Geospatial Water Quality Analysis of Downstream of Tamiraparani River – Tamilnadu

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ABSTRACT

A physicochemical analysis of River Tamiraparani was carried out to determine critical environmental issues using GIS mapping techniques. A large proportion of water is used for power generation and intense agricultural activities, mostly paddy is grown in the river banks. It is the only drinking water source for the entire Tirunelveli. The present study aimed at application of GIS techniques to understand the spatial distribution pattern of important water quality parameters with ArcMap 10.2.1. Water samples were collected and analysed following standard methods from 11 different locations covering the stretch from Authoor to Punnakayal during November 2020. A comprehensive physicochemical assessment of 10 indicator parameters namely conductivity, alkalinity, hardness, calcium, magnesium, chloride, sulphate, Total Dissolved Solids (TDS), sodium and potassium were carried out. The results showed that all the parameter apart from alkalinity exceeded the permissible limits specified by World Health Organization (WHO) and Bureau of Indian Standards (BIS) 2012. It was found that the first three locations (Authoor, Mukkani and Sertnthapoomangalam) met the specified drinking water standards because there is no such sea water intrusion happened. It is found that Kailasapuram that is the 4 sampling location onwards the concentration of TDS varies in the range of 19,600-27,650 mg/l, conductivity is in the range of 40,000-48,000 µs/cm, hardness is in the range of 1,500-4,200 mg/l, chloride is in the range of 12,000-17,000 mg/l, calcium varies in the range of 300-435 mg/l, magnesium is in the range of 800-1100 mg/l, sulphate is in the range of 1300-1600 mg/l, sodium is in the range of 6000-9,000 mg/l and potassium varies in the range of 450-600 mg/l. This could be due to pollution loads entering from sewage discharge, washing of clothes, bathing and sea

water intrusion. The study is mandatory for the decision makers and public for reduce the contamination levels in the study area, since it is a major source of water for domestic and agricultural activities of surrounding.

Keywords- Tamiraparani river, Surface water quality, Physicochemical analysis, GIS.

INTRODUCTION

Water is the very common and essential for all life. It has played a vital role in determining the course of the history of the earth. It is the most potent and the most wonderful thing on the face of our earth. The preservation and utilisation of water is thus essential for human welfare. Water quality analysis is the basic method used to comprehend the variation of water quality of polluted water bodies and hence protect and preserve them [1]. In developing countries like India, where almost 70% of the surface water is contaminated because of discharge of domestic and industrial wastewater, thus water quality assessment become an important issue for satisfying the basic needs of the people throughout their lives [2].

This situation has been emerging as a delicate and life-threatening problem in several countries. Therefore, many researches have been carried out to address this issue [3–5]. In coastal regions, salt water intrusion into fresh water has become a severe consequence because of unplanned exploitation of water resources [6]. Contamination of water bodies also increase the risk of waterborne diseases. Almost 80% of all the infections in human beings are waterborne. In India, access to safe drinking water continues to be a crucial requirement, because much of the population entirely depends on untreated surface or groundwater [7]. Therefore, it is very much essential to determine the variations in river water quality and availability to come up with contaminated regions for sustainable management of water resources [8].

GIS is an information system used to input, store, recover, manipulate, and analyse spatial and non-spatial data. It is avaluable tool to analyse spatial data and derive useful outputs and modelling. It can be effectively used to for assessing water quality, checking water availability and developing solutions for water resources problems and managing water resources. The overlay GIS mapping techniques are widely used for pollution studies. There are few literatures available for river and groundwater water quality mapping and analysis using GIS techniques [9-11].

The key aim of the present study is to analysis the physicochemical parameters and represents changes in these parameters using GIS mapping techniques and to find the critical zones of the river in need of immediate action. The study begins with collecting the samples as per the standards, subsequently laboratory analysis carry out by means of pH, Conductivity, Turbidity meter for determining the Physio-chemical parameters. Besides, GIS techniques helps to prepare and analyse the spatial distribution of water quality contamination through Inverse Distance Weighted (IDW) methods.

STUDY AREA

The River Tamiraparani is the only perennial river in Tirunelveli, Tamil Nadu. It originates on the eastern slopes of the Western Ghats at an altitude of 2000 m, travels about 125-128 km in the hills and plains, covering a total area of 5369 km^2. The study area lies between 78° 4'-78°7' E longitudes and 8° 37'- 8° 38' N latitudes (Figure 1). The variation in annual rainfall and temperature is found to be between 1,000- 1100 mm and 20 to 38 °C respectively [12].

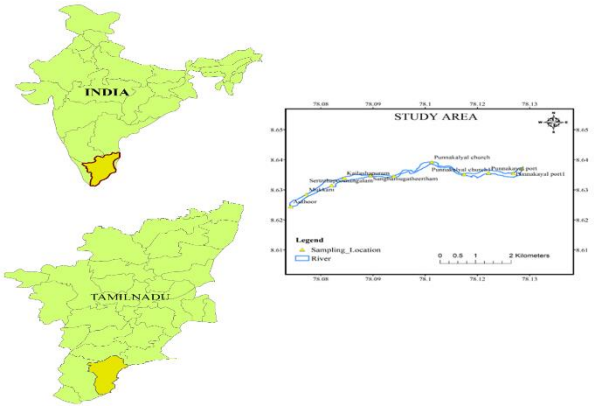

Figure 1 The study area map with sampling locations

The elevated areas are covered with moderately dense tropical wet evergreen and tropical moist deciduous forests, following dendritic to sub-dendritic drainage pattern [13]. The major tributaries of the River are: Servalar, Manimuthar, Gadananathi, Chittar, Pachaiyar, Karaiyar and Ramanathi. The upper reaches of the bed of the river is made up of igneous and metamorphic rocks and the middle and the lower reaches are sandy in nature. The river basin has extensive alluvium deposition which is used for cultivation. The major soil types found in the basin are red soils and the mixture of the red and black clay soils [12-13].

A large proportion of water is used for power generation and intense agricultural activities, mostly paddy is grown in the river banks and is the only drinking water source for the entire district. The causes of the river pollution in the area are: a large amount of wastewater from residences, industries, illegal sand mining, illegal encroachments, religious practices like bathing and sea water intrusion.

MATERIALS AND METHODOLOGY

The study area Thamiraparani River was delineated from Cartosat-1 orthophotos, which is used as source for selecting the sampling locations. According to the base map, samples were collected in the month of November 2020 from 11 different sampling sites as depicted in the (Figure 1). The latitudes and longitudes of the sampling locations were noted down using the GPS. The water samples were collected, transported, preserved and analysed as per the standard methods prescribed in APHA [14]. Furthermore; samples incubated for laboratory analysis to determine the Physicochemical parameters namely pH, turbidity, conductivity, alkalinity, hardness, Calcium (Ca), Magnesium (Mg), Chloride (Cl), Sulphate (SO_4), Total Dissolved Solids (TDS), Sodium (Na) and Potassium (K). The measurement of pH, TDS and EC was done using portable sensors, in addition Titrimetric methods were used to analyse alkalinity, hardness, chloride, calcium and magnesium. The flame photometer was used to determine sodium and potassium [15 –16]. Database was created for the analysed samples with their corresponding sampling locations using GIS software. The sampling station name with their corresponding latitude and longitude are shown in the Table 1.

Table 1 Geographical positions of the sampling sites of Tamirabarani river.

Sl.No	Sampling station	Latitude	Longitude
1	Authoor	8.626117	78.06862
2	Mukkani	8.630392	78.07262
3	Saernthapoomangalam 1	8.633611	78.07896
4	Kailasapuram	8.636278	78.08219
5	Sangamugatheertham	8.636725	78.08886
6	Saernthapoomangalam 2	8.636928	78.09473

7	Punnakayal Church part 1	8.641475	78.10434
8	Punnakayal Church part 2	8.637558	78.1125
9	Punnakayal Port 1	8.637706	78.11869
10	Punnakayal Port 2	8.637903	78.12494
11	Estuary Mouth	8.639567	78.12711

The following figure 2 represents the steps which is followed for this work. It includes sample collection, testing, comparison, mapping, understand the pollution level of tamiraparani river and reason for the same.

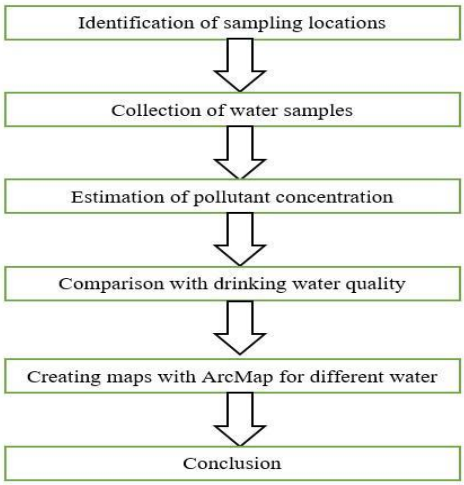

Figure 2 Methodology flow chart

RESULTS AND DISCUSSION

Waste water from residences and industries find its way directly to the river water making it unfit for human use. In addition, Sea water intrusion is also a major reason for making this water unsuitable for human consumption. The key aim of the study is to analysis the physicochemical parameters and represents changes in these parameters using Geospatial techniques also to find the critical zones of the river in demands immediate action [17]. The water quality sampling places and the results obtained from water quality analysis are shown in Table 2.

Table 2 Physio-chemical characteristics of Thamiraparani River at sampling stations

S. No.	TDS (mg/l)	EC (µs/cm)	Alkalinity (mg/l)	Hardness (mg/l)	Chloride (mg/l)	Ca (mg/l)	Mg (mg/l)	Sulphate (mg/l)	Na (mg/l)	K (mg/l)
1	351	615	113	104	112	28.32	26	58	50	4
2	403	792	96	109	156.27	24.84	21.2	64	78	6
3	493	856	91	115	161.2	25	27	66	75	7
4	21054	42384	84	1682	12034	285.61	793	1329	6106	451
5	20812	40327	118	1975	13132	372	811	1284	6892	469
6	19588	39026	125	2387	12454	364	860	1502	6321	452
7	26031	44580	137	2539	13611.89	431	970.4	1632.27	7958	517
8	26545	45327	146	3006	14834	418	1012	1608	8107	528
9	25672	45678	154	3598	15761	404	1104	1576	8341	595
10	27035	46017	169	3619	16679	369	1093	1537	8503	608
11	27643	48028	178	4190	16854.62	435.64	1126.2	1624.1	8729	616

The fitness of river water for drinking, domestic and agricultural usage was evaluated by comparing the results with those prescribed in the standards. BIS and WHO standards for the drinking water is depicted in the Table 3.

Table 3 The standards for drinking water laid down by BIS and WHO

Sl. No.	Parameter (mg/L)	Acceptable limit (IS10500:2012)	Sl. No.	Parameter (mg/L)	Acceptable limit (IS10500:2012)
1	TDS	500	5	Magnesium	30
2	Alkalinity	200	6	Sulphate	200
3	Total Hardness	200	7	Calcium	75
4	Chloride	250	8	Sodium	200 (WHO)

Physicochemical parameters

Alkalinity

The major chemical species to constitute alkalinity in the water environment are dissolved carbon dioxide, bicarbonate, carbonate, hydrogen and hydroxyl ions [18]. The BIS standards for total alkalinity as $CaCO_3$ is 200 mg/l. It is understood from the figure 3 that highest level of alkalinity 178 mg/l is shown in the Estuary mouth whereas the lowest alkalinity observed as 84 mg/l from Kailasapuram.

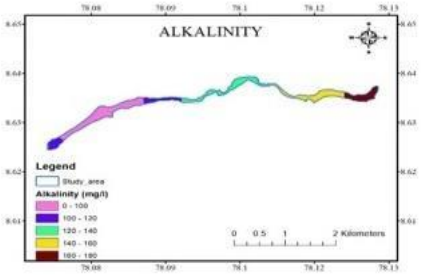

Figure 3 Variation of alkalinity along Tamiraparani River

Conductivity

The major chemical species to constitute conductivity in the water environment are dissolved ions. The natural compounds do not conduct electric current and for this reason do not impart conductivity [24]. Figure 4 clearly show that there is a significant increase in conductivity values from sampling location 4 onwards. The maximum value of 48028 µS/cm is observed

at Punnakayal Port. This could be due to sea water intrusion. The other sources could be industrial and domestic waste water entering the river. Water with conductivity values above 500 μS/cm is not appropriate for drinking water purposes as per BIS standards.

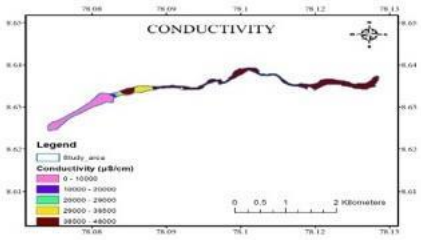

Figure 4 Variation of conductivity along Tamiraparani River

TDS

The occurrence of TDS in water affects its palate, clogs gills of the fish, increases its temperature and blocks photosynthetic activities of underwater plants [32]. The drinking water is considered excellent if its TDS value is less than 300 mg/l, good if it varies between 300–600 mg/l, fair if it varies between 600–900 mg/l, poor if it varies between 900–1,200 mg/l and unacceptable if it is more than 1,200 mg/l.Figure 5 shows the variation in total dissolved solids concentration of the analysed samples. The results show that the TDS values of the samples collected from locations Authoor, Mukkani and Sertnthapoomangalam are within the permissible limits by BIS. The highest TDS concentration of 27643 mg/l was observed at Punnakayal Port.

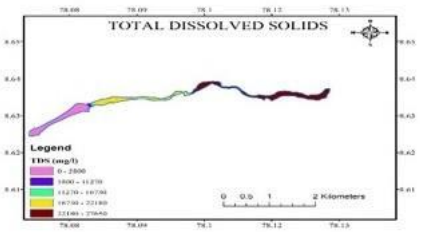

Figure 5 Variation of TDS along Tamiraparani River

Total Hardness

The dissolution of the metal ions like calcium and magnesium makes surface water sources hard. The hardness of the collected samples is found to be in the range of 100–4200 mg/l as depicted in figure 6. The hardness value of the first three locations was found to be varying between 100-115 mg/l. Water with hardness < 100 mg/l has a low buffering capacity and can corrode water pipes. Whereas, the rest of the locations have very high hardness values. Water with hardness > 200 mg/l cause scale formation in the water treatment facilities [31].

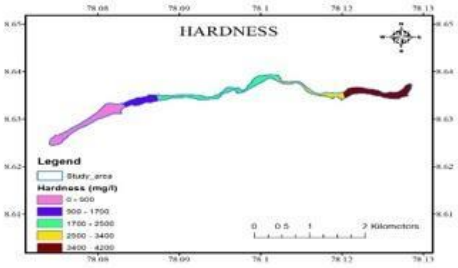

Figure 6 Variation of total hardness along Tamiraparani River

Calcium

Calcium often is the most abundant cation in river water. Calcium leads to poor lathering, deterioration of clothes, incrustation in pipes and scale formation [38]. The results obtained from analysis for calciumin the present study showed that the values were well within the standard limits for first three locations namely Authoor, Mukkani and Sertnthapoomangalam. The concentration of calcium for rest of the locations did not meet the prescribed standards. From the results and figure 7 the calcium concentration in the samples of study area varied in the range of 25 – 435.64 mg/l.

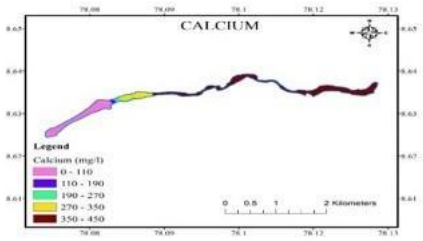

Figure 7 Variation of calcium along Tamiraparani River

Magnesium

The analysis results of magnesium carried out in the present study showed that the values were well within the standard limits for first three locations namely Authoor, Mukkani and Sertnthapoomangalam. The concentration of magnesium at remaining locations did not meet the prescribed standards. This could be due to fertilizers and waste entering from chemical industries [23]. From figure 8 the concentration of the magnesium of the measured samples varied between 20– 1126.2 mg/l.

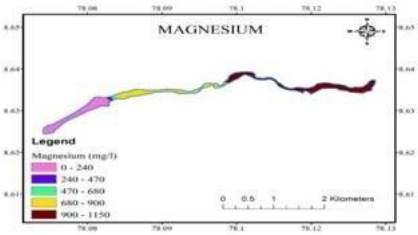

Figure 8 Variation of magnesium along Tamiraparani River

Sodium

Sodium metal is not found in free form in nature because of its high reactivity.It has an average taste threshold of about 200 mg/l at room temperature. It can have adverse health effects on humans, especially people with high blood pressure [25]. The WHO standards recommended for sodium as 200 mg/l. The concentration of sodium in water samples analysed range between 50 and 8729 mg/l, figure9. It can find its way in water from fertilizers and untreated sewage waste.

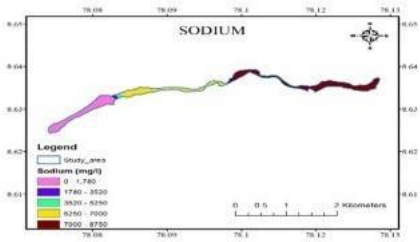

Figure 9 Variation of sodium along Tamiraparani River

Chlorides

Sodium, potassium, calcium and magnesium chlorides are commonly found in natural water. The average taste threshold of sodium, potassium and calcium chloride lies between 200 to 300 mg/l at room temperature. The chloride anion taste threshold depends on the related cations [27]. Based on taste threshold criteria, The BIS standards for chlorides as 1000 mg/l for drinking water. The concentration of chlorides obtained in water samples between 112–16854.62 mg/l, figure 10. The high concentrations could be due to salt water intrusion.

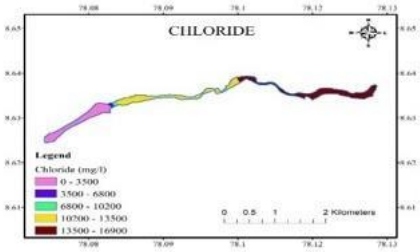

Figure 10 Variation of chloride along Tamiraparani River

Sulphates

Sulphate is the most common form of sulphur present in well aerated natural waters. The taste of the drinking water changes noticeably in the presence of the sulphates and if present in high levels can causeadverse effect in humans [23]. As per BIS the desirable limit for sulphate in drinking water as 200 mg/l. Figure 11 shows the variation in sulphate concentration of the water samples analysed for the present study, higher concentration in 7th location of 1632.27 mg/l. It is observed that it is not within the acceptable limits prescribed by BIS for drinking water.

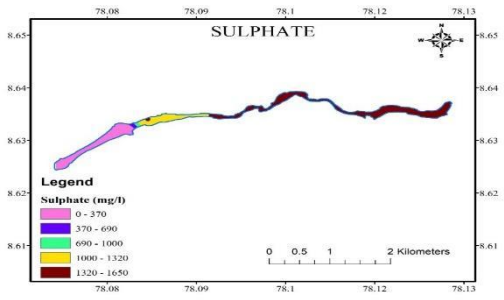

Figure 11 Variation of sulphate along Tamiraparani River

Potassium

Potassium is avital element needed for proper functioning of human body and could be a concern if found in high levels in drinking water [22]. The concentration of potassium in water samples between 4–616 mg/l shown in figure 12. In drinking water, 10 mg/l of potassium is permissible. The major reason for high concentration in water sample is due to presence of fertilizers [24].

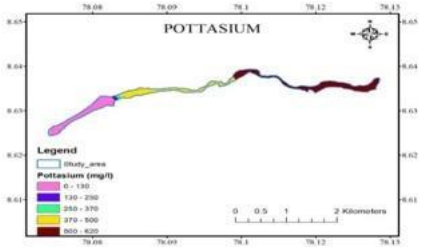

Figure 12 Variation of potassium along Tamiraparani River

Conclusions

GIS based mapping techniques were used to analyse the variation and distribution of physicochemical characteristics of important water quality parameters at Thamiraparani River. The study revealed that except alkalinity all the parameters were exceeded the prescribed limits specified by BIS. Particularly the last location which is near to sea has higher amount of TDS 27643 mg/l and conductivity as 48028 µs/cm due to sea water intrusion. Besides, GIS techniques spatially represented the level of contamination with reference to the analyzed samples. It came to know from the study that are many parameters are influences the contamination in which sea water intrusion, anthropogenic activities and direct discharge of sewage in to the river from the industrial activities are the major influential parameters. Thus, leads to reduce the suitability for drinking, domestic and irrigation purposes. Consequently, the investigation prescribes to distinguish and limit the both point and non-point source contamination by methods for geospatial techniques. In the event that legitimate measures are taken for the treatment of sewage before release and limitations are put on different anthropogenic exercises in upstream and downstream, the estuary would stay sound over the long haul. This examination encourages us to comprehend the nature of the water just as to create judicious management practices to safeguard the water resources.

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