Ilkogretim Online - Elementary Education Online, 2020; Vol 19 (Issue 4): pp. 6737-6760
http://ilkogretim-online.org
doi: 10.17051/ilkonline.2020.04.765078

Assessment Of Water Quality Using Physiochemical Parameters Of Tamirabarani River Basin, South India

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Abstract- The river Tamirabarani is one of the perennial rivers in India which feed two major districts (Tirunelveli and Thoothukudi) of Tamil Nadu, India. Due to high anthropogenic activities, urbanization practices, irrigational and livestock activities along the river bank habitations increases pollution threat. The present study was carried out in January to December , 2020 to assess the quality of water and to classify the river stretches using multiplicative aggregation function. The results showed water quality deterioration during the month of April whereas remaining periods showed the quality up to fair level. Excellent quality of water was recorded at
21.53 %, very good quality at 28.47 %, good quality at 33.33 %, fair quality at 13.89 % and marginal quality at 2.78 % of sampling sites during the study tenure.

Correlation study between physicochemical properties also reveals significant negative relationship with the Water Quality Index (WQI) scores. The index function makes easy interpretation of results which in-turn increases the effectiveness of management strategies to bringing back the originality of the river.

Keywords- Water Quality Index; Tamirabarani; Sub Index; Correlation; Urbanization

I. INTRODUCTION

Pollution of surface and ground water is a major problem due to rapid urbanization and industrialization. The large scale urban growth due to increase in population and migration of people from rural areas to urban centers has increased domestic effluents while industrial development manifested either due to setting up of new industries or expansion activities resulting in generation of copious volume of industrial effluents (Avnish and Saksena, 2010). Clean and adequate water supply is a necessity for the health of all living organisms and ecosystems, including people and their activities. Water quality monitoring has one of the highest priorities in environmental protection policy (Pesce and Wunderlin, 2000; Simeonov et al., 2002) to control and minimise the incidence of pollutant-oriented problems, and to provide water of appropriate quality to serve various purposes such as drinking water supply, irrigation, recreational and industrial; and to protect the valuable freshwater resources to safeguard public health (Bartram et al., 2002). Ascertaining the quality is crucial before use for various purposes (Sargaonkar and Deshpande 2003; Khan et al., 2003).

Traditional approaches to assess water quality are based on a comparison of experimentally determined parameter values with existing guidelines. However, it does not readily give an overall view of the spatial and temporal trends in the water quality in a watershed (Debels et al., 2005). The classification, modelling and interpretation of monitoring data are the most important steps in the water quality assessment; the quality is difficult to evaluate from a large number of samples each containing concentrations for many parameters (Almeida et al., 2007).

The index method was initially proposed by Horton in 1965. Since then, the formulation and use of indices has been strongly advocated by agencies responsible for water supply and control of water pollution. The concept of Water Quality Index (WQI) is based on the comparison of the water quality parameters with respective to regulatory standards and gives a single value to the water quality of a source, which translates the list of constituents and their concentrations present in a sample (Abbasi, 2002; Khan et al., 2003). It is a mechanism for presenting a cumulatively derived numericalexpression defining a certain level of water quality (Bordaloet al., 2006).

WQI is a numeric expression used to transform large quantities of water characterization data into a single number (Sanchez et al., 2007) and it is a measure of how the water quality variables compare to the water quality guidelines or objectives for a specific site. The WQI has been considered as one criterion for surface water classifications, based on the use of standard parameters for water characterization. It is basically a mathematical means of calculating a single value from multiple test results. The index result represents the level of water quality in a given water basin. WQI assess the appropriateness of the quality of the water for a variety of uses (Cude, 2001) such as habitat for aquatic life, irrigation, recreation, drinking water etc. It is considered more appropriate for disseminating information to generalaudiences.

Rapidly increasing urbanization and industrialization activities along the banks of the river Tamirabarani and adjoining areas have adversely influenced the quality of the water resource. Tamirabarani is the main receptor of domestic and sewage discharges of both the districts added to these direct discharges from the bank side; industries which consist of untreated or semi-treated effluent and solid wastes also increase the pollution incidence throughout the basinarea. Number of authors have studied the pollution status of

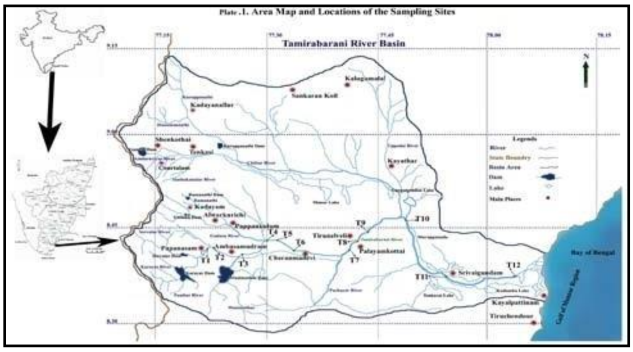
the perennial river Tamirabarani which includes; water quality profile (Murugesan et al., 1994; Umamaheswari, 2004; Thillai Arasu et al., 2007); domestic and industrial pollution (Murugesan, 2000); toxic impacts (Murugesan et al., 2002); conservation and restoration of catchment areas (Murugesan et al., 2002a); pollution load (Hema and Muthalagi, 2009); sewage mixing and coliforms (Murugesan et al., 2004; Mophin Kani and Murugesan, 2010); industrial impacts (John De Britto and Peter Baskaran, 2010); urbanization (Chandrasekar et al., 2010). There is no previous classification study based on the WQI scores on the river Tamirabarani hence the present study was undertaken to enumerate water quality as well as spatial and temporal variations of the perennial river using mathematical aggregation of water quality index as an indicator of the environmental quality and to classify the river basin based on the International (WHO) and Indian standards. The use of WQI is exploited for the classification and zoning of river Tamirabarani.

Sampling, preservation, and assessment of the water quality were carried out as per standard methods (APHA, 1999).

C. Selection of Parameters

Based on the site specific actions and experts advice 14parameters (pH, TDY, EC, TDS, TSS, DO, NH4-N, NO3,
NO2, COD, BOD5, Na, F and TC) were selected for the determination of water quality index (WQI) of the river basin that best characterizes the local aquatic life which dependson the land use practices in the watershed area.

The water velocity (V), discharge (Q), cross-sectional area (A), pH and electrical conductivity (EC) was measured in situ. Chemical and biological analysis was carried out at laboratory based on APHA (1999) methods (Table.2).



II. METHODOLOGY

A. Study Area

The river Tamirabarani is one of the symbols of Tamil culture and history; referred in Tamil literature as Porunai nathi. The main river originates on the eastern slopes of Western Ghats in Tirunelveli district which is situated between latitudes 8°30'N and 9°18'N and longitudes 77°07'30"E and 78°15'E. The origin of Tamirabarani and its principal springs are situated at the peaks called "Aduppukkal Mottai", "Agasthiyamalai" (Periya Pothigai) and "Cherumunji Mottai", with an altitude of 1725 m above MSL; it traverses a length of about 125 km passing through Tirunelveli and Thoothukudi districts before confluences with the Gulf of Mannar region of the Bay of Bengal (Murugesan et al., 2002a; Murugesan et al., 2004) at an latitude of 8°38'26"N and longitude of 78° 7'38"E. The river is fed by both southwest and the northeast monsoon periods and is seen in full spate twice a year if both the monsoons do not fail. The main river drains with its springs and tributaries with the total catchment area of about 4500 sq.km with the total river basin area of 5942 sq.km (Plate.1). Most of its extensive catchment area lies in the eastern slopes of Western Ghats; the river enjoys the full benefit of both the monsoons which makes the river perennial and prone to heavy floods, especially during the northeast monsoon periods. The average rainfall of the river basin area is 1082 mm (northeast 565 mm; southwest 233 and summer and winter 284 mm) with the annual average temperature of 25.5°C - 34.4°C (20.9°C min, 39°C max) (RDA-AER, 2008; PWD-WRO; 1999; 2006; 2007). Population density of the river basin is 362 persons per sq.km against the state averageof 428 persons per sq.km.

B. Sampling

12 sampling stations (T1-T12) of main river (Plate.1; Table.1) were chosen for the present study based on the river habitat walk (USEPA, 1997) and with the experts advice based on the pollutant intrusion, tributary convergence and runoff entry points, onsite activities like huge gathering, agricultural and livestock, laundry activities.

Water samples were collected during first week of eachmonth (January 2020 to December 2020)

Table.1 GEOGRAPHICAL POSITIONS OF THE SAMPLING SITES OF RIVER TAMIR ABARANI

Site ID	**Locations**	**Latitude**	**Longitude**
T1	Pabanasam	8°42’39”N	77°22’2”E
T2	V.K.Puram	8°42’25”N	77°22’56”E
T3	Ambasamudram	8°41’38”N	77°27’43”E
T4	Thiruppudaimaruthur	8°43’41”N	77°29’45”E
T5	Mukkudal	8°43’57”N	77°30’48”E
T6	Cheranmahade	8°42’4”	77°33’56”

	vi	N	E
T7	Kurukkuthurai	8°42’37”N	77°41’49”E
T8	Tirunelveli – Kokkirakulam	8°43’38”N	77°42’49”E
T9	Tirunelveli – Vannarappettai	8°44’21”N	77°43’6”E
T10	Seevalapperi	8°46’53”N	77°48’36”E
T11	Srivaigundam	8°37’35”N	77°54’44”E
T12	Aattur	8°37’35”N	78° 4’8”E

III. CALCULATION OF WATER QUALITY INDEX (WQI)

The WQI concept is based on the comparison of the water quality parameter with respective regulatory standards (Khan et al., 2003). The development process of water quality index consists of four steps:

Selecting the set of water quality variables of concern – parameter selection

Transformation of the different units and dimensions of water quality variables to a common scale – developing sub- indices

Table.2 PHYSICOCHEMICAL PARAMETERS SELECTED FOR THE STUDY AND THE METHODS OF ANALYSIS

Parameter	**Methods of analysis**	**Units of Measurement**
Velocity (Velo)	Float buoyant	m/sec
Discharge (Disch)	Calculation of Area followed by Velocity	m^3/sec
Temperature (Temp)	Thermometer&Electrometr	°C

	Ic	
Physicochemical parameters selected for aggregation of WQI		
Electrical Conductivity (EC)	Electrometric	µS/cm
Turbidity (TDY)	Turbidometric	NTU
pH	Electrometric	
DissolvedOxygen (DO)	Modified Winkler's	mg/L
TDS	Gravimetric method	mg/L
TSS		
BOD	5 days incubation at 20°C followed by titration	mg/L
COD	Closed reflux	mg/L
Ammonia (NH4N)	Titration by H2SO4	mg/L
Nitrate (NO3)	Ultraviolet screening	mg/L
Nitrite (NO2)	Spectrophotometric	mg/L
Sodium (Na)	Flame Photometer	mg/L
Fluoride (F^-)	Spectrophotometric	mg/L
Total coliform (TC)	Multiple tube fermentation Technique	Count/100 ml

Table.3 SUB INDEX FUNCTIONS FOR VARIOUS PHYSICOCHEMICAL PARAMETERS

Variable	Range		SI Function
	Min	Max	
pH	6.5	8.5	100
	6.5	6.3	y = 100x –

	1	2	y = -20x + 120
	2	5	y = -6.6667x + 93.333
	5	8	y = -6.6667x + 93.333
	8	10	y = -10x + 120
		>10	10
TSS	<2.5		100
	2.5	12.5	y = -2x + 105
	12.5	20	y = -2.6667x + 113.33
	20	22.5	y = -8x + 220
	22.5	25	y = -8x + 220
		>25	10
NH_4 -N	<0		100
	0	0.75	y = -26.667x + 100
	0.75	1.2	y = -44.444x + 113.33
	1.2	1.35	y = -133.33x + 220
	1.35	1.5	y = -133.33x + 220
		>1.5	10
NO_2	<0.02		100
	0.02	0.1	y = -250x + 105
	0.1	0.16	y = -333.33x + 113.33
	0.16	0.18	y = -1000x + 220
	0.18	0.2	y = -1000x + 220
		>0.2	10
TC	<5		100
	5	500	y = -0.0404x + 100.2
	500	2500	y = -0.01x + 85
	2500	4000	y = -0.0133x + 93.333
	4000	5000	y = -0.02x + 120
		>5000	10
Variable	Range		SI Function
	Min	Max	
NO_3	<5		100
	2	25	y = -x + 105
	25	40	y = -1.3333x + 113.33
	40	45	y = -4x + 220
	45	50	y = -4x + 220
		>50	10
PO_4	<1		100
	1	2.5	y = -13.333x + 113.33
	2.5	4	y = -13.333x + 113.33
	4	4.5	y = -40x + 220
	4.5	5	y = -40x + 220
		>5	10
COD	<2		100
	2	5	y = -6.6667x + 113.33
	5	8	y = -6.6667x + 113.33
	8	9	y = -20x + 220
	9	10	y = -20x + 220
		>10	10
BOD	<1		100
	1	2.5	y = -13.333x + 113.33
	2.5	4	y = -13.333x + 113.33
	4	4.5	y = -40x + 220
	4.5	5	y = -40x + 220
		>5	10
F	<0.3		100
	0.3	0.75	y = -44.444x + 113.33
	0.75	1.2	y = -44.444x + 113.33
	1.2	1.35	y = -133.33x + 220
	1.35	1.5	y = -133.33x + 220
		>1.5	10

			550
	6.3	6.1	y = 100x – 550
	6.1	5.5	y = 33.333x – 143.33
	5.5	4.9	y = 33.333x – 143.33
	<4.9		10
	8.5	8.7	y = -100x + 950
	8.7	8.9	y = -100x + 950
	8.9	9.5	y = -33.333x + 356.67
	9.5	10.1	y = -33.333x + 356.67
		>10.1	10
EC	<250		100
	250	500	y = -0.08x + 120
	500	1250	y = -0.0267x + 93.333
	1250	2000	y = -0.0267x + 93.333
	2000	2500	y = -0.04x + 120
		>2500	10
DO		>7	100
	6	7	y = 20x – 40
	5	6	y = 20x – 40
	4	5	y = 20x – 40
	3	4	y = 20x – 40
	<3		10
Na	<20		100
	20	40	y = -x + 120

	40	100	y = -0.3333x + 93.333
	100	160	y = -0.3333x + 93.333
	160	200	y = -0.5x + 120
		>200	10
Variable	Range		SI Function
	Min	Max	
TDY	<1		100

Weighting of the water quality variables based on their relative importance to overall water quality – assignment of weights and Formulation of overall water quality index - aggregation of sub-indices to produce an overall index

Water Quality Index is a mathematical instrument used to simplify the presentation of results of an investigation related to a water body, as it summarises in single value which represents the overall water quality status.

1 Development of SubIndex

Development of Sub Index is based on the quality criteria with the segregation of six classes (A, B, C, D, E and F). The classes were assessed based on the percentage calculation of maximum acceptable standard level of each parameters [10^{th} % (A), 20^{th} % (B), 50^{th} % (C), 80^{th} % (D), 90^{th} (E) and 100% (F)]. Site-specific water quality standards (CPCB, 2008; BIS, 2003) were used for the determination of percentcalculation (Khan et al., 2003; Lumb et al., 2006).

Variables which meet the desirable levels were assigned with 100 and the levels which exceeded the maximum acceptable values were assigned with the sub index level of
10. The intermediate levels were assigned with the linear regression equations. The set of sub index functions with mathematical equations were described in Table.3 and SIrating curves are presented in Figure.1 and Figure.1arespectively.

Figure.1. Rating curves for Sub-Index (SI) development of water quality parameters

Figure.1a. Rating curves for Sub-Index (SI) development of water quality parameters

B. Assignment of Weightage to Each Parameter

Each parameter has been assigned to a temporary weight (Table.3a) according to its relative importance and site specific conditions of the river. The maximum weight of 10 has been assigned to the parameters pH, DO, NH4-N, TSS BOD and TC due to its major importance in river quality assessment. The minimum weight of 1 was assigned to

qi – sub index score of ith parameter and n – number ofparameters

The index equation generates a number between 1 and 100, with 1 being the poorest and 100 indicating the excellent water quality. Within this range designations have

fluoride because of its low level of occurrence. The weightfactor (Wi) is calculated from the following equation.

(1)

Where,

wi – temporary weight of each parameter and n – number of parameters

Table.3a TEMPORARY WEIGHT AND WEIGHT FACTORS ASSIGNED FOR INDIVIDUAL VARIAB LE

Parameter	Temporary Weight (Wi)	Weight Factor (W)
DO	10	0.0 91
pH	10	0.0 91
BOD	10	0.0 91
NH4	10	0.0 91
TC	10	0.0

		91
TSS	10	0.0 91
EC	9	0.0 82
NO2	9	0.0 82
TDY	9	0.0 82
NO_3	6	0.0 55
COD	6	0.0 55
PO4	6	0.0 55
Na	4	0.0 36
F	1	0.0 09

C. Aggregation of Water Quality Index

Aggregation is another most important factor for the concept of WQI. To produce a WQI, Sub Index scores and weight factors of all parameters are aggregated using multiplicative aggregation function (Gupta et al., 2003; Sedeño-Díaz and López-López, 2006). Researchers like Landwehr et al., (1974) and Dinius (1987) have employed weighted geometric mean for aggregation of WQI. Ott (1978); Landwehr and Deininger (1976); Walski and Parker (1974) and Gupta et al. (2003) showed multiplicative indices are superior because a geometric mean is less affected by extreme values than an arithmetic mean. In addition, recently several authors have applied this index (Zoppou, 1999; Gergel et al., 2002; Gupta et al., 2003; Shiow-Me et al., 2004; Ramesh et al., 2010). Hence the present study also undertaken with the weighted multiplicative aggregation of water quality index [Equation – 2].

D. Weighted Geometric Mean (Multiplicative) Wqi

Water quality was assessed using the multiplicative weighted index proposed by Brown et al., (1970); Cude (2001).

(2)

Where,

wi – relative weight (weigh factor) of the ith parameter been set by CCME (2006) to classify water quality as poor, marginal, fair, good, very good and excellent.

Six points of water quality classification (TABLE.1) was used for the present study based on the Canadian Council of Ministers of the Environment (CCME, 2006).

TABLE.1 CLASSIFICATION SCHEME FOR WATER QUALITY INDEX SCORES

Classification	Range	Description
Excellent	> 94 – 100	Water quality is protected with a virtual absence of impairment; conditions are very close to pristine levels. These index values can only be obtained if all measurements meet recommended guidelines virtually all the time.
Very Good	> 88 ≤ 94	Water quality is protected with a slight presence of impairment; conditions are close to pristine levels.
Good	> 79 ≤ 88	Water quality is protected with only a minor degree of impairment; conditions rarely depart from desirable levels.
Fair	> 64 ≤ 79	Water quality is usually protected but occasionally impaired; conditions sometimes depart from desirable levels.
Marginal	> 44 ≤ 64	Water quality is frequently impaired; conditions often depart from desirable levels.
Poor	≤ 44	Water quality is almost always impaired; conditions usually depart from desirable levels.

IV. STATISTICALANALYSIS

Statistical determinations like descriptive summary, correlation matrix and cluster analysis were calculated using SPSS package (version 15) and the WQI scores were formulated using MS office excel (version 2003).

V. RESULTS

The descriptive summary of spatial and temporal variations in the WQI score levels are presented in Table.4 and Table.5. Sampling station T1 showed excellent to very good quality of water during the study within the score range of 90.24-99.45 and the mean score is 96.53. WQI score level was recorded within the range of 70.16-99.00 and 74.52-98.85 at stations T2 and T3 and the mean level is 93.25 and 88.92 respectively within the quality range of excellent to fair. Excellent to good quality of water was observed at station T4 within the score level of 83.21-97.55 and the average level is 88.48. Station T5 and T6 showed the water quality of excellent to fair during the study within the scoreof 67.71-97.45 and 67.23-96.06 and the average level is 88.38 and 84.28 respectively during the study. Excellent to marginal water quality was observed at station T7 during the study within the score level of 62.84-94.03, and the average level is 85.88. Water quality deterioration was recorded at stations T7, T8 and T9 within the quality criteria of very good to marginal during the study; within the score of 63.88- 89.48, 61.89-92.21 and 54.39-94.46 and the average level is 81.93, 83.01 and 80.54 respectively. Sampling stations T11 and T12 showed the water quality of very good to fair quality during the study and scored within 75.31-92.69 and 71.42-90.21 respectively. Kurtosis results followed normal distribution at stations T1 and T7 whereas remaining stations followed plati-kurtic and lectokurtic of distribution.

Temporal variations in the WQI score level showed excellent to fair quality of water during the month of January and the river showed excellent quality at 16.67 %, very good and good quality at 33.33 % and fair quality at 16.67 % of the sampling sites. February month results classified the river quality into excellent (16.67 %), very good (75 %) and good (8.33 %). During the month of March water quality of the river was recorded within excellent to fair quality correspondingly at 25 %, 33.33 %, 25 % and 16.67 % of the sampling sites. April month results showed very good to marginal quality of water in the order of 8.33 %, 16.67 %, 41.67 % and 33.33 % of the sampling stations. May June and July month score levels showed the water quality of excellentto good at 8.33 %, 16.67 % and 75 %; 58.33 %, 8.33 % and 33.33 %; 8.33 %, 33.33 % and 58.33 % of the samplingstations respectively. Excellent to fair quality of water wasrecorded during the period of August to Novembercorrespondingly at 25 %, 33.33 %, 25 % and 16.67 %; 50 %, 33.33 %, 8.33 % and 8.33 %; 16.67 %, 8.33 %, 25 % and 50 %; 16.67 %, 16.67 %, 50 % and 16.67 % of the samplingsites. December month showed excellent quality at 16.67 %,both very good and good quality at 41.67 % of the sampling sites. Kurtosis results followed normal distribution during the month of May whereas remaining months followed plati- kurtic and lectokurtic distribution throughout the study.

WQI score level during the study showed significant temporal variations (Fig.2) whereas April month showed high level of deterioration, this may be due to less discharge level from the headwater regions and high organic discharges and tributaries contribution at downstream areas which increase the discharge level also.

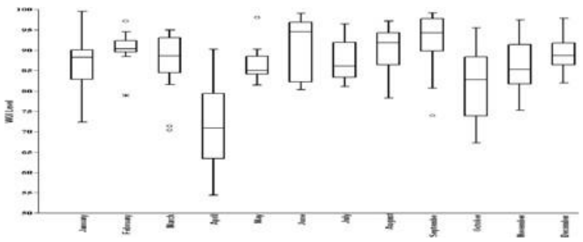


Figure.2. Box plot showed the temporal variations of WQI score levels

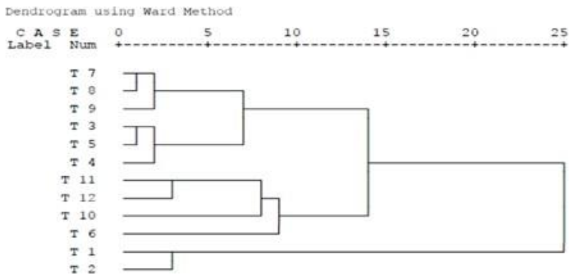


Figure.3. Hierarchical clustering of sampling stations based on WQI score levels

TABLE.4. DESCRIPTIVE SUMMARY OF SPATIAL VARIATIONS IN THE WQI SCORE LEVELS OF RIVER TAMIRABARANI DURING THE YEAR 2020

Site	N	Min	Max	Mean		Stdev	Variance	Kurtosis	
	Statistic	Statistic	Statistic	Statistic	SE	Statistic	Statistic	Statistic	SE
T1	12	90.24	99.45	96.5292	.7017	2.4308	5.909	3.688	1.232
T2	12	70.16	99.00	93.2492	2.2839	7.9117	62.594	7.569	1.232
T3	12	74.52	98.85	88.9250	1.9275	6.6772	44.585	.622	1.232
T4	12	83.21	97.55	88.4858	1.4664	5.0798	25.804	-.876	1.232
T5	12	67.71	97.45	88.3833	2.1566	7.4708	55.813	5.798	1.232

T6	12	67.23	96.06	84.2792	2.7618	9.5671	91.529	-1.061	1.232
T7	12	62.84	94.03	85.8825	2.5291	8.7611	76.757	3.971	1.232
T8	12	63.88	93.74	85.2800	2.2886	7.9278	62.851	4.702	1.232
T9	12	61.89	92.21	83.0125	2.2943	7.9478	63.168	4.355	1.232
T10	12	54.39	94.46	80.5375	3.2653	11.3113	127.945	1.277	1.232
T11	12	75.31	92.69	85.7608	1.5722	5.4464	29.663	-.583	1.232
T12	12	71.42	90.21	79.7742	1.7957	6.2206	38.695	-.985	1.232

TABLE.5. DESCRIPTIVE SUMMARY OF TEMPORAL VARIATIONS IN THE WQI SCORE LEVELS OF RIVER TAMIRABARANI DURING THE YEAR 2020

Months	N	Min	Max	Mean		Stdev	Variance	Kurtosis	
Year 2020	Statistic	Statistic	Statistic	Statistic	SE	Statistic	Statistic	Statistic	SE
January	12	72.30	99.45	87.0675	2.2348	7.7416	59.932	.187	1.232
February	12	78.92	97.15	90.4083	1.2588	4.3605	19.014	4.602	1.232
March	12	70.37	94.92	86.8275	2.4119	8.3549	69.804	.584	1.232
April	12	54.39	90.24	71.5942	2.9587	10.2491	105.045	-.425	1.232
May	12	81.40	98.01	86.4825	1.2807	4.4365	19.683	3.637	1.232
June	12	80.24	99.00	90.7683	2.1521	7.455	55.576	-1.741	1.232
July	12	81.03	96.39	87.6750	1.4493	5.0205	25.205	-1.174	1.232
August	12	78.15	97.16	90.3525	1.5772	5.4635	29.850	.705	1.232
September	12	73.90	99.11	92.0392	2.2503	7.7951	60.764	1.651	1.232
October	12	67.23	95.44	81.6017	2.7177	9.4144	88.632	-1.090	1.232
November	12	75.24	97.37	85.9117	1.9614	6.7944	46.163	-.640	1.232
Decembe	12	81.97	97.84	89.3708	1.3835	4.7927	22.970	-.111	1.232

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TABLE.6. CORRELATION MATRIX OF BETWEEN PHYSICOCHEMICAL VARIABLES AND WATER QUALITY INDEX SCORE LEVELS AT RIVER TAMIRABARANI

DURING THE STUDY – YEAR 2020

		Velo	Disch	pH	EC	DO	TDY	TDS	TSS	NH4-N
Velo	R	1	.723(**)	-.206	-.207	-.430	-.210	-.207	-.056	-.349
	P		.008	.520	.519	.163	.513	.518	.862	.266
Disch	R	.723(**)	1	-.185	-.389	-.478	-.244	-.388	.126	-.081
	P	.008		.565	.211	.116	.444	.213	.696	.803
pH	R	-.206	-.185	1	.784(**)	-.523	.556	.784(**)	.687(*)	.422
	P	.520	.565		.003	.081	.060	.003	.013	.172
EC	R	-.207	-.389	.784(**)	1	-.512	.741(**)	1.000(**)	.747(**)	.535
	p	.519	.211	.003		.089	.006	.000	.005	.073
DO	r	-.430	-.478	-.523	-.512	1	-.504	-.514	-.725(**)	-.255
	p	.163	.116	.081	.089		.095	.087	.008	.424
TDY	r	-.210	-.244	.556	.741(**)	-.504	1	.743(**)	.838(**)	.341
	p	.513	.444	.060	.006	.095		.006	.001	.278
TDS	r	-.207	-.388	.784(**)	1.000(**)	-.514	.743(**)	1	.749(**)	.536

	p	.518	.213	.003	.000	.087	.006		.005	.073
TSS	r	-.056	.126	.687(*)	.747(**)	-.725(**)	.838(**)	.749(**)	1	.555
	p	.862	.696	.013	.005	.008	.001	.005		.061
NH4 -N	r	-.349	-.081	.422	.535	-.255	.341	.536	.555	1
	p	.266	.803	.172	.073	.424	.278	.073	.061	
NO2	r	.760(**)	.497	.162	.323	-.639(*)	.110	.322	.318	.183
	p	.004	.100	.614	.306	.025	.733	.307	.314	.568
NO3	r	.184	.321	.556	.543	-.799(**)	.360	.544	.612(*)	.648(*)
	p	.566	.310	.061	.068	.002	.251	.067	.034	.023
COD	r	-.230	.153	.704(*)	.567	-.522	.467	.568	.745(**)	.754(**)
	p	.473	.635	.011	.055	.082	.126	.054	.005	.005
BOD	r	.239	.499	.586(*)	.429	-.749(**)	.286	.431	.683(*)	.676(*)
	p	.455	.099	.045	.164	.005	.368	.162	.014	.016
Na	r	-.200	-.432	.774(**)	.992(**)	-.450	.704(*)	.992(**)	.689(*)	.531
	p	.534	.161	.003	.000	.142	.011	.000	.013	.076
F	r	.423	.678(*)	.037	.012	-.524	.117	.013	.431	.375
	p	.170	.015	.909	.969	.080	.718	.967	.161	.229
FC	r	-.211	.197	.216	.193	-.109	.022	.194	.371	.862(**)
	p	.509	.540	.499	.547	.737	.945	.546	.235	.000
WQI	r	-.123	-.157	-.726(**)	-.806(**)	.813(**)	-.704(*)	-.807(**)	-.894(**)	-.662(*)
	p	.703	.626	.007	.002	.001	.011	.002	.000	.019
Velo		NO2	NO3	COD	BOD	Na	F	FC	WQI	
		.760(**)	.184	-.230	.239	-.200	.423	-.211	-.123	
Disch		.004	.566	.473	.455	.534	.170	.509	.703	
		.497	.321	.153	.499	-.432	.678(*)	.197	-.157	
		.100	.310	.635	.099	.161	.015	.540	.626	
PH		.162	.556	.704(*)	.586(*)	.774(**)	.037	.216	-.726(**)	
		.614	.061	.011	.045	.003	.909	.499	.007	
EC		.323	.543	.567	.429	.992(**)	.012	.193	-.806(**)	
		.306	.068	.055	.164	.000	.969	.547	.002	
DO		-.639(*)	-.799(**)	-.522	-.749(**)	-.450	-.524	-.109	.813(**)	
		.025	.002	.082	.005	.142	.080	.737	.001	
TDY		.110	.360	.467	.286	.704(*)	.117	.022	-.704(*)	

		.733	.251	.126	.368	.011	.718	.945	.011	
TDS		.322	.544	.568	.431	.992(**)	.013	.194	-.807(**)	
		.307	.067	.054	.162	.000	.967	.546	.002	
TS		.318	.612(*)	.745(**)	.683(*)	.689(*)	.431	.371	-.894(**)	
		.314	.034	.005	.014	.013	.161	.235	.000	
NH4 N		.183	.648(*)	.754(**)	.676(*)	.531	.375	.862(**)	-.662(*)	
		.568	.023	.005	.016	.076	.229	.000	.019	
No2		1	.607(*)	.222	.522	.334	.617(*)	.181	-.581(*)	
			.036	.489	.082	.289	.032	.573	.048	
NO3		.607(*)	1	.776(**)	.855(**)	.505	.486	.483	-.823(**)	
		.036		.003	.000	.094	.109	.112	.001	
COD		.222	.776(**)	1	.785(**)	.524	.399	.693(*)	-.757(**)	
		.489	.003		.002	.080	.198	.013	.004	
BOD		.522	.855(**)	.785(**)	1	.396	.622(*)	.648(*)	-.828(**)	
		.082	.000	.002		.203	.031	.023	.001	
N a		.334	.505	.524	.396	1	-.008	.191	-.780(**)	
		.289	.094	.080	.203		.981	.552	.003	
F		.617(*)	.486	.399	.622(*)	-.008	1	.592(*)	-.501	
		.032	.109	.198	.031	.981		.042	.097	
Fc		.181	.483	.693(*)	.648(*)	.191	.592(*)	1	-.449	
		.573	.112	.013	.023	.552	.042		.143	
WQI		-.581(*)	-.823(**)	-.757(**)	-.828(**)	-.780(**)	-.501	-.449	1	
		.048	.001	.004	.001	.003	.097	.143		

TABLE.7. PHYSICOCHEMICAL PROPERTIES OF RIVER TAMIRABARANI DURING THE STUDY (MEAN±SD)

Station	Velocity	Discharge	pH	EC	DO	TDY	TDS	TSS
	m/sec	m^3/sec		µS/cm	mg/L	NTU	mg/L	mg/L
T1	0.33±0.19	11.96±8.46	7.52±0.31	59.97±16.18	7.63±1.13	1.50±0.88	42.33±11.24	2.25±1.55
T2	0.22±0.14	12.77±7.76	7.80±0.37	88.25±41.81	7.11±1.08	1.47±0.58	62.17±29.73	2.67±1.72
T3	0.23±0.09	17.83±7.55	7.67±0.29	113.48±51.35	6.58±1.23	1.96±1.58	80.50±36.32	4.00±2.79
T4	0.34±0.12	21.01±7.74	7.84±0.32	145.45±78.01	6.55±1.04	3.39±3.60	103.17±55.09	6.17±4.75
T5	0.30±0.09	19.54±7.42	7.77±0.38	149.50±73.21	6.44±1.32	3.21±2.99	105.83±51.96	6.42±4.17
T6	0.36±0.15	20.19±7.82	7.73±0.26	143.50±64.10	6.41±1.04	5.82±5.51	101.67±45.62	7.33±6.51
T7	0.34±0.19	21.15±9.06	7.70±0.29	181.63±83.59	6.50±1.35	3.40±2.81	128.50±59.18	6.42±4.27
T8	0.22±0.13	21.00±9.19	7.88±0.27	186.89±77.03	6.66±1.17	3.11±2.20	132.17±54.46	7.33±5.07
T9	0.34±0.12	20.66±9.06	7.78±0.40	186.69±74.47	6.30±0.96	3.49±3.03	131.83±52.61	6.75±4.49
T10	0.79±0.42	24.36±12.54	7.84±0.36	237.08±108.79	5.90±1.48	3.27±2.75	167.17±77.25	6.25±3.89
T11	0.14±0.16	7.83±13.05	7.83±0.19	247.51±90.22	6.56±1.40	4.89±3.41	175.00±63.87	6.33±3.87
T12	0.03±0.03	3.94±3.77	7.99±0.17	396.31±95.41	6.55±1.24	5.95±4.10	279.17±66.37	8.25±3.77
	NH4-N	NO2	NO3	COD	BOD	Na	F-	TC
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Count/100ml
T1	0.03±0.04	0.01±0.01	0.24±0.19	5.25±2.96	1.40±0.73	7.95±3.48	0.004±0.01	63.25±93.893
T2	0.04±0.04	0.01±0.01	0.40±0.19	6.67±4.27	2.13±1.56	11.24±6.49	0.004±0.01	49.67±54.125
T3	0.09±0.06	0.01±0.02	0.48±0.22	6.92±3.34	2.74±1.21	12.18±5.21	0.006±0.01	132.25±99.503
T4	0.01±0.03	0.01±0.01	0.38±0.24	7.33±3.92	2.51±1.29	15.81±11.81	0.007±0.01	34.67±25.819
T5	0.05±0.04	0.01±0.01	0.39±0.27	6.50±3.83	2.64±1.68	15.30±6.13	0.008±0.01	42.25±35.798

T6	0.07±0.05	0.02±0.02	0.44±.30	7.08±2.94	2.69±1.67	16.32±6.02	0.014±0.01	67.08±92.098
T7	0.10±0.06	0.04±0.03	0.51±0.30	7.83±3.49	2.70±1.75	19.94±8.85	0.014±0.01	201.33±340.058
T8	0.17±0.09	0.02±0.05	0.51±0.33	8.58±4.69	3.86±1.27	22.71±9.13	0.016±0.02	414.50±621.979
T9	0.10±0.07	0.04±0.02	0.47±0.33	7.33±3.99	3.04±1.90	22.78±9.05	0.025±0.03	260.25±459.983
T10	0.06±0.04	0.07±0.10	0.54±0.32	6.92±3.63	3.40±2.46	30.19±15.82	0.014±0.02	59.50±42.656
T11	0.08±0.06	0.01±0.02	0.45±0.26	7.17±4.30	2.49±1.02	29.25±12.80	0.005±0.02	89.83±135.022
T12	0.13±0.09	0.02±0.03	0.47±0.28	7.83±4.57	2.71±1.88	51.76±17.48	0.003±0.01	137.17±133.859

Correlation study between physicochemical properties and WQI score level (Table.6) showed significant negative relationship with pH, EC, DO, TDY, TDS, NH4-N, NO2, NO3, COD, BOD and Na respectively at the levels of $p<0.01$ and $p<0.05$ whereas WQI score level doesn't reveal any significant relationship with velocity and discharge level of the river. Physicochemical properties of the river during the study are tabulated in Table.7.

Cluster analysis showed 11 hierarchical arrangements of sampling stations based on WQI score levels (Fig.3). Sampling station T1 and T2 showed similar quality, T3, T4 and T5 forms a cluster, T7, T8 and T9 showed similar score levels and remaining 4 stations grouped together through hierarchical arrangement.

VI. DISCUSSION

Spatial variations in the WQI score levels may due to the in-stream activities like higher washing, bathing, sand mining, animal cleaning etc., runoff from agricultural fields, livestock discharges and from rural and urban areas, whereas the quality was mainly deteriorated by various organic inputs

along the river course through canals which consists of domestic wastes, sewage discharges without treatment, open defecation, hospital wastes and dumping of garbage wastes at

the bank areas (Murugesan, 2000; Murugesan et al., 2004). Damming at downstream reaches increase the growth of aquatic weeds which in-turn, decreases the photosynthesis activity of hydrophytes and also depletes the dissolved oxygen content. The variation in pH level also regulates most of the biochemical and chemical reactions; affecting water composition (Bellos and Sawidis, 2005).

Present study from January to December during the year 2020 clearly indicates that decreasing water quality during the summer period, although not as dramatic drop in river flow. Similar findings were recorded by Barros et al., (1995); Adriano et al., (2006). Temporal variation of most water quality variables is usually high in lotic environments (France and Peters, 1992; Chambers et al.,1992; Cattaneo and Prairie, 1995). Present study results (Figure.2) also reveal similar results in the WQI score levels during the study. Moreover the results give a cumulatively derived numerical expression which defines the level of water quality at river Tamirabarani.

VII. CONCLUSION

The present study from January to December during the year 2020 was carried out with the aim of assessing the pollution potential of the perennial river Tamirabarani and classifies the river stretches based on the mathematical aggregation function. The results classifies the water quality into excellent (21.53 %), very good (28.47 %), good (33.33
%), fair (13.89 %) and marginal (2.78 %) out of 144 samplings during the study. Most of the physicochemical properties of the water significantly alter the quality at downstream areas after sampling stations T3. During the study BOD and DO levels exceed the standard levels at various stretches of the river. The present study concludes that the WQI classification function is one of the best tools to enumerate the pollution potential in comprehensive manner and also used for classification of water quality that is easy for everyone to understand based on scientific criteria for water quality.

This, in turn, is essential for comparing the water quality of different stretches and in monitoring the changes in the water quality of a water body as a function of time and other influencing factors. The concept also aims at eliminating the subjective assessment of water quality and the individual biases of water resource managers.

REFERENCES

[1] Abbasi, S.A., (2002). Water quality indices', state of the art report. Scientific contribution No.INCOH/SAR-25/2002. Roorkee: INCOH, National Institute of Hydrology, p. 73.

[2] Adriano, A. Bordalo., Rita Teixeira., and William, J. Wiebe., (2006). A Water Quality Index Applied to an International Shared River Basin: The Case of the Douro River. Environ Manage, 38: 910-920.

[3] Almeida, C.A., Quintar, S., Gonzalez, P., and Mallea, M.A., (2007). Influence of urbanization and tourist activities on the water quality of the Potrero de los Funes River (San Luis-Argentina). Environmental Monitoring and Assessment, 133: 459-465.

[4] APHA (American Public Health Association.), (1999). Standard methods for examination of waters and wastewaters (20th ed.). Washington, DC, p. 1325. ISBN-10: 0875532357.

[5] Avnish, K.Verma., and Saksena, D.N., (2010) Assessment of Water quality and Pollution Status of Kalpi (Morar) River, Gwalior, Madhya Pradesh: with special

reference to Conservation and Management plan, Asian J.Exp.Biol.Sci, 1(2): 419-429.

[6] Barros, M.C., Mendo, M.J.M., and Negra˜o, F.C.R., (1995). Surface water quality in Portugal during a drought period. Science of the Total Environment, 171: 69-76.

[7] Bartram, J., Cotruvo, J, Exner, M., Fricker, C., and Axec, G., (2002). Heterotrophic plate count measurement in drinking water safety management; report of an expert meeting Geneva, Int. J. Food Microbiol, 92: 241-247.

[8] Bellos, D., and Sawidis, T., (2005). Chemical pollution monitoring of the River Pinios (Thessalia-Greece). Journal of Environmental Management, 76(4): 282-292.

[9] BIS (Bureau of Indian Standards), (2003). Indian standard drinking water specifications; IS 10500: 1991, Edition 2.2 (2003 - 09), Bureau of Indian Standards, New Delhi.

[10] Bordalo, A.A., Teixeira, R., and Wiebe, W.J., (2006). A water quality index applied to an international shared river basin: the case of the Douro river. Environ. Manage, 38: 910-920.

[11] Brown, R.M., McClelland, N.I., Deininger, R.A., and Tozer, R.G.,(1970). A water quality index: Do we dare? Water & Sewage Works, 117(10): 339-343.

[12] Cattaneo, A., and Prairie, Y.T., (1995). Temporal variability in the chemical characteristics along the Riviere de l'Achigan: How many samples are necessary to des cribe stream chemistry? Can. J. Fish. Aq. Sci, 52: 828-835.

[13] CCME (Canadian Council of Ministers of the Environment)., (2006). A Canada-wide framework for water quality monitoring. Water Quality Task Group. PN.1369, p. 25. Retrieved from: www.ccme.ca/assets/pdf/wqm_framework_1.0_e_web.pdf

[14] Chambers, P.A., Prepas, E.E., and Gibson, K., (1992) Temporal and spatial dynamics in riverbed chemistry: The influence of flow and sediment composition. Can. J. Fish. Aq. Sci, 49: 2128-2140.

[15] Chandrasekar, N., Sivasubramanian, P., and John Prince Soundranayagam., (2010). Ecological Consequences of Rapid Urban Expansion: Tirunelveli, India. African Journal of Basic & Applied Sciences, 2 (5-6): 167-176.

[16] CPCB (Central Pollution Control Board), (2008). Guidelines for Water Quality Monitoring. MINARS//2007-08, p. 35.

[17] Cude, C., (2001). Oregon Water Quality Index: a tool for evaluating water quality management effectiveness. J. Am. Water Resour. Assoc, 37(1): 125-137.

[18] Debels, P., Figueroa, R., Urrutia, R., Barra, R., and Niell, X., (2005). Evaluation of water quality in the Chilla'n River (Central Chile) using physicochemical parameters and a modified water quality index. Environmental Monitoring and Assessment, 110: 301-322.

[19] Dinius, S.H., (1987) Design of an index of water quality. Water Resources Bulletin, 23(5): 833-843.

[20] France, R.L., and Peters, R.H., (1992). Temporal variance function for total phosphorus concentration. Can. J. Fish. Aq. Sci, 49: 975- 977.

[21] Gergel, S.E., Turner, G.M., Miller, R.J., (2002). Landscape indicators of human impacts to riverine systems. Aquat Sci, 64: 118-128.

[22] Gupta, A.K., Gupta, S.K. and Patil, R.S., (2003). A comparison of water quality indices for coastal water. Journal of Environmental Science and Health (Part A), 38(11): 2711-2725.

[23] Hema, S., and Muthalagi, S., (2009) Mass balance approach for assessment of pollution load in the Tamiraparani river. Int. J. Chem. Tech. Res, 1(2): 385-389.

[24] John De Britto, A., and Peter Baskaran , P., (2010). Impact of industrial effluents and sewage on river Thamirabarani and it's concerns. Bioresearch Bulletin, 1: 16-18.

[25] Khan, F., Husain, T., and Lumb, A., (2003). Water quality evaluation and trend analysis in selected watersheds of the Atlantic region of Canada. Environmental Monitoring and Assessment, 88: 221-242.

[26] Landwehr, J.M., and Deininger, R.A., (1976). A comparison of several water quality indices. Water Pollut Control Federation, 48(5): 954-958.

[27] Landwehr, J.M., Deininger, R.A., McClelland, N.L., and Brown, R.M., (1974). An objective water quality index. Discussion by Ralph D. Harkins. Journal of Water Pollution Control Federation, 46(7): 1804- 1809.

[28] Lumb, A., Halliwell, D., and Sharma, T., (2006). Application of the CCME water quality index to monitor water quality: A case study of the Mackenzie River Basin, Canada. Environmental Monitoring and Assessment, 113; 411-429.

[29] Mophin Kani, K., and Murugesan, A.G., (2010). Determination of water quality deterioration using Coliforms as pollution indicators at river Tamirabarani, Tamil Nadu, India. Journal of Basic and Applied Biology, 4(1&2): 209-215.

[30] Murugesan, A.G., (2000). Environmental status of the perennial river Tamirabarani with special reference to domestic and industrial pollution. Workshop on enhancing the public awareness on the ecological and environmental status of the river basins; Proc, p.15-20.

[31] Murugesan, A.G., Abdul Hameed, K.M.S.A., and Sukumaran, N., (1994). Water Quality Profile of the Perennial River Tamirabarani. Indian Journal of Environmental Protection (IJEP). 14(8): 567- 572.

[32] Murugesan, A.G., John Ruby and Sukumaran, N., (2002). Toxic impact of Environmental Pollutants on Freshwater Habitats - An overview. In ecology of polluted waters (Ed. Arvind Kumar) Ashish Publishing Corp, New Delhi, India, p.1207-1218.

[33] Murugesan, A.G., John Ruby and Sukumaran, N., (2004). Pollution status of perennial river Tamirabarani with special reference to sewage mixing and coliform bacteria. Management of sustainable environment, p.187-195.