HYDROGEOCHEMISTRY AND ENVIRONMENTAL IMPLICATION OF PERIYAR RIVER SOUTHERN WESTERN GHATS INDIA

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Abstract - *The Periyar River is the longest river in the state of Kerala with a length of 244km. It is one of the perennial rivers in the region and is known as the 'lifeline of Kerala' as it provides drinking water for several major towns. The Idukki Dam, which is a part of the Periyar River contributes to the generation of a significant portion of the Kerala's electrical power. After the flood which occurred in August 2018, the level of water on the Periyar River rose considerably. The flood have also changed the water and soil properties of the area.*

This study deeply look into the analysis of the water and soil of the Periyar river basin after the flood. The chemical content (PO4, NO2, SiO4, NO3, Ammonia, Carbonates, HCO3, DO, BOD, Chloride, Sulphate, Total hardness, Calcium, Magnesium, Sodium, Potassium, pH, Conductivity, Turbidity, Total dissolved solids, NaCl, Air temperature, Water temperature) of the surface water and ground water of different regions of the basin along with the Loss on Ignition (LOI) and X-Ray fluorescence (XRF) of various soils are found out in this study. The results were compared with the standards prescribed by World Health Organization and Bureau of Indian Standards.

Key Words: *Periyar River Basin, Loss on Ignition, X – Ray Fluorescence*

1.INTRODUCTION

1.1 WATER

Water is a prime natural resource essential for the subsistence of life and is a basic human need. About 70% of the Earth is covered by water. The total amount of water on the world is approximately 1.4 billion km^3 of which 97.5% is salt water and the rest is fresh water. Of the 35 million km3 of freshwater on earth, about 24.4 million km^3 are locked up in the form of glacial ice or permanent snow. Groundwater and soil moisture account for 10.7 million km^3. Freshwater lakes and marshlands hold about 0.1 million km^3.

Rivers, the most visible form of fresh water account for 0.002 million km^3 or about less than 0.01% of all forms of fresh water. The major source of fresh water is the evaporation on the surface of the oceans amounting to 505,000 km^3 a year. Another 72,000 km^3 evaporates from land surfaces annually. Approximately 80% of all the precipitation (about 458,000 km^3) falls on the oceans and the remaining 20% (119,000 km^3) falls over the land. The difference between precipitation onto land surfaces and evaporation from these surfaces is runoff and the groundwater recharge approximately is 47,000 km^3 per year. Of all fresh water not locked up in ice caps or glaciers, some 20% is in areas too remote for humans to access and of the remaining 80%, about three quarters comes at the wrong time and place i.e., in monsoons and floods and is not always captured for use by people. The remainder is less than 0.08 of 1% of the total water on the Earth.

In India, development of groundwater in different parts of the country has not been uniform. Highly intensive development of groundwater in certain areas in the country has resulted in over exploitation leading to decline of groundwater levels and subsequently the sea water intrusion into the coastal aquifers. Development and management of this resource are planned on the basis of natural hydrologic boundaries and also on administrative boundaries. Application of an integrated hydrological methodology is a pre-requisite for any type of watershed development. To meet the two-fold challenge of increased water demands and reduced availability of fresh water in the country, the governments have promoted the practice of artificial recharge to groundwater including rain water harvesting. Impact assessment of the artificial recharge structures has shown arrest of declining trends, rise in groundwater levels, improvement in groundwater quality and increased sustainability of groundwater abstraction structures.

Watershed based hydrological and hydrogeological studies are helpful in managing the water resources. Excessive pumping of our aquifers has resulted in an environmental catastrophe on many occasions. Groundwater is part of the longer hydrologic cycle that provides freshwater to lakes, rivers, and streams. Excessive groundwater exploitation disrupts this cycle and causes irreversible environmental damage.

Considering the aforesaid factors, Government of India, after a detailed deliberation over the water problems of the country, adopted a National Water Policy in 2002. The main objectives of this policy envisage the need for judicious and scientific water resource management and conservation. Water is a scarce and precious national resource to be planned, developed, conserved and managed as such on integrated and environmentally sound basis keeping in view the socioeconomic aspects and the needs of the States. Exploitation of groundwater resources should be so regulated without exceeding the recharging possibilities.

The detrimental environmental consequences of overexploitation of groundwater need to be effectively prevented by the Central and State Governments. Groundwater recharge projects should be developed and implemented for improving both the quality and availability of groundwater resource. Transfer of water from one river basin to another, especially to areas of water shortage may be required in certain cases. Monitoring of surface and groundwater quality and effluent treatment before releasing are also significant. Management of water resources for diverse use involves the participation of users, stakeholders and the government agencies. The objective of the study is to compare different water quality parameters with the BIS and WHO standards.

1.2 SOIL

Soils represent one of the most complex and dynamic natural systems and are one of the three major natural resources, other than air and water. Knowledge of their chemical, physical and biological properties is a prerequisite both for sustaining the productivity of the land, e.g. agriculture, and for conservation purposes. Soil is an integral part of a terrestrial ecosystem and fulfils numerous functions including the capacity to generate biomass and the filtering or buffering activities between the atmosphere and the groundwater in the biosphere. The word 'soil' means different things to different people but basically it may be defined as the solid material on the earth's surface that results from the interaction of weathering and biological activity on the soil's parent material or underlying hard rock.

Soil is a three dimensional body with properties that reflect the impact of (1) climate (2) vegetation, fauna, man (3) relief on the soils (4) parent material over a variable and (5) time span. The nature and relative importance of each of these five 'soil forming factors' vary in time and space. With few exceptions soils are still in a process of change; their 'soil profile' shows signs of differentiation or alteration of the soil material incurred in a process of soil formation or 'pedogenesis'.

Soil is made up of three main components – minerals that come from rocks below or nearby, organic matter which is the remains of plants and animals that use the soil, and the living organisms that reside in the soil. The proportion of each of these is important in determining the type of soil that is present. But other factors such as climate, vegetation, time, the surrounding terrain, and even human activities (eg. farming, grazing, gardening, landscaping, etc.), are also important in influencing how soil is formed and the types of soil that occur in a particular landscape. The formation of soils can be seen as a combination of the products of weathering, structural development of the soil, differentiation of that structure into horizons or layers, and lastly, of its movement or translocation. In fact, there are many ways in which soil may be transported away from the location where it was first formed.

Soils have many important functions. Perhaps the best appreciated is the function to support the growth of agricultural and horticultural crops. Soil is the mainstay of agriculture and horticulture, forming as it does the medium in which growth and ultimately the yield of food producing crops occurs. Farmers and gardeners have worked with their soils over many centuries to produce increasing amounts of food to keep pace with the needs of a burgeoning world population. The soil's natural cycles go a long way in ensuring that the soil can provide an adequate physical, chemical and biological medium for crop growth. The objective of the study is to find LOI and XRF of the soils samples collected from the Periyar River Basin.

1.3 STUDY AREA

The Periyar River is the longest river of the State (PWD, 1974; CESS, 1984) and is indeed the life line of Central Kerala. Periyar was known as 'Chhoorni nadhi' (nadhi means river) in Sangham poetry. The activities along the long stretches of its banks are always hectic as life proceeds along with the flow of water downstream. The river is highly beneficial to Idukki and Ernakulam districts for irrigation, drinking and navigation. There are a series of dams and power stations in this river (Table1.1). The Idukki hydro-electric project is the most important scheme of its kind in Kerala. The river plays a very important role in the agricultural, industrial and commercial development of the State. The Periyar Valley Irrigation Project was capable of irrigating a net area of 30414 ha. The city of Cochin and the surrounding Municipalities and Grama Panchayats get their drinking water from the Periyar River.

The Periyar is sacred to the people around, materially, spiritually and creatively. It is not just a sacred river or Dakshina-Ganga or just a source for the State's drinking water and hydel power. It is also an inspiration for the writers, the muse of poets, the final destination of departed souls, the transmitter of culture and a source of income for the environmentally unfriendly who ravage it. The mountain ranges from where the Periyar originates and the serene beautiful lakes reflecting the nature around and along with the forest abounding in attractive wild life are all perennial attractions to the tourists. The Thekkady Lake with boating facilities, the Bhoothathankettu reservoir and the beautiful wild life sanctuary adjacent to it, the natural beauty of Munnar etc., attract nature lovers and tourists from all over the world. The famous Malayattoor church, Kalady, the birth place of Sankaracharya, the greatest Advaitha Philosopher, is on the bank of the Periyar.

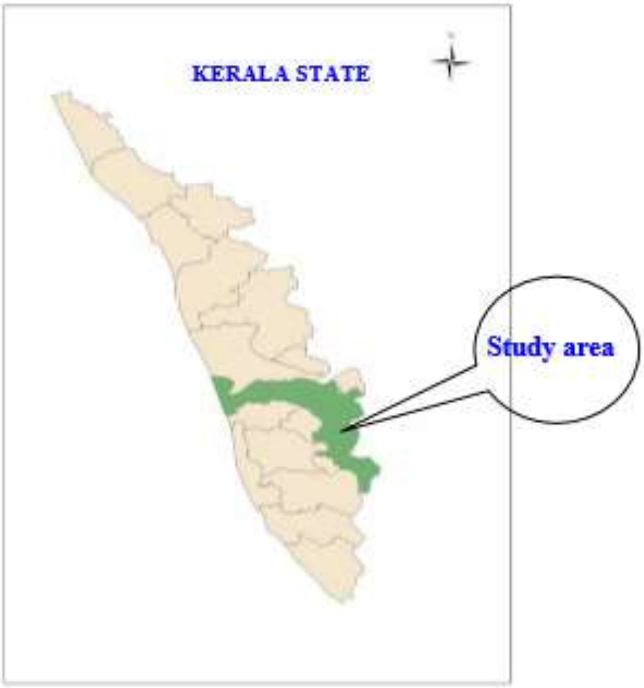
Thattekkad bird sanctuaries, Aluva Sivarathri Manalpuram etc., are along the banks of the river Periyar.

1.3.1 Location

The area selected for the present study, the Periyar River Basin, falls within the central part of Kerala and lies between North latitudes 9°15'30" and 10°21'00", East longitudes 76°08'38" and 77°24'32" and spreads in the districts of Idukki, Thrissur and Ernakulam (Fig 1.1)

Table 1.1 Important Reservoirs in the Periyar River Basin (*Source: KSEB*)

Sl. No.	Name of Reservoir	Year of completion	Height (m)	Length (m)	Gross Reservoir Capacity (Mm^3)
1.	Kundala	1946	32.30	259	7.79
2.	Matupetty	1956	85.34	237	55.23
3.	Sengulam	1957	26.80	144	0.71
4.	Kallarkutty	161	43.00	183	6.88
5.	Ponmudi	1963	59.00	294	51.54
6.	Anayirangal	1965	34.00	292	49.84
7.	Idukki	1974	168.90	366	1998.57 (Common Reservoir)
8.	Cheruthoni	1976	138.20	650	
9.	Kulamavu	1977	100.00	385	
10.	Idamalayar	1985	102.80	58	1089.8
11.	Erattayar	1989	20.00	146	5.35
12.	Kallar	1989	12.20	373	0.79
13.	Lower Periyar	1999	39.00	244	5.3



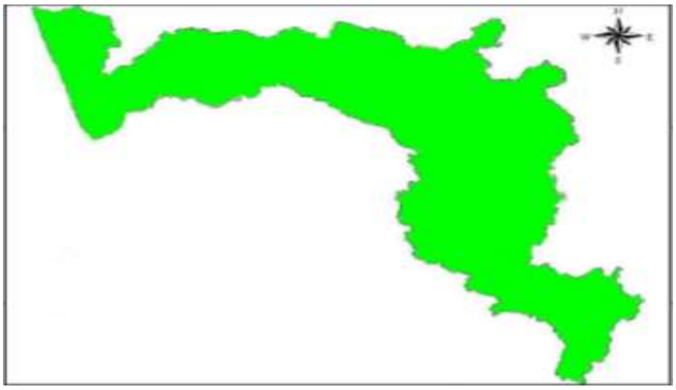


Fig -1.1: Location map of the study area

Table 1.2: Location details for the present study of water

Sample No.	Surface Water/Ground Water	Location
PRO1	Surface Water	Kayatinkara
PRO2	Surface Water	Thantrikavidyapeedam
PRO3	Surface Water	Bhoothathankettu Dam
PRO4	Surface Water	Hanging Bridge Injathotti
PRO5	Surface Water	Nedumkandam
PRO6	Ground Water	Olanad
PRO7	Ground Water	Gothuruth Ferry
PRO8	Ground Water	Thiruvallam Chuzhi
PRO9	Ground Water	Panthaykal Temple
PRO10	Ground Water	Nariyampara

Table 1.3: Location details for the present study of soil

Sample No.	Location	Latitude	Longitude
PRJ1	Grampi Estate	9°33'6.3"	77°03'43.3"
PRJ2	Grampi Thodu	9°33'24.2"	77°05'44.1"
PRJ3	Anavilasom	9°38'44"	77°06'22.8"
PRJ4	Pullumedu	9°40'12.6"	77°02'52.9"
PRJ5	Mary Kulam	9°40'41.6"	77°03'1.2"
PRJ6	Vikas Upputhara	9°41'56.2"	77°01'20.0"
PRJ7	Ayyappan Kovil	9°42'15.1"	77°02'25.8"
PRJ8	Ayyappan Kovil Temple	9°43'10"	77°01'36.4"
PRJ9	Palakada Kanchiyar (Bismi Hotel)	9°45'43.2"	77°04'19.6"
PRJ10	Kanchiyar	9°44'46.2"	77°04'42.8"

2. METHODOLOGY

2.1 INTRODUCTION

Water and soil investigations of river basins involve a variety of procedures and techniques. The methodology is dependent on the objectives of the work, terrain conditions, the availability of infra-structure, etc.

2.2 WATER

Tests were conducted to find out many chemical parameters of the water collected from different locations of the Periyar River Basin mentioned on Table1.2. The chemical parameters studied here are:

- Phosphate
- Nitrite
- Silicate
- Nitrate
- Ammonia
- Carbonate
- Bicarbonate
- Dissolved oxygen
- Biological Oxygen Demand
- Chloride
- Sulphate
- Total Hardness
- Calcium
- Magnesium
- Sodium
- Potassium
- pH
- Turbidity
- Conductivity
- Total Dissolved Solids
- Sodium Chloride
- Air Temperature
- Water Temperature

2.2.1 Determination of Nutrients (Phosphate, Nitrite, Nitrate, Silicate, Ammonia)

Nutrients such as phosphate, nitrite, nitrate, silicate and ammonia were found out using the equipment Continuous Flow Analyser (CFA) (Fig 3.1). The samples were taken in a cuvette and then placed in the analyser. The analyser directly shows the amount of nutrients present in the particular sample.

Fig - 2.1: Continuous flow analyser

2.2.2 Determination of carbonates and bicarbonates

Carbonates and bicarbonates were determined by titration with 0.05M sulphuric acid. 25ml sample was taken in an Erlenmeyer flask. 5 drops of phenolphthalein was added. The solution turns pink showing the presence of carbonates. Sulphuric acid was added from the burette drop wise until the solution became colourless. The reading was noted. Then to the same solution 3 drops of methyl orange was added. The solution turned yellow. Again titration was carried out by adding sulphuric acid drop wise from the burette until the solution turned orange. Then the reading was noted. The amount of carbonates and bicarbonates were calculated.

2.2.3 Determination of Dissolved Oxygen and Biological Oxygen Demand

DO and BOD was estimated using Winkler's method. The water sample was taken in a 250ml bottle. 2ml manganous sulphate solution followed by 2ml alkali iodide azide reagent were added. The bottle was stoppered without any air bubble and mixed by inverting the bottle several times. The formed precipitate was allowed to settle for down and 2ml conc.H_2SO_4 was added, the bottle was re-stoppered and mixed by inverting for several times until the dissolution was complete.

50.0ml sample from the bottle was pipetted out into a clean conical flask and heated against a 0.025 N thiosulphate solution until it turned to a pale straw colour. At that stage a few drops of starch solution was added and titration was continued by adding the thiosulphate drop wise to first disappearance of blue colour. Then DO was calculated using the formula,

$$\text{DO (mg/L)} = \frac{\text{Volume of thio} \times \text{Strength of thio} \times 8 \times 1000}{\text{Volume of sample taken} \times \frac{\text{Total capacity of BOD bottle} - \text{Volume of thio consumed}}{\text{Total capacity of BOD bottle}}}$$

After finding DO the same sample was used for the determination of BOD. Two sets of BOD bottles were filled with samples elevated water with same dilution water. The non-seeded dilution water filled in two sets. This serves as blank. If seeding is done, the BOD of seeding material is also determined. One set of bottle is used for initial DO determination. The other set of bottles where inoculated for 5 days at 20°C in BOD incubators. The DO was determined after 5 days. Then BOD was calculated using the formula,

$$BOD\ (mg/L) = (DO_0 - DO_5) - [(B_0 - B_5) \times 1000] / V$$

Where,

DO_0 = Initial DO content in mg/L

DO_5 = DO content after incubation of 5 days

B_0 = DO content of blank on initial day

B_5 = DO content of blank after incubation of 5 days

V = Volume of sample taken in ml

2.2.4 Determination of Chloride

The amount of chloride was determined using titration (Mohr's method). 10ml of the sample was taken and 15ml of distilled water was added to it. The pH was adjusted to 7 to 8. 1ml of potassium chromate indicator solution was added and then titrated against silver nitrate. The end point was colour change from yellow to red. Then the amount of chloride ion was determined using the formula,

$$\text{Amount of } Cl^- \text{ (mg/L)} = \frac{\text{Volume of silver nitrate} \times \text{normality of silver nitrate} \times 35.45 \times 1000}{\text{Volume of sample taken for titration}}$$

2.2.5 Determination of sulphates

Determination of sulphates was done using spectrophotometer. 50ml sample was taken in an Erlenmeyer flask. 20ml of buffer solution was added and was mixed thoroughly. While stirring, 0.15g of barium chloride was added to the sample and again stirred using the magnetic stirrer for an hour. Absorbance was measured against the blank at 420nm using spectrophotometer. The sample solution was processed to obtain solutions of different strengths (mg/L) in similar way and absorbance of each were noted. Standard sulphate calibration curve was plotted with strength on X – axis and absorbance on Y – axis. Using the standard calibration curve sulphate concentration in the given sample was found out.

2.2.6 Determination of Total Hardness

20 ml of the sample was taken in a conical flask. 1 to 2ml of buffer solution and a pinch of eriochrome black – T powder was added to it. The solution turned wine red. That solution was titrated against EDTA until the colour changed from wine red to blue. Total hardness was then calculated using the formula,

$$\text{Amount of hardness (mg/L)} = \frac{\text{Volume of EDTA} \times \text{Normality of EDTA} \times 50 \times 1000}{\text{Volume of sample taken for titration}}$$

2.2.7 Determination of Calcium, Magnesium, Sodium and Potassium

Calcium, Magnesium, Sodium and Potassium was determined using Microwave Plasma – Atomic Emission Spectroscopy (MP – AES) (Fig 3.2). The instrument directly gives the amount of calcium, magnesium, sodium and potassium present in the sample of water.

Fig - 3.2: Microwave Plasma – Atomic Emission Spectroscopy (MP – AES)

2.2.8 Determination of Turbidity

Nephelometric cuvette was filled with distilled water and placed in the sample holder. The lid of the sample compartment was closed. By adjusting the 'set zero' knob, the meter reading was adjusted to zero. The sample tube with distilled water was removed and the 40 NTU standard solution was filled in the tube, and the meter reading was set to 100. The turbidity of the unknown solution was then found out by fitting the sample tube with the sample and the reading was noted in NTU unit.

2.2.9 Determination of pH, Conductivity, Total Dissolved Solids, Sodium Chloride

Determination of pH, conductivity, Total dissolved solids, sodium chloride was done using water quality analyser. Water quality analyser is a brief cased instrument which on insertion of the sample on the rods provided, directly gives the values of the parameters. The sample was filled on the rods provided on the instrument. The value of pH, conductivity, total dissolved solids, sodium chloride was directly shown digitally (Fig 3.3).

Fig 3.3 Water Quality Analyser

2.2.10 Determination of Air Temperature and Water Temperature

Air temperature and water temperature was determined using thermometers. Thermometers were inserted into the sample collected and the temperature reading was noted.

2.3 SOIL

Tests conducted on soil were Loss on Ignition (LOI) and X – Ray Fluorescence (XRF). The sample was prepared from the soil collected from specific sites of the Periyar River Basin listed on Table 1.3.

2.3.1 Loss on Ignition

Loss on ignition is a test used in the analysis of minerals. It comprises of heating a sample of the material heavily at a given temperature, enabling the escape of volatile substances until their mass ceases to change. The simple test consists of placing a few grams of the sample in a tared, pre – ignited crucible and determining its mass, placing it in temperature controlled furnace for a set time, cooling it in a controlled atmosphere and redetermining the mass. Then loss on ignition was found out using the formula,

$$\text{LOI}(\%) = \frac{N2-N3}{N2-N1} \times 100$$

Where,

N_1=Weight of empty crucible

N_2=Weight of crucible with sample from oven

N_3=Weight of crucible and sample after taking from muffle furnace

2.3.2 X – Ray Fluorescence

XRF (X-ray fluorescence) (Fig 3.4) is a non-destructive analytical technique used to determine the elemental composition of materials. XRF analysers determine the chemistry of a sample by measuring the fluorescent X-ray emitted from a sample when it is excited by a primary X-ray source. Each element in a sample generates a collection of distinctive fluorescent X-rays that is peculiar to that particular element, making XRF spectroscopy an outstanding technology for qualitative and quantitative material composition assessment.

Fig - 3.4: X – Ray Fluorescence analyser

2.3.3 Preparation of soil sample

Prior to LOI and XRF the soil has to prepared and processed. The raw soil samples from the field was first taken in glass dishes and kept in oven at 80°C overnight. The samples were taken out of the oven the next day and cooled to atmospheric temperature.

Cone and quartering of the dried samples were done. A portion of this sample were ground to fine powder using the mortar and pestle. The grounded powder was then sieved through 0.063mm sieve (IS 63). After sieving the sample was stored in boxes with proper labelling.

Crucibles were weighed empty (N_1). 5g of the sieved sample was weighed and taken in the crucible. Then the crucible was kept in oven for 1hr at 100°C. After taking out from the oven the samples were again weighed (N_2). Then the samples were kept in muffle furnace for 1hr at 900°C. After cooling the samples were again weighed (N_3). The values were noted to find LOI. The samples were then made into pellets for doing XRF.

3. RESULTS AND DISCUSSION

3.1 WATER

Analysis of chemical parameters of water collected from different sites of Periyar River Basin was done and the results were obtained.

Table - 3.1: Experimental values of water sample

Sample No.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CO_3	HCO_3 (ppm)	DO	BOD	Cl	SO_4	Total Hardness	Ca	Mg	Na (ppm)	K (ppm)	NaCl (ppm)	pH	Turbidity (NTU)	Conductivity (µS)	TDS (ppm)	AT	WT
PRJ1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PRJ2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PRJ3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PRJ4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PRJ5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PRJ6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PRJ7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PRJ8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PRJ9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PRJ10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The water quality parameter values obtained from the analysis of the water sample collected from Periyar River Basin was compared with WHO and BIS standards. The values are within the limit as specified in WHO and BIS. From this it is understood that the pollution rate of Periyar River Basin is comparatively low.

3.2 SOIL

LOI and XRF were done on the soil sample collected from Periyar River Basin Table (3.2).

Table 3.2: LOI values of soil sample

Sample No.	Loss on Ignition (LOI) (%)
PRJ1	19.62
PRJ2	13.56
PRJ3	19.96
PRJ4	15.87
PRJ5	14.88
PRJ6	16.63
PRJ7	15.84
PRJ8	15.19
PRJ9	18.13
PRJ10	19.12

The LOI values should be less than 20% for soils. The values obtained are within the limit. From the study it is clear that the sample soils are fit for agricultural purposes. It contains all the relevant nutrients that are needed for the plant growth.

Table 3.3: XRF values of soil sample

Sample	PRJ1	PRJ2	PRJ3	PRJ4	PRJ5	PRJ6	PRJ7	PRJ8	PRJ9	PRJ10
SiO_2	25.59	42.24	44.87	41.86	42.36	39.28	30.73	45.86	35.53	33.41
TiO_2	1.24	0.58	0.87	1.17	0.82	1.00	1.36	0.78	1.21	1.31
Al_2O_3	35.82	30.62	20.77	26.65	25.87	29.60	31.66	22.98	29.84	30.27
MnO	0.04	0.04	0.11	0.07	0.12	0.11	0.09	0.20	0.08	0.15
Fe_2O_3	15.78	8.51	7.60	11.29	7.26	10.26	18.77	8.35	12.66	13.67
CaO	0.10	0.16	0.67	0.45	1.38	0.26	0.22	0.69	0.59	0.36
MgO	0.40	0.60	1.25	0.94	2.81	0.98	0.37	1.25	0.61	0.56
Na_2O	0.27	0.54	0.58	0.33	1.13	0.28	0.28	0.67	0.34	0.23
K_2O	0.84	2.55	2.34	1.00	2.89	1.09	0.40	3.41	0.65	0.43
P_2O_5	0.24	0.17	0.74	0.24	0.37	0.15	0.12	0.33	0.19	0.20
LOI	19.62	13.56	19.96	15.87	14.88	16.63	15.84	15.19	18.13	19.12
TOTAL	99.92	99.56	99.76	99.87	99.88	99.63	99.84	99.69	99.83	99.72

The soil sample were tested for XRF and the values of major oxides were obtained as a result of XRF analysis Table (3.3).

4. SUMMARY AND CONCLUSION

This study mainly focuses on the water quality parameters of water and LOI and XRF of soils. Experiments were conducted on water sample to find out the amount of phosphate, nitrite, silicate, nitrate, ammonia, carbonate, bicarbonate, DO, BOD, chlorides, sulphates, total hardness, calcium, magnesium, sodium, potassium, pH, turbidity, conductivity, total dissolved solids, sodium chloride, air temperature and water temperature. All the parameters are tabulated. Experiments were conducted on soil to find out the amount of loss on ignition and the amount of oxides present in the soil.

From this study it is obvious that the pollution rate of Periyar River is comparatively lower as the values of most of the parameters fall within the limit. Hence this water can be effectively used for irrigation purposes and in at most cases this water can be supplied for drinking purposes after proper disinfection. Soil of this river basin can be used effectively for agriculture. The nutrient content of soil is acceptable for the proper growth of crops and plants.

REFERENCES

1. **Abdul, S., Mallikarjun, N., Dandigi., Vijay, K** (2012). Correlationregression model for physico-chemical quality of groundwater in the South Indian city of Gulbarga, African Journal of Environmental Science and Technology, 6 (9), 353 – 364.

2. **Antonio, G, C., Paola, A., Fiore, C., Giuliano, L., Fabio, T., Simona, V** (2018). Monitoring metal pollution in soils using portable-XRF and conventional laboratory-based techniques: Evaluation of the performance and

limitations according to metal properties and sources, Science of the Total Environment, 643, 516 – 526.

3. **Binaya, K., Ram, K. R., Yoshifumi, M., Kensuke, F., Pankaj, K., Chitresh, S** (2017). Assessment of Bagmati river pollution in Kathmandu Valley: Scenario-based modeling and analysis for sustainable urban development, Sustainability of Water Quality and Ecology, 13, 1481 – 1492.

4. **Biplab, K. D., Devashish, K** (2015). Physico-Chemical Parameters and Drainage Types of River Siang in Arunachal Pradesh, India, International conference on water resources, coastal and ocean engineering, 4, 53 – 56.

5. **Hafizan, J., Sharifuddin, M. Z., Mohd, K. Y., Tengku, H. T. I., Mohd, A. S., Mohd, E,T., Mazlin,M** (2011). Spatial water quality assessment of Langat River Basin (Malaysia) using environmetric techniques, Environmental Monitoring Assessment, 173, 625 – 641.

6. **Haiyang, C., Yanguo, T., Sijin, L., Yeyao, W., Jinsheng, W** (2015). Contamination features and health risk of soil heavy metals in China, Science of the Total Environment, 512 – 513, 143 – 153.

7. **Hefni, E., Romanto., Yusli, W** (2015). Water quality status of Ciambulawung River, Banten Province, based on pollution index and NSF-WQI, Procedia Environmental Sciences, 24, 228 – 237.

8. **Ji-Hoon, K., Rak-Hyeon, K., Jeongho, L., Tae-Jin, C., Byoung-Woo, Y., Ho-Wan, C** (2015). Multivariate statistical analysis to identify the major factors governing groundwater quality in the coastal area of Kimje, South Korea, hydrological processes, 19, 1261 – 1276.

9. **Kang, T., Biao, H., Zhe, X., Wenyou, H** (2018). In situ investigation of heavy metals at trace concentrations in greenhouse soils via portable X-ray fluorescence spectroscopy, Environmental Science and Pollution Research, 18, 639 – 651.

10. **Anil, K. S., Priju, C. P., Narasimha, N, B** (2015). Study on Saline Water intrusion into the Shallow Coastal Aquifers of Periyar River Basin, Kerala using Hydrochemical and Electrical Resistivity Methods, International conference on water resources, coastal and ocean engineering, 4, 32 – 40.

11. **Anjos, M. J., Lopes, R. T., Jesus, E. F. O., Assis, J. T., Cesareo, R., Barradas, C. A. A** (2000). Quantitative analysis of metals in soil using X-ray fluorescence, Spectrochimica Acta Part B, 55, 1189 – 1194.

12. **Mohammad, H and Assefa, M. M** (2016). Assortment and spatiotemporal analysis of surface water quality using cluster and discriminant analyses, Catena, 3, 59 – 71.

13. **Preeti, J and Dwarakish, G. S** (2015). Temporal Analysis of Spatial Distribution of Built-Up Area in PeriUrban Areas of Cochin, Kerala: Case-Study of Sub-Watershed in Periyar River, International conference on water resources, coastal and ocean engineering, 4, 1445 – 1451.

14. **Salam, H. E., Salwan, A. A., Safaa, A. K** (2018). Prediction the Tigris River Water Quality within Baghdad, Iraq by Using Water Quality Index and Regression Analysis, Environmental Technology & Innovation, 6, 1256 – 1271.

15. **Krishna, K. S., Logeshkumaran, A., Magesh, N. S., Prince, S.G., Chandrasekar, N** (2015). Hydro-geochemistry and application of water quality index (WQI) for groundwater quality assessment, Anna Nagar, part of Chennai City, Tamil Nadu, India, Applied Water Sciences, 5, 335 – 343.

16. **Rajiv, D. K., Sarojini, D. B., Suganthi, K., Munisamy, G** (2017). Development of a water quality index (WQI) for the Loktak Lake in India, Applied Water Sciences, 7, 2907 – 2918.

17. **Tibor, T., Zsófia, A.K., Márk, R** (2019). XRF-measured rubidium concentration is the best predictor variable for estimating the soil clay content and salinity of semi-humid soils in two catenas, Geoderma, 342, 106 – 108.

18. **Chakraborty, S., Man, T., Paulette, L., Deb, S., Li, B., Weindorf, D.C., Frazier, M** (2017). Rapid assessment of smelter/mining soil contamination via portable X-ray fluorescence spectrometry and indicator kriging, Geoderma, 306, 108 – 119.

19. **Seyyed, A. A. N., Sriya, P., Joseph, D. B., Jing, T., Paul, T. I** (2019). Quantifying biochar content in a field soil with varying organic matter content using a two-temperature loss on ignition method, Science of the Total Environment, 658, 1106 – 1116.

20. **Will, M. B., Richard, P. A., George, E. H** (2014). Evaluating a Great Lakes scale landscape stressor index to assess water quality in the St. Louis River Area of Concern, Journal of Great Lakes Research, 12, 323 – 335.