas at Thengumarahada site the maximum value observed is 1.6 which indicates river was more polluted at Savandapur site when compared to Thengumarahada site.

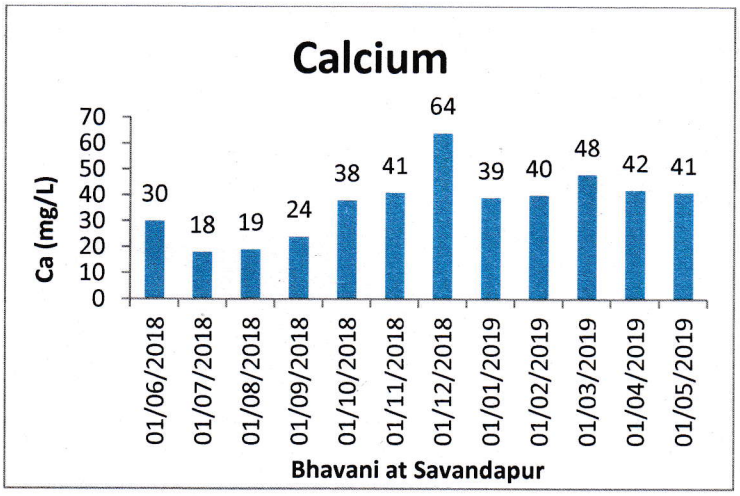
Chemical Oxygen Demand

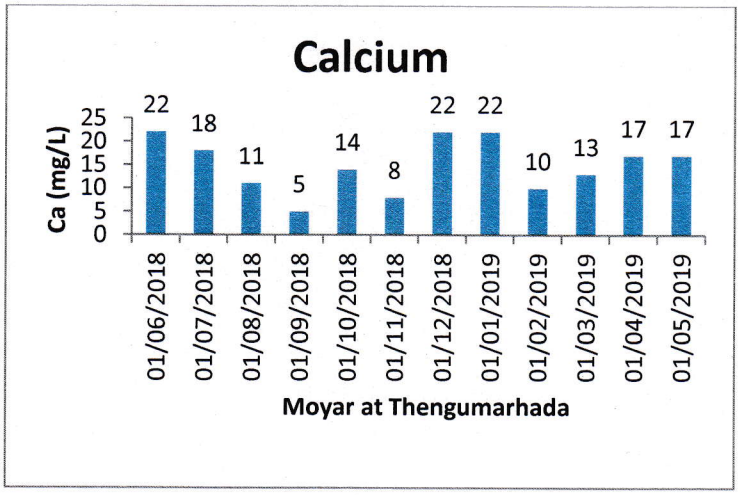




Chemical Oxygen Demand (COD): is a measure of the oxidation of reduced chemicals in water. It is commonly used to indirectly measure the amount of organic compounds in water. The measure of COD determines the quantities of organic matter found in water. This makes COD useful as an indicator of organic pollution in surface water. Similar to BOD the maximum chemical oxygen demand (COD) was observed at Savandapur site of Bhavani river.

Calcium

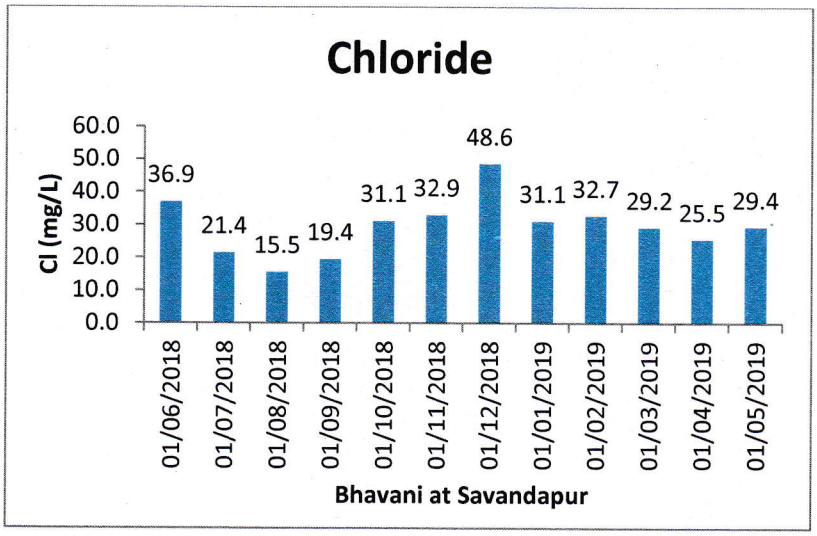


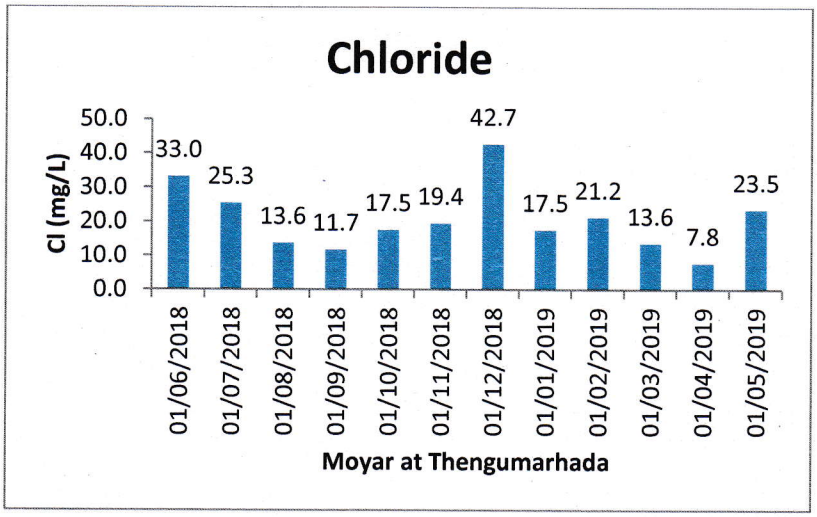


The calcium and Magnesium together constitutes the harness of water. It is a very important mineral for the bone development and various biological phenomena taking place in the human body.the maximum value of 64 mg/L was observed in the month of December 2018 at Savandapur site.

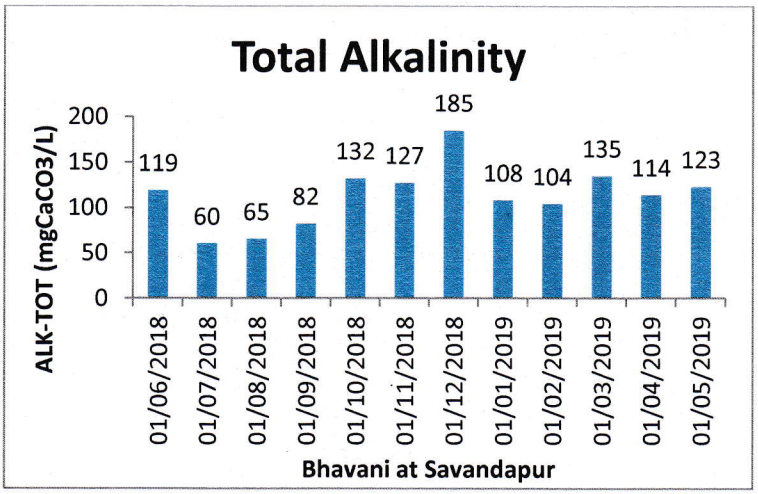
Chloride

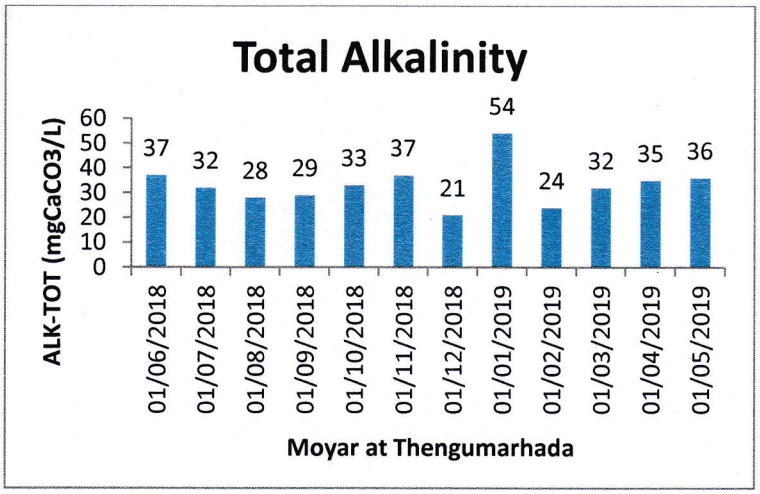
It occurs naturally in all types of waters. High concentration of chlorides is considered to be the indicators of pollution due to organic wastes of animal or industrial origin. Chlorides are troublesome in irrigation water and also harmful to aquatic life . The chloride content showed very narrow changes in sampling points between four sites. Higher concentration of chloride is hazardous to human consumption and creates health problems. Desirable limit of chloride by IS (2012) for drinking purpose is 250 mg/l. the range of chloride content from upstream to down stream is 7.8 to 48.6 mg/L





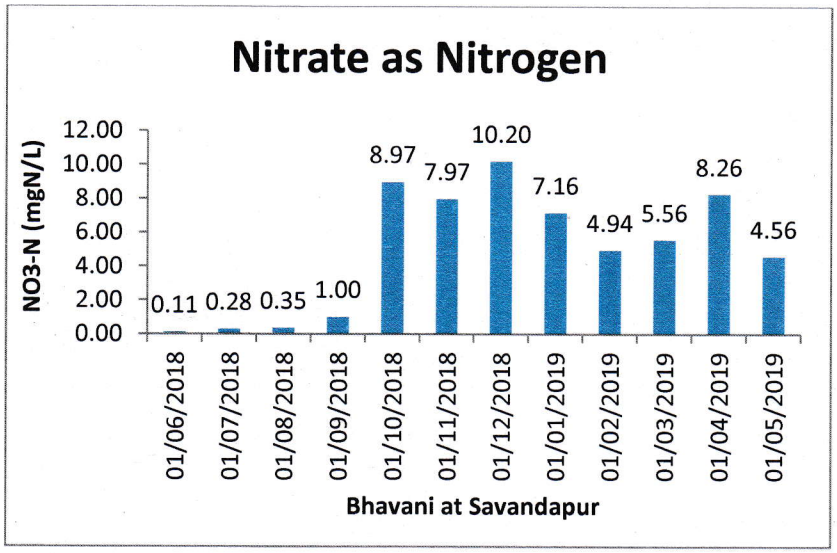
Total Alkalinity

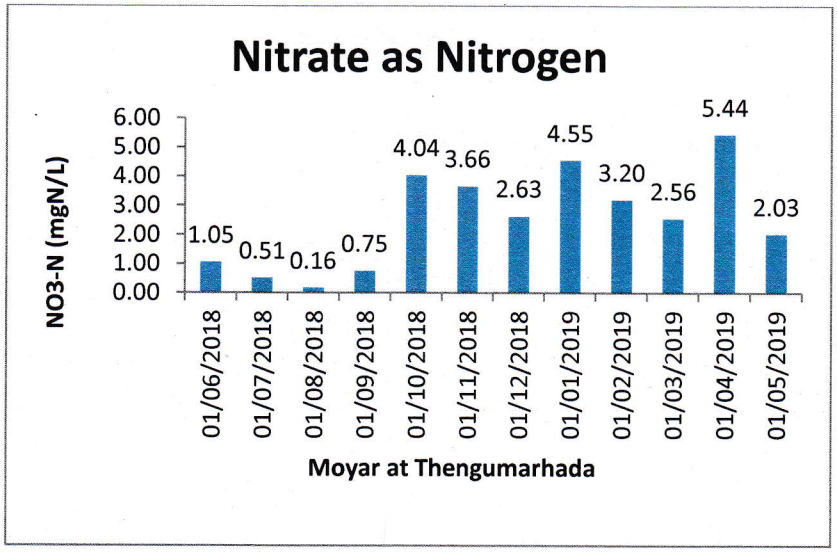




The acceptable limit of total alkalinity as per IS 10500:2012 is 200mg/L as CaCO3. In this study the range was observed to be within the range with maximum being observed at Savandapur site.

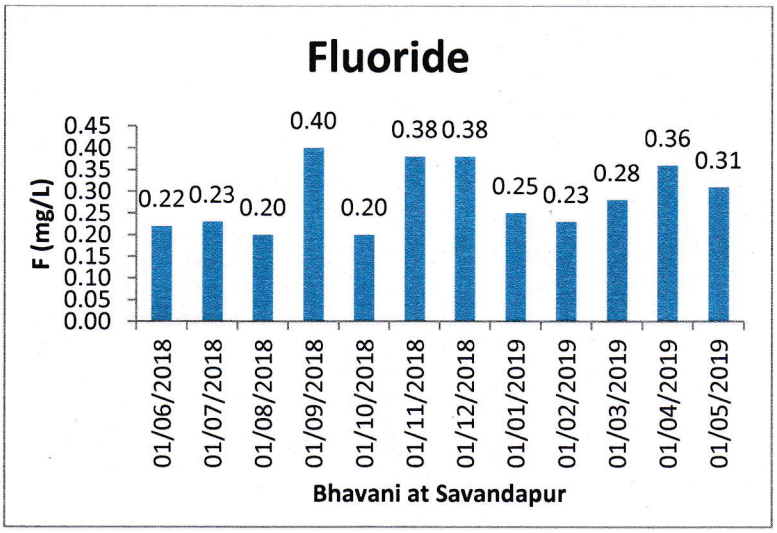
Nitrate

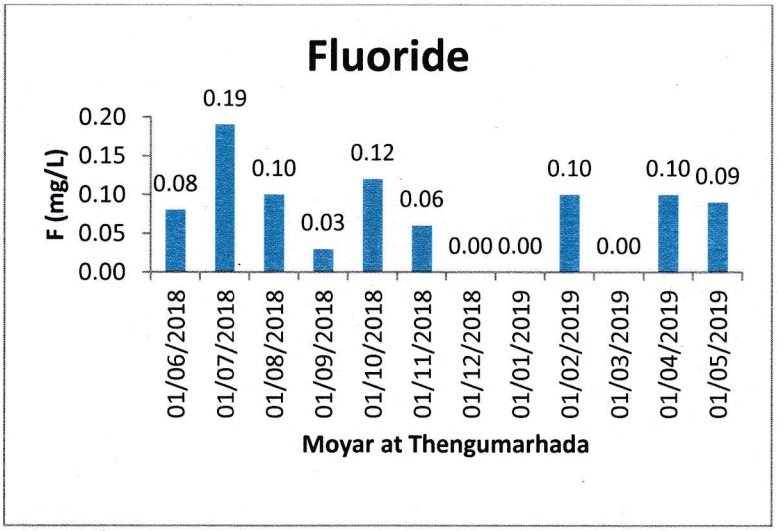




The concentration of nitrates in the water from site Thengumarahada to Savandapur 0.16 to 10.20 indicated a steady increase from upstream to down stream. The nitrate concentration if exceeds 45 ppm, it would drastically affect health of infants which may lead to 'blue baby disease.

Fluoride



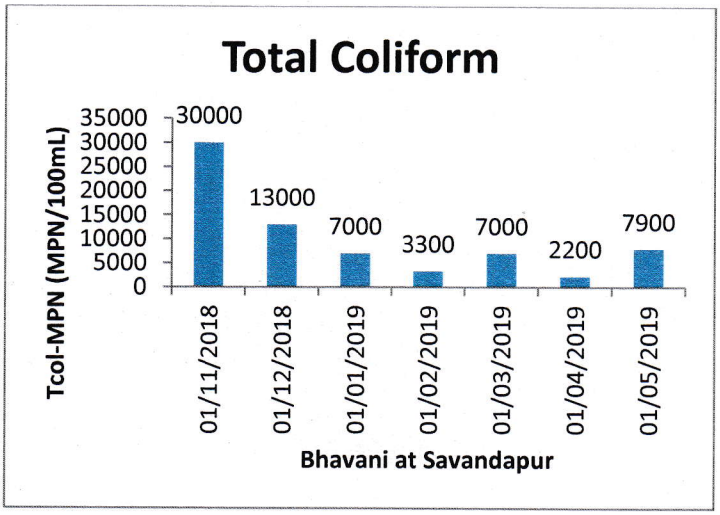


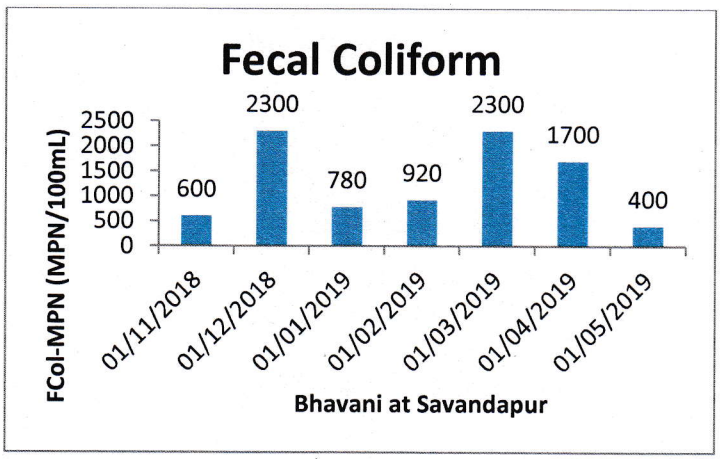
Fluoride is an important constituent for the body at low concentration but at high concentration it may cause bone deformities at high concentration. The is permissible limit is 1 mg/L. from the above result it is found that fluoride content is within the acceptable limit.

Bacteriological study

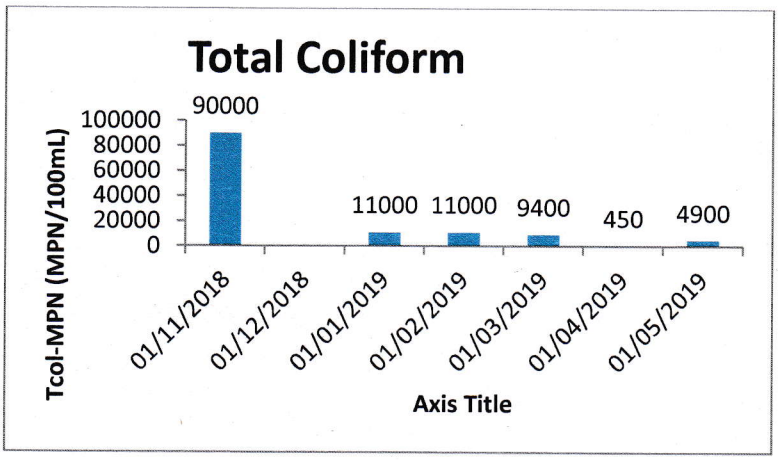
In the present study the bacteriological count was assessed based on the Total Coliform and Fecal coliform most probable number method. The samples for bacteriological analysis from site Thengumarahada in the month of December, 2018 has not received in the lab. The count of Total Coliform and Fecal Coliform in the drinking water as per Indian Standards is to be zero. But the present analysis of the river at Savandapur and Thengumarahada sites proved that the water is not fit for drinking purposes without proper disinfection treatment.

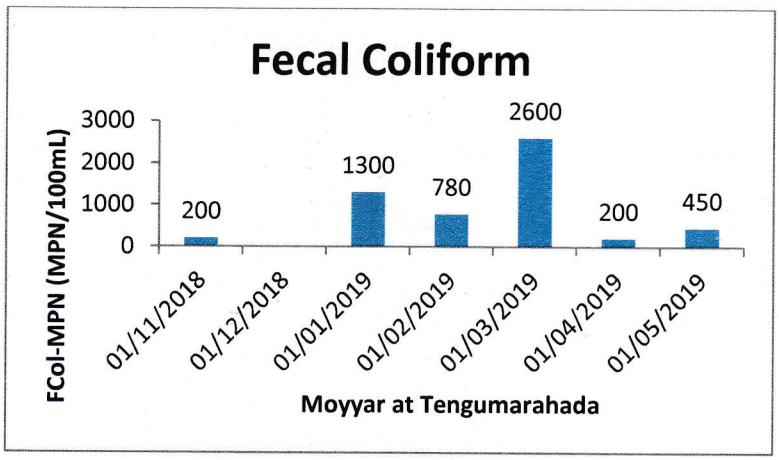
Total Coliform and fecal coliform at savandapur site.





Total Coliform and Fecal Coliform at Thengumarhada site





CONCLUSION

The analysis of the water samples at Thengumarahada and Savandapur sites of Moyyar River and Bhavani River respectively at upstream and downstream revealed that the river was more polluted at Savandapur site. This may be due to human activities, discharge of industrial effluents etc around the Savandapur site. The water at Savandapur site and Thengumarhada site is not found to be fit for drinking pusposes due to the presence of Coiforms. But the water may use for irrigatoional purpose.

References

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[2] S. Sivakumar1, M. Prasanthrajan1* S. Shalini2 and J. Jaya Sri Balaji1, Environmental quality assessment of Bhavani river water for drinking and irrigation purpose.

[3] APHA, Standard methods for the examination of water and wastewaters, 23rd Ed. Washington DC, USA: American Public Health Association 2017.

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[5] Water Quality Year Book of Central Water Commission, Department water resources and Ganga Rejuvenation, Ministry of Jal Shakti.

Assessment of Intra-Annual Variation in Water Quality Parameters in River Tambraparani at Murappanadu site for the period June 2018 to May 2019

By Smt. Srujana Radha, SRA, CWC, Coimbatore.

Abstract:

The present study was conducted to assess the physico-chemical characteristics of Tambraparani river basin at staion Murappanadu. An assessment of various physico-chemical characteristics of water such as pH, temperature, Dissolved Oxygen, Biological Oxygen Demand(BOD), Chemical Oxygen Demand(COD), Total Alkalinity, Chloride, Fluoride and Nitrate was carried for a period of 12 months from June 2018 to May 2019.

In this study, Murappanadu is a trend station, where samples are collected once in a month based on availability of discharge. The time of sampling was around 08.00AM to 08.30 AM. The samples are collected in clean 1 litre polyethylene bottles for physio-chemical analysis and two 300ml BOD bottles for bacteriological studies like DO and BOD. Also, 125 ml sterilized BOD bottle for bacteriological studies(Total coliform & Fecal coliform). The Analysis results of such respective parameters in all the seasons were compared with the water quality standards as set by BIS and other regulatory authorities guidelines.

Introduction:

Rivers are very important natural resource for every living organism. River water quality is a key concern as it is used for drinking and domestic purpose, irrigation and aquatic life including fish and fisheries. Water is also crucial for the quality of life. The ecological balance maintained by the quantity and quality of water determines the way of life of people. On the other hand, polluted water is the greatest source of disease and besides debasing the land also becomes unfit to sustain life. Today the problem is not only of water availability but of environmental quality and ecological balance. With increasing industrialization, urbanization and technological advance in all fields, sources of water are getting more and more seriously polluted. The survival of life on earth will be threatened if the present rate of pollution continues unabatedly. Natural waters are afflicted with a wide variety of inorganic, organic, and biological pollutants. In some cases, such as that of highly toxic cadmium, a pollutant is directly toxic at a relatively low level. In other cases, the pollutant itself is not toxic, but its presence results in conditions detrimental to water quality. For example, biodegradable organic matter in water is often not toxic, but the consumption of oxygen during its degradation prevents the water from supporting fish life (Trivedi, 1992).

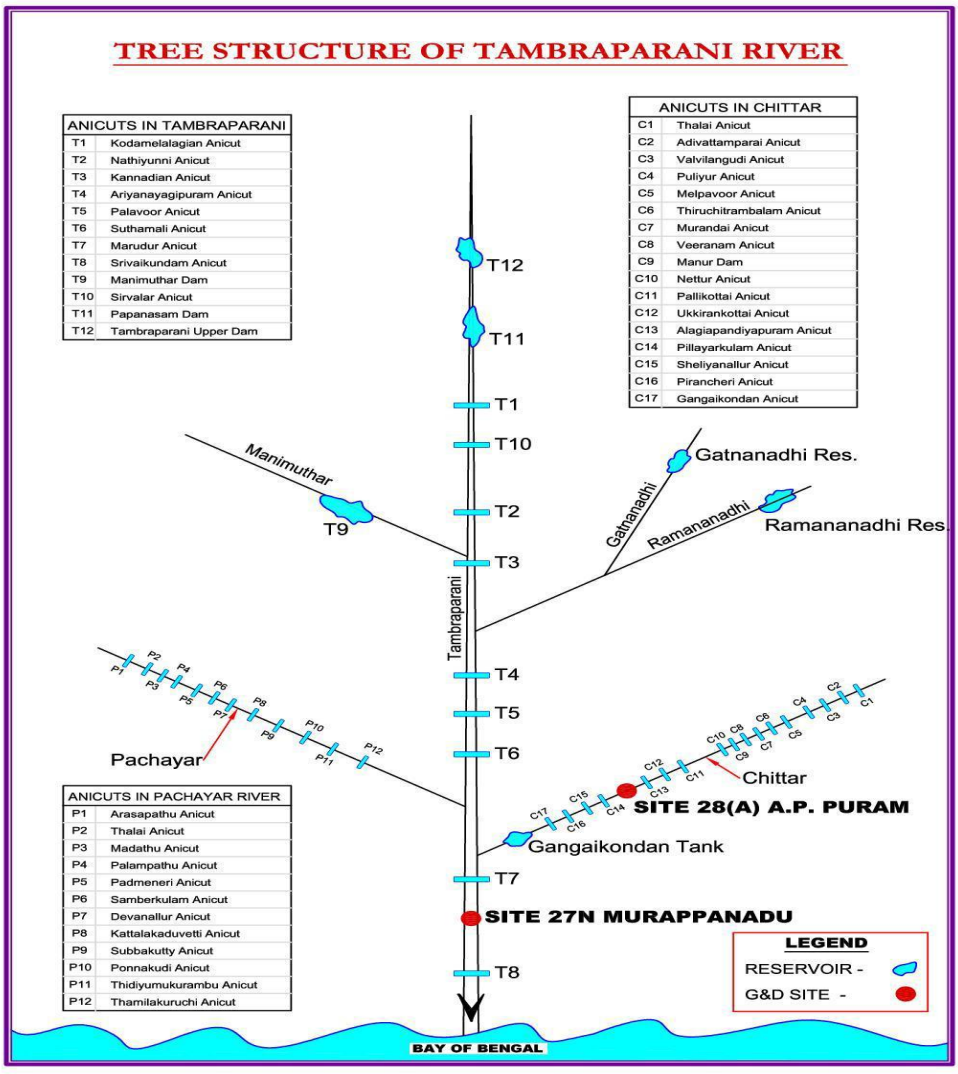
Tambraparani river is one o the Perennial river in Tamilnadu State, which rises on the Eastern slopes of the Western Ghats at an elevation of about 1,400 m at North latitude 8° 46' and East longitude 77° 15' near Alwarkurichi village in Thirunelveli district of Tamil Nadu to flow in a generally Easterly direction for a total length of 130 km and join the gulf of Mannar. The Chittar and Manimuthar are the important left and right bank tributaries of the Tambraparani. The Tambraparani drains an area of 5,482 Sq.Km. Three Hydrological Observation Stations are being operated by Central Water Commission two on Right- Tambraparani at Murappanadu, Kallidaikurichi and at A.P.Puram(On Right tributary-Chittar). Where Murappanadu is the only water quality station on main stream of Tambraparani. The river Tambraparani has major importance for irrigation in Thirunelveli district.

The climate of the region is divided into Winter, Summer, South-East monsoon and North-East monsoon. In winter season, which extends from January to march, the climate is generally pleasant in the entire basin. In the hot weather season, which extends from March to May, the eastern parts of the basin experiences more heat than the western parts. The south-west monsoon generally sets in by the first week of June and ends by the end of September. During this period, the western part of the basin receives the

major part of its rainfall. The north-east monsoon period is from October to December. The eastern part of the basin covering the coastal districts receives very heavy rainfall during these months. The ambient mean temperature during sampling was lowest in January and february (25 °C) and highest in May (29 °C).

Geology of Tambraparani basin comprises of crystalline rocks of Archaean age on the western portion and sedimentary formation of Tertiary and Quaternary ages on the eastern coastal area. Nearly 90% of the basin area is covered by the crystalline rocks such as metamorphosed rocks (gneisses and charnockites). Sedimentary formations of Tertiary age consists of calcareous tufa sandstones and shell limestones. Quaternary formations are laterite, kankar, shell limestone, alluvium, theri sands and silts. The windblown red sanddunes of Sawyerpuram theri and Kudiraimozhi theri occur in the northeastern and southeastern part of the basin respectively. (*Source: Central Water Commsion, Sediment year book 2018-19.)

Figure 1. Tree Structure of River Tambraparani showing Site of Water sample collection.



Material and Method:

Study area:

The study was performed for one year at Murappanadu site along the stretch of river Tambraparani from June 2018 to May 2019. Murappanadu site is at a lattitude of 08°42'52" and Longitude of 77°50'06". A structural sketch of river Tambraparani along with Murappanadu site location is shown in figure 1. Several anicuts and dams on the river shows the importance of Tambraparani river for Irrigation in Tirunelveli district.

Sample Collection:

Water samples were collected for the study from the site Murappanadu. A.P.Puram is the site on Right-tributary of Tambraparani (i.e. Chittar) river was dry for whole year. Murappanadu is a trend station, where samples are collected once in a month based on availability of discharge. The time of sampling was around 08.00AM to 08.30 AM. The samples are collected in clean 1 litre polyethylene bottles for physio-chemical analysis and two 300ml BOD bottles for bacteriological studies like DO and BOD. Also, 125 ml sterilized BOD bottle for bacteriological studies(Total coliform & Fecal coliform). Samples after collection, immediately preserved in a dark insulating box of temperature below 4 ˚C with ice or cold packs. Once in the laboratory, sample should be transferred as soon as possible into refrigerator for preservation.

RESULTS AND DISCUSSION:

2.1 **Temperature:** Water Temperature is a key water quality parameter, which regulates the biogeochemical activities in the aquatic environment and relatively easy to measure in water bodies which naturally show change in temperature seasonally. The temperature of River Tambraparani at Murappanadu ranges between 25.0 to 29 ^{0}C (Figure 3). The maximum temperature 29.0^{0}C was observed during Pre Monsoon sampling(May 2019), whereas, minimum 25.0^{0}C was recorded during Post monsoon period(January and February). There is no significant change in temperature is observed with change of seasons at murappanadu.

2.2 pH: pH of a water body is very important in determination of water quality since it affects other chemical reactions such as solubility and metal toxicity. The fluctuation in optimum pH ranges may lead to an increase or decrease the toxicity of poisons in water bodies (Ali, 1991) The pH value recorded ranges between 7.1 to 8.0 (Figure 4). The pH values in the Tambraparani are in the permissable range as prescribed by BIS – IS: 10500 – 2012.

2.3 Electrical Conductance: EC is a measure of water capability to transmit electric current and also it is a tool to assess the purity of water (Murugesan et al., 2006). Electrical conductivity recorded in River Tambraparani at Murappanadu ranges between 88 µS/cm to 349 µS/cm (Figure 5). The high value of conductivity was recorded during the monsoon season(Nov) at Murappanadu where as low value was recorded during monsoon season (Sept). A number of ions enter in to the river through point and nonpoint sources in the form of dissolved salt and inorganic material such as alkalis, chloride, sulfides and carbonate compound may be a significant cause of change in the EC of river system.

2.4 Total Dissolved Solid: Higher TDS in the water depicts more ionic concentration, which is of inferior palatability and causes an unfavorable physicochemical reaction in the consumers. Kataria et al., (1996) reported that increase in value of TDS indicate pollution by extraneous Sources. The amount of TDS recorded in the water of River Tambraparani ranges between 49 mg/l to 195 Mg/l (Figure-6). The minimum amount of TDS at Murappanadu of river Tambraparani was recorded during monsoon season,

whereas the maximum amount of TDS in water was recorded during Post-monsoon season. Lower values of TDS indicates that the water at Murappanadu have less scope of organic matter mixing into the river.

2.5 Total Alkalinity: Total Alkalinity of Water is its capacity to neutralize a strong acid and it is normally due to the presence of bicarbonate, carbonate and hydroxide compound of calcium, sodium, and potassium. The amount of Total Alkalinity recorded in the water of River Tambraparani ranges between 29 mg/l to 102 mgCaCO3/L (Figure-7). Thought the values of Total alkalinity in all 12 months data is in permeable limt, the lowest amount of Alkalinity at Murappanadu was recorded during south-west monsoon season, whereas the maximum amount of alkalinity in water was recorded during north-east monsoon season and post monsoon season.

2.6 Chloride: The chlorides concentration serves as an indicator of pollution by sewage and industrial effluent. People accustomed to higher chloride in water are subjected to laxative effects. The amount of chloride recorded at Murappanadu ranges between 9.7 mg/l to 36.9 mg/l (Figure-8). The amount of chloride in the water of river Tambraparani is under permissable level. Due to minimum human interaction with the river, perennial Tambraparani river water is considered as good quality.

2.7 Total Hardness: Hardness is the parameter of water quality used to describe the effect of dissolved minerals (mainly Ca and Mg), determining suitability of water for domestic, industrial, and drinking purpose attributed to presence of bicarbonates, Sulphate, chlorides and Nitrates of calcium and Magnesium. (Taylor, E.W). The amount of Hardness recorded in the water of River Tambraparani at Murappanadu ranges between 32 mg/l to 124 mg/l (Figure-9). Agriculture runoff, urban discharge, Industrial effluent and Clothe washing station through open drains in water bodies causes increase in the value of hardness in river water bodies. Tambraparani at Murappanadu is soft with average value of Total Hardness 68 mgL.

2.8 Nitrate: Nitrates are contributed to freshwater through discharge of sewage and industrial wastes and run off from agricultural fields (Verma et al., 2012) .The amount of nitrate recorded in the water at Murappanadu of river Tambraparani ranges between 0.05 mg/l to 6.98 mg/l (Figure-10). The minimum amount of nitrate at Murappanadu of river Tambraparani was recorded during south-west monsoon season, whereas the maximum amounts of nitrate in water was recorded during north-east and post monsoon season. Increasing trend of Nitrate in river water bodies may be due to runoff from agricultural fields.

2.9 Dissolved Oxygen: One of the important parameter in water quality assessment is Dissolve Oxygen. Its presence is essential to maintain variety of forms of life in the water and the effect of waste discharge(organic matter) in a water body are largely determined by the oxygen balance of system. It can be rapidly depleted from waste water by discharge of oxygen demanding waste. The amount of dissolve oxygen recorded in the water at Murappanadu of river Tambraparani ranges between 5.5 mg/l to 7.5 mg/l (Figure-11). The DO study of current year data shows that the river water at murappanadu is in acceptable limits according to standards mentioned by BIS and other agencies. Table.

2.10 Biological Oxygen Demand: BOD determination is still the best available test for assessing organic pollution. High value of BOD indicates higher the organic pollution (Verma et al., 2010). (A.P. Singh et al). The amount of BOD recorded in the water at Murappanadu of river Tambraparani ranges between 0.6 mg/l to 6.2 mg/l (Figure-12). The average value of BOD at Murappanadu is 2.4 mg/L.The fluctuation in BOD in the water at Murappanadu of river Thambraparan was recorded during monsoon season. The minimum amount of BOD in water was recorded during post monsoon season. Permissible limit of BOD for aquatic system is around 3 mg/l.

2.11 Chemical Oxygen Demand: COD test is quite useful in assessment of pollution strength of industrial waste and domestic sewage. COD as is the amount of O_2 required for a sample to oxidize at its organic and inorganic matter. The amount of COD recorded in the water at Murappanadu of river

Tambraparani ranges between 3.5 mg/l to 18.3 mg/l (Figure-13). The fluctuation in COD throughout the year was recorded

2.12 Total Coliform and Fecal Coliform: Total coliform and Fecal coliform were studied as microbiological pollution indicators from November 2018 to May 2019. The data from the analysis depicts that the fecal coliform are above the permissible limits.

Table 1: Preservation techniques of the water samples for chemical analysis

Sr. No.	Tests/Properties Measurements'	Recommended Sample volume(ml)	Type of Containe r	Preservation	Allowable holding time
1	Temperature	100	P,G	Determined at site	NA
2	p^H Value	100	P,G	Determined at site	NA
3	Conductivity	100	P,G	Determined at site	NA
4	TDS	100	P,G	Determined at site	NA
5	Alkalinity	100	P,G	Refrigerate -4^{0}C	24hr
6	Hardness	100	P,G	Determined at site	7days
7	Chloride	50	P,G	Refrigerate -4^{0}C	7days
8	BOD	1000	P,G	Refrigerate -4^{0}C	24hr
9	DO	100	P,G	Determined at site	NA
10	COD	50	P,G	H_2SO_4 to pH >2	7days
11	Sulphate	50	P,G	Refrigerate -4^{0}C	7 days
12	Nitrate	100	P,G	Refrigerate -4^{0}C, H_2SO_4 to pH<2	24 hr
13	Fecal Coliform	100	P,G	Refrigerate -4^{0}C	6hr
	E Coli	100	P,G	Refrigerate -4^{0}C	6hr

Table 2: Water and Waste water Test (APHA Methods are based On 23rd Edition: 2017)

Sr. No.	Tests/Properties Measurements'	Std. Method/Techniques	Reference
1.	pH	Electrometric Method	APHA 4500H^+ B
2.	Electric Conductivity	Electrometric Method	APHA 2510 B
3.	Total Dissolved Solids	Electrometric Method	APHA
4.	Total Alkalinity as $CaCO_3$	Titrimetric Method	APHA 2320 B
5.	Chloride	Argentometric Method	APHA 4500 Cl^- B
6.	Hardness	EDTA Titrimetric Method	APHA 2340 C
7.	Nitrate	ISE Method	APHA 4500 NO_3^- D
8.	DO	Azide Modification Method	APHA 4500, O-C
9.	BOD	5 Days BOD Test Method (Dillution Method)	APHA 5210 B
10.	COD	Closed Reflux, Colorimetric Method	APHA 5220 D
11.	Fluoride	ISE Method	APHA 4500 F^- C
12.	Fecal Coliform	Multiple-Tube Fermentation Method	APHA 9221 E
13.	Total Coiform	Multiple-Tube Fermentation Method	APHA 9221B

Table 3: Water Quality data of Tambraparani river at site Murappanadu during the period of June-2018 to May-2019.

S.No	Parameters	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May
1	Temp (deg C)	28.5	28.5	28.0	27.0	27.5	26.5	26.0	25.0	25.0	27.5	28.5	29.0
2	EC (µmho/cm)	173	123	103	88	185	349	315	308	176	175	183	144
3	pH	7.3	7.1	7.2	7.2	7.4	7.6	8.0	8.0	7.8	7.2	7.3	7.1
4	TDS (mg/L)	96	70	58	49	104	195	176	172	99	98	102	82
5	TOT Alkalinity (mgCaCO3/L)	58	36	36	29	62	102	95	92	44	52	51	47
6	Total Hardness (mgCaCO3/L)	60	40	36	32	72	124	112	111	56	62	64	52
7	Cl (mg/L)	15.5	15.5	9.7	9.7	21.4	34.9	36.9	31.1	23.1	19.4	19.6	15.7
8	F (mg/L)	0.12	0.71	0.25	0.05	0.30	0.37	0.12	0.36	0.12	0.09	0.19	0.11
9	Fe (mg/L)	0.000	0.010	0.010	0.000	0.000	0.010	0.005	0.010	0.000	0.000	0.095	0.010
10	NO2-N (mgN/L)	0.00	0.03	0.00	0.11	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	NO3-N (mgN/L)	0.22	0.11	0.05	0.26	2.54	6.98	6.04	5.15	2.88	2.91	4.27	1.33
12	SO4 (mg/L)	6.8	5.8	3.5	3.1	4.5	13.5	10.6	9.8	6.1	3.7	4.5	5.1
13	BOD3-27 (mg/L)	0.6	6.0	5.9	1.0	6.2	0.8	1.0	1.0	2.2	2.4	0.6	1.2
14	COD (mg/L)	3.5	7.9	7.7	4.6	18.3	6.7	6.7	7.5	10.1	15.1	5.5	9.7
15	DO (mg/L)	6.0	5.8	6.2	5.5	6.1	6.1	5.9	5.5	5.6	7.5	6.8	6.0
16	FCol-MPN (MPN/100mL)						800	450	1100	2100	450	200	1100
17	Tcol-MPN (MPN/100mL)						2200	2200	11000	9400	1700	200	3300

Table 4. Water Quality Standards By various Authorised Agencies

Characteristics	ICMR	WHO	CPCB	BIS – IS: 10500 – 2012
pH (pH units)	7.0–8.5	7.0–8.5	Class A – 6.5–8.5 Class B – 6.5–8.5 Class C – 6.5–9.0	Class A – 6.5–8.5 Class B – 6.5–8.5 Class C – 6.5–8.5 and Permissible – no relaxation
TDS (mg L^{-1})	500	500	–	Class A – 500 mg L^{-1} Class B – 500 mg L^{-1} Class C – 1500 mg L^{-1} and Permissible – 2000 mg L^{-1}
Total Alkalinity as $CaCO_3$, mg/L				200 maximum of 600 mg/L
Total Hardness as $CaCO_3$, mg/L	300			200 Max.
Chloride, mg/L	200	250		250 permissable limit 1000
NO_3-N (mg N L^{-1})	20	45	–	Class A – 20 mg L^{-1} Class B – 20 mg L^{-1} Class C – 50 mg L^{-1} and
BOD (mg L^{-1})	–	–	Class A – 2 mg L^{-1} Class B – 3 mg L^{-1} Class C – 3 mg L^{-1}	Class A – 2 mg L^{-1} Class B – 3 mg L^{-1} Class C – 3 mg L^{-1} and No relaxation (permissible)
DO (mg L^{-1})	–	–	Class A – 6 mg L^{-1} Class B – 5 mg L^{-1} Class C – 4 mg L^{-1}	Class A – 6 mg L^{-1} Class B – 5 mg L^{-1} Class C – 4 mg L^{-1} and No relaxation (permissible)

Conclusion: The present study took into account of a variation throughout the one year so as to make the necessary conclusions. The analysis result data for different parameters at site Murappanadu for time period June 2018 to May 2019 shows that the water quality is satisfactory when compared to IS 1050:2012. Except for Bacteriological quality indicators of coliforms (Total coliform & Fecal coliform).

This data shows Tambraparani river water at Murappanadu is considerable for consumption as drinking water after proper Disinfection as Fecal coliform values are not within permittable limits. Major Anthropogenic activities practiced in and around the stretch: Agricultural, obstraction of water for irrigation and drinking, washing cloth and utensils and discharging of sewage waste along the stretch were generating serious threat to biota by altering the physico-chemical and biological concentration of river system.

Figure 3: Variation of Temperature for the period of June 2018- May 2019

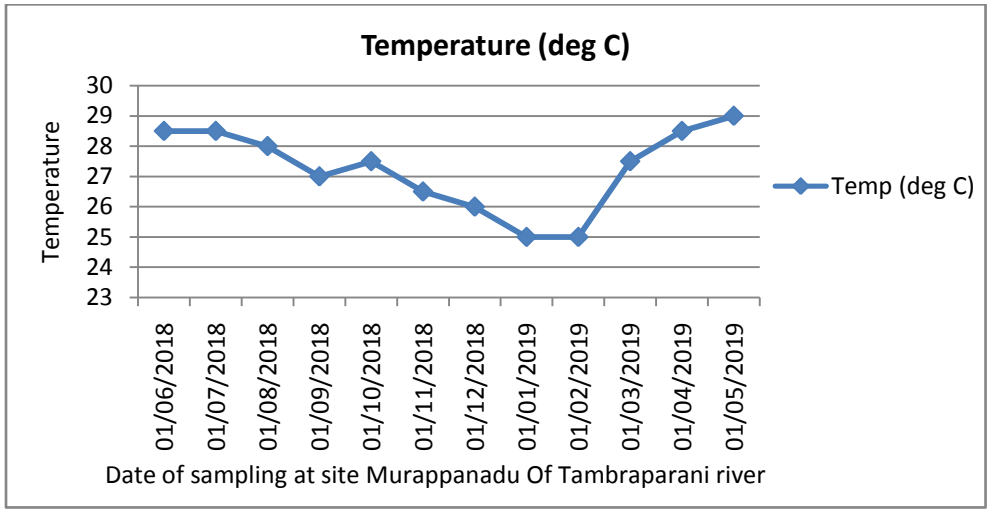


Figure 4: Variation of pH for the period of June 2018- May 2019

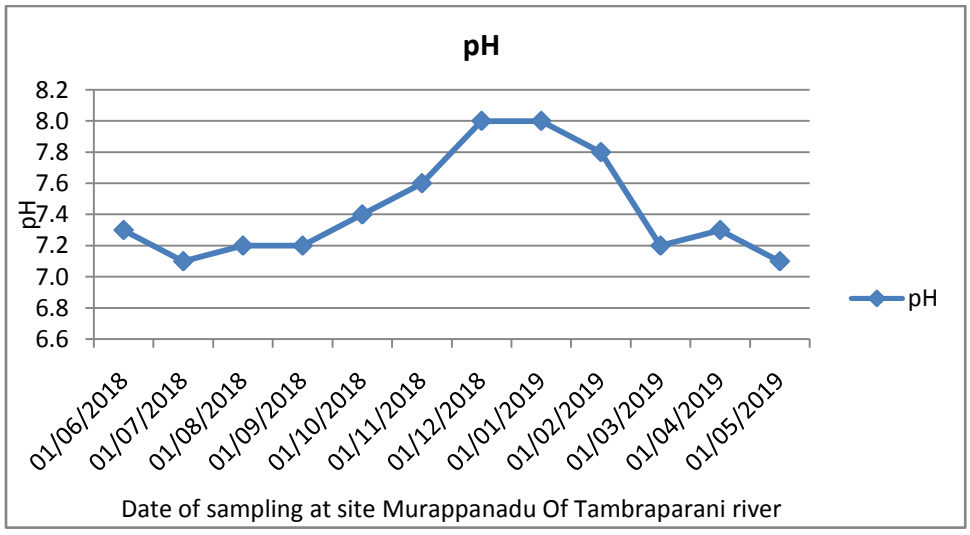


Figure 5: Variation of Electric Conductivity for the period of June 2018- May 2019

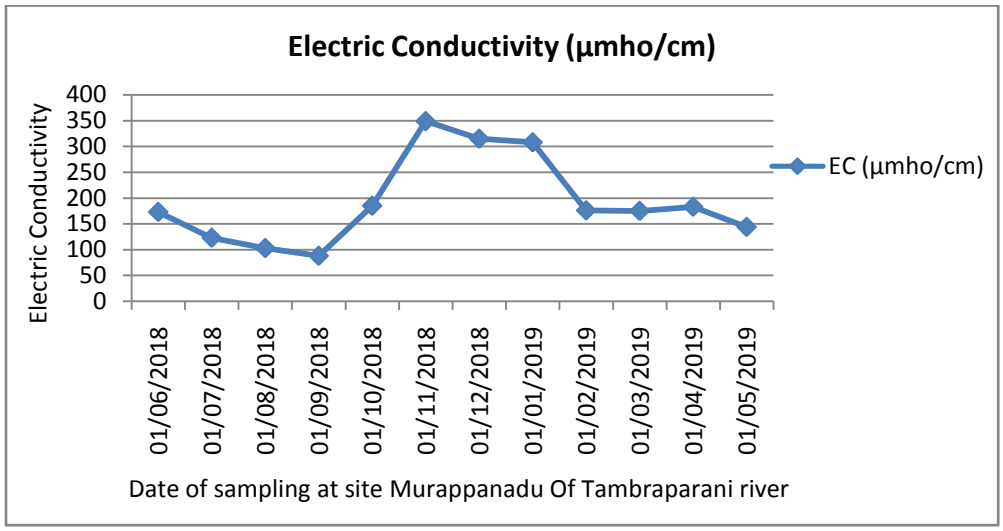


Figure 6: Variation of Total Dissolved Solids for the period of June 2018- May 2019

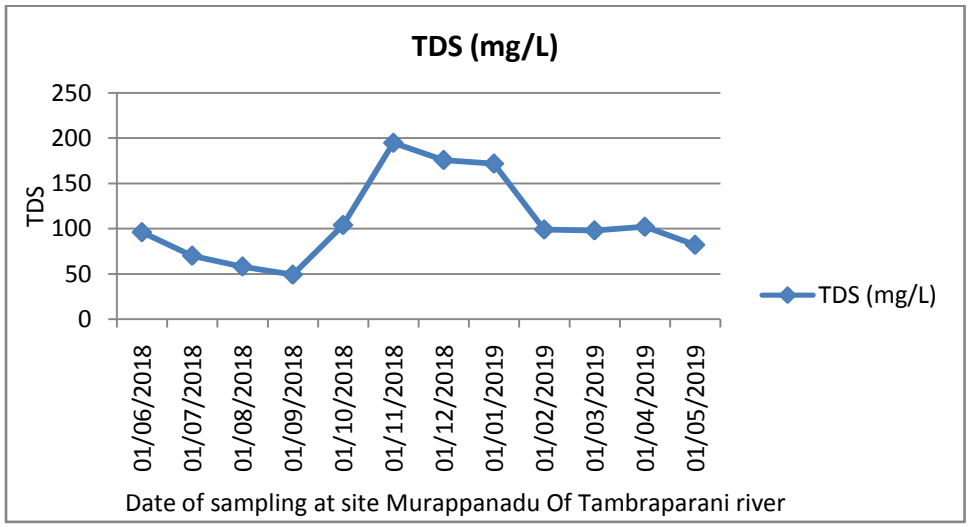


Figure 7: Variation of Total Alkalinity for the period of June 2018- May 2019

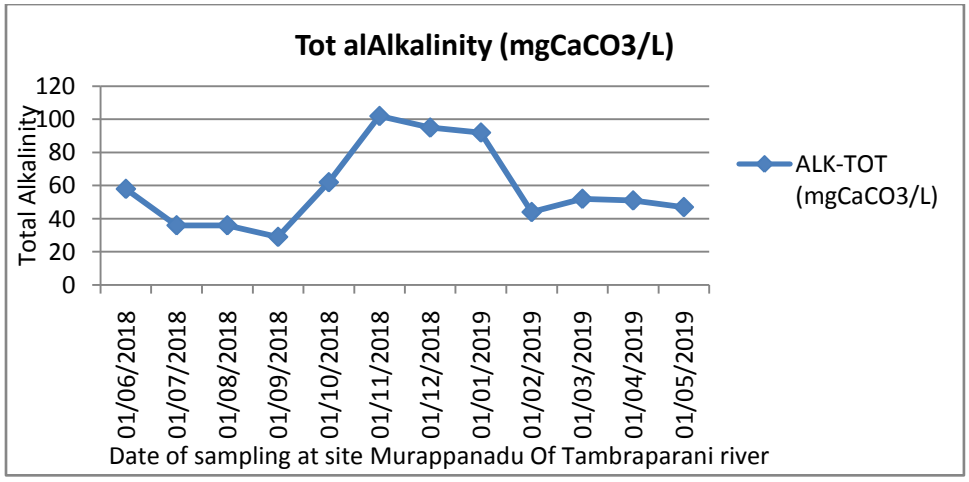


Figure 8: Variation of Chloride for the period of June 2018- May 2019

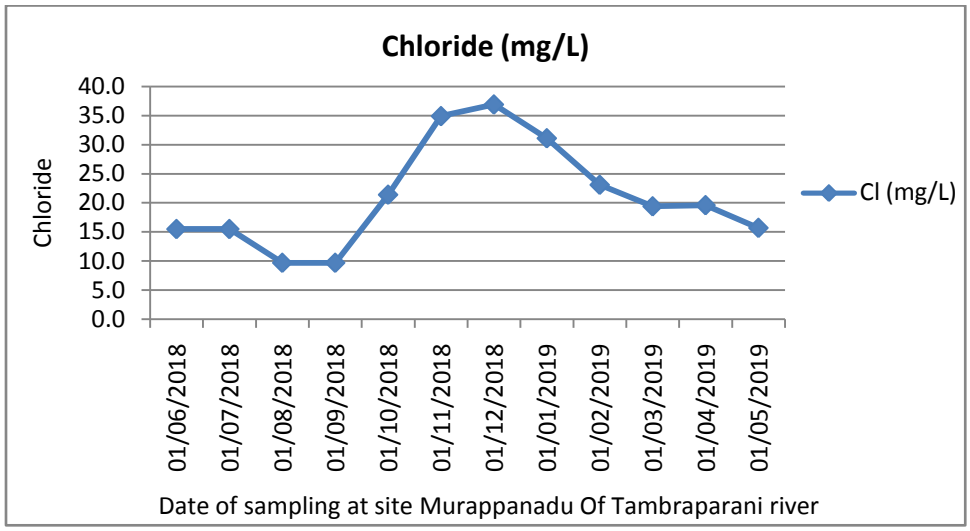


Figure 9: Variation of Total Hardness for the period of June 2018- May 2019

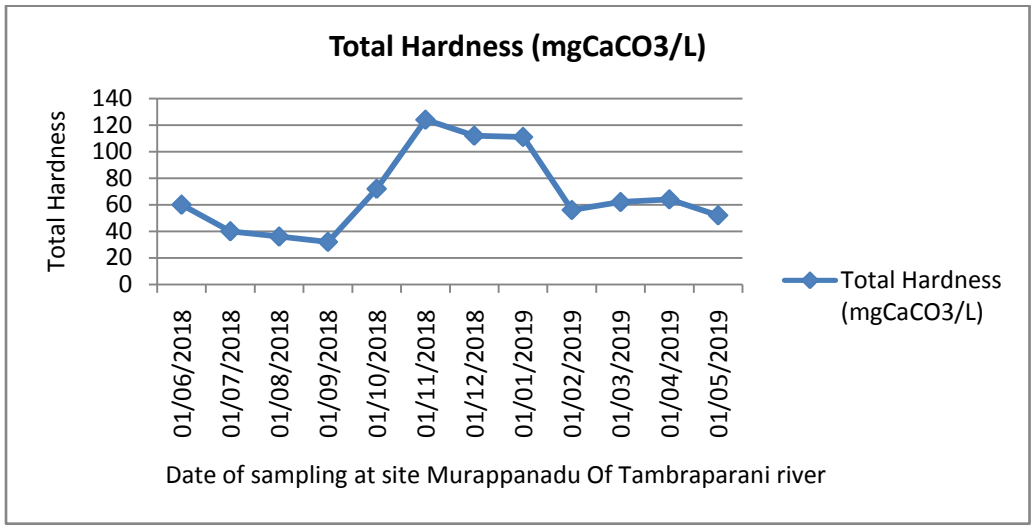


Figure 10: Variation of Nitrate for the period of June 2018- May 2019

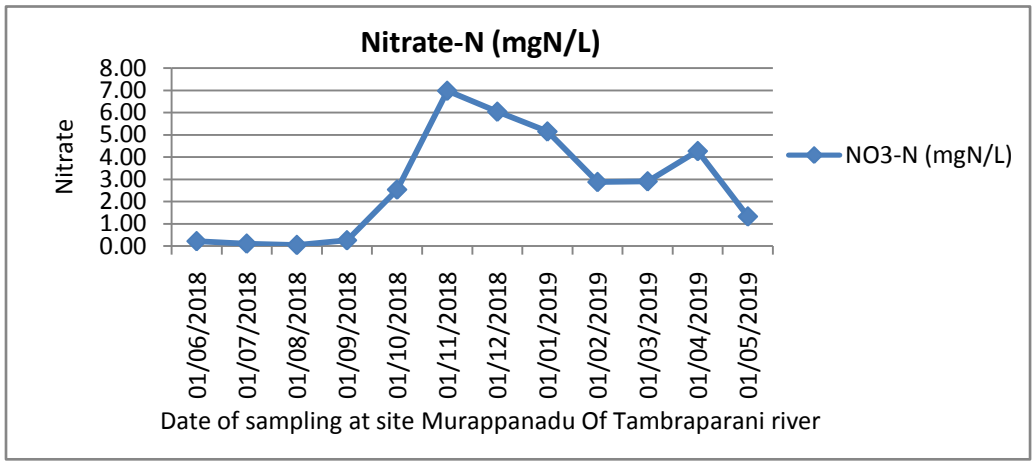


Figure 11: Variation of Dissolved Oxygen for the period of June 2018- May 2019

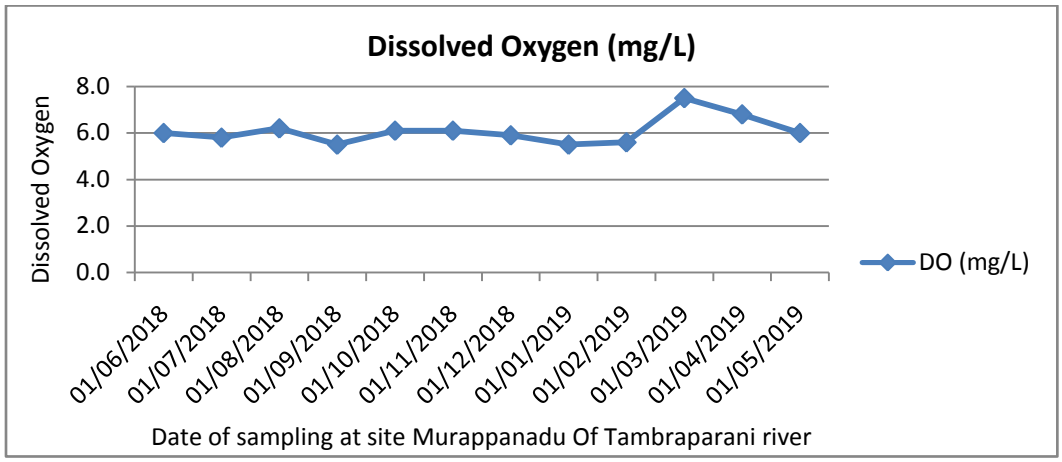
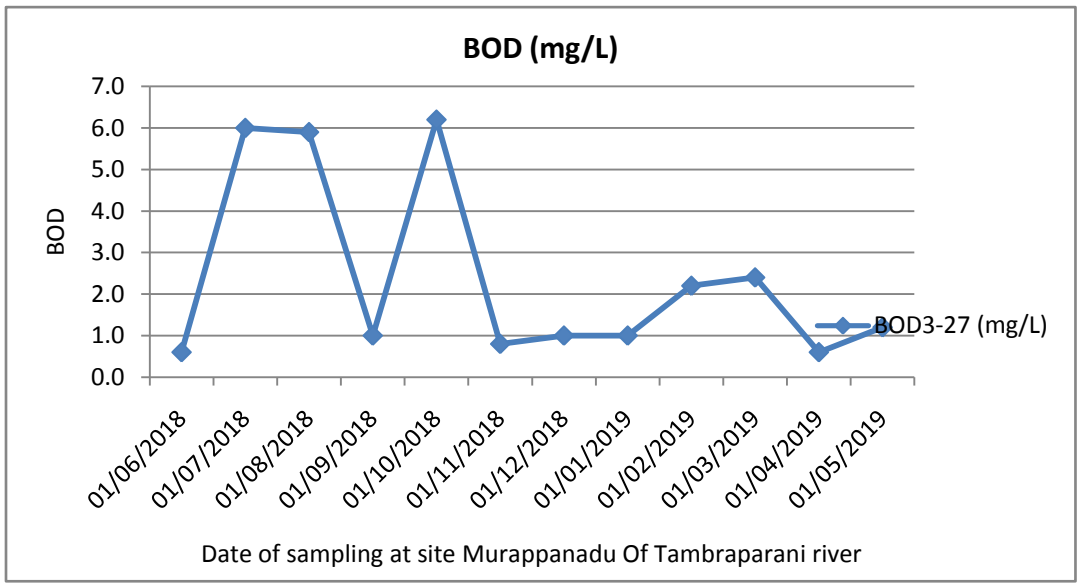


Figure 12: Variation of Biological Oxygen Demand for the period of June 2018- May 2019



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