Quality Determination and Bio-mapping of River Tamirabarani Emphasizing on Physicochemical and Biological aspects

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Abstract- Water quality of the river Tamirabarani during the period of 2008-09' was assessed with special reference to physicochemical and biological aspects for the enumeration of the current pollution scenario of the river. The results showed that the quality of water was worsening at downstream areas after the sampling point T3 and the quality of the water was mainly deteriorated through high coliform content and higher organic inputs through various in-stream and bank activities like religious, rituals, agricultural, open defecation, direct mixing of sewage and domestic wastes, dumping of garbage wastes and other activities. Significant temporal variations also were record during the study. Tributaries contribute significant pollutant load to the main flow along its course. At main river flow 91.67% of the sampling stations showed class "B" quality and the remaining 8.33% of the sites showed class "C" quality of water. Tributaries were classified into class "A" 16.67%, class "B" 8.33%, class "C" 16.67%, class "D" 25% and class "E" 33.33% respectively.

Keywords - Bio-mapping, River Tamirabarani, Primary water quality criteria (PWQC), Biological water quality criteria (BWQC), Macro-invertebrate organisms, Arc-View GIS.

I. INTRODUCTION

Urbanization, industrialization and agricultural activities were high along the river banks of developing countries like India. Outdoor bathing and washing and allied activities are important *in situ* utilization of water bodies, which demands water quality requirements for drinking as well as bathing purposes. Lakes, rivers and streams are rich environments; also used as source of drinking water, irrigation, industry, fishery and energy production [1]. Human societies are putting ever increasing pressure with population explosion and urbanization activities on the planet's water resources which affect freshwater system and its structure and function in an ever alarming way [2]. Urban centers put huge amounts of organic and synthetic waste into rivers. Improper agricultural practices like excessive use of agro chemicals alter river and its ecological integrity. Changes in land use patterns like canalization, damming, mining, diversions and recreational activities also deteriorate river ecosystem [2-6]. The impact of these anthropogenic activities has been so extensive that the water bodies have lost their self-purification capacity to a large extent [7]. Indeed, anthropogenic pollution of freshwater systems by the addition of organic matter and nutrients is an increasing phenomenon that affects many rivers worldwide [8-9] which enters mainly through storm water runoff and discharges of sewage [10-11] surface water posses a high possibility of organic, bacterial and viral contamination [12]. India is a country of religious and various rituals; rivers play an important role in performing these activities. The ancient myths and rituals were centered on rivers. People believed them as holy and have the power to wash away sin [13]. In many regions of India, river water is the prime source of drinking. Urban centers, capitals and most productive agricultural lands are tied to rivers. In India, water pollution comes from three main sources: domestic sewage, industrial effluents and run-off from irrigational lands and urban areas [14].

Bio-mapping is the technique of transforming physicochemical and biological water quality of a river basin into coloured map by decision support system like GIS; this can be used for taking quick decision. GIS is a powerful tool for spatial discretion, parameterization and visualization of water quality [15-16]. Different colours on a basin map, such as blue, light blue, green, orange and red, indicate various water quality classes in terms of clean, slight pollution, moderate pollution, heavy pollution and severe pollution of a water body respectively [17]. The present

study was undertaken with the aim of assessing current pollution scenario of the perennial river and to convert observed data into coloured map.

II. METHODOLOGY

A. *Study area*

Perennial river Tamirabarani is originates at the eastern slops of the Western Ghats of Tirunelveli district of Tamil Nadu, India. It originates at Agasthiya hills with an altitude of 1725 m above MSL; situated between latitudes 8°30'N and 9°18'N and longitudes 77°07'30"E and 78°15'E. It traverses a length of about 125 km and enriches the economy of two southern districts Tirunelveli and Thoothukudi before it confluences with the Gulf of Mannar region of the Bay of Bengal. Urbanization practices along the river course increases pollution threat at several places with direct discharge of domestic, sewage and agricultural runoffs without any treatment. Added to these huge gathering of peoples to take holy dip at most part of the river stretches, open defecation, livestock farm wastes, industrial discharges, sand mining and other bank activities also diminishes the originality of the river [18-19].

The river was the major source for both the major districts and neighboring areas for its potable water supply, domestic uses, industrial needs, agricultural practices and other water related activities. 24 sampling stations (12 at main river flow and 12 at tributaries) (Plate.1) were selected for the present study based on the habitat assessment and with expert's advice which were based on the pollution intrusion points, tributary entry points, huge gathering localities and runoff entry points from invasion agricultural practices, urban and rural areas. Sampling was carried out during each quarter period of the study tenure (January 2008-March'09), separately for physicochemical and biological assessment.

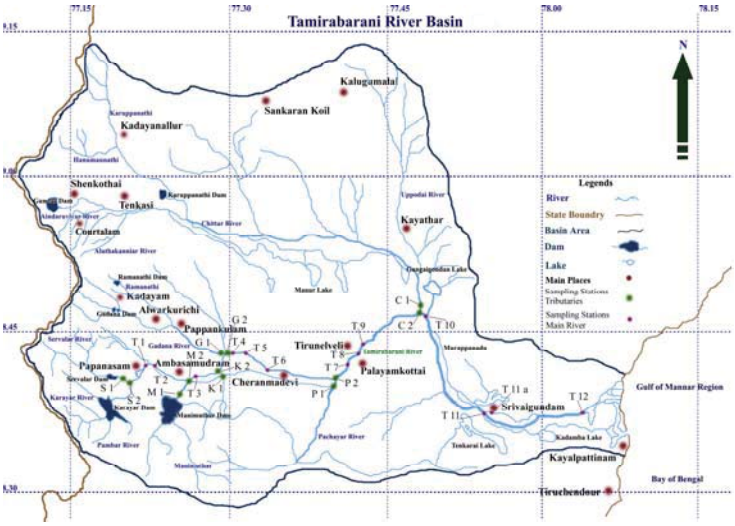

Plate.1. Study area and Sampling Locations

B. *Physicochemical, biological and biomonitoring study*

Physicochemical analyses were carried out based on APHA [20] methodologies. Macrobenthic organism samples were collected using a three-minute single-habitat kick sampling method [21] formulated by Environmental Protection Agency and based on a methodology manual of Subramanian and Sivaramakrishnan [22]. The family level identification of macrobenthic organisms were carried out using the key factors given by Patrik [23] Dudgeon [24] and Subramanian and Sivaramakrishnan [25]. Saprobic and diversity scores were calculated based on Central Pollution Control Board [26] methodologies. Bio-mapping of the river was made through overlapping of primary water quality criteria (PWQC - Table.1) and biological water quality criteria (BWQC - Table.2) of CPCB, India, using GIS (ArcView GIS, version.3.2) as a mapping tool. The map was created using mathematical (logical) function (Table.3) to overlap both physicochemical and biological classification schemes; it gives the exact water quality class using the logical formula and change the indicative colour of the sampling locality accordingly.

Table.1. Primary water quality criteria for various uses of fresh waters, as laid down by the Central Pollution Control Board

S. No.	Variables	A*	B*	C*	D*	E*
1.	Dissolved oxygen (DO), (mg/L), Min.	6	5	4	4	-
2.	Biochemical oxygen demand (BOD) (mg/L), Max.	2	3	3	-	-
3.	Total coliform organism** (MPN/100 ml), Max.	50	500	5,000	-	-
4.	pH value	6.5-8.5	6.5-8.5	6-9	6.5-8.5	6.5-8.5
5.	Chlorides (as Cl), (mg/L), Max	250	-	600	-	600
6.	Free Ammonia (as N), (mg/L) Max	-	-	-	1.2	-
7.	Sodium adsorption ratio, Max.	-	-	-	-	26
8.	Boron, (mg/l), Max	-	-	-	-	2
9.	Sulphates (as SO_4), (mg/L) Max	400	-	400	-	1000
10.	Nitrates (as NO_3), (mg/L) Max	20	-	50	-	-
11.	Conductivity at 25˚C, (micromhos/cm), Max	-	-	-	1000	2250
12.	Total Dissolved Solids (mg/L) Max	500	-	1500	-	2100
13.	Fluorides (as F), (mg/L), Max	1.5	1.5	1.5	-	-

Use class : (A) drinking water source without conventional treatment but after disinfection, (B) outdoor bathing Organized, (C) drinking water source with conventional treatment followed by disinfection, (D) propagation of wildlife, fisheries, (E) irrigation, industrial cooling controlled waste disposal.

** If the coliform is found to be more than the prescribe tolerance limits, the criteria for coliforms shall be satisfied if not more than 20 percent of samples show more than the tolerance limits specified, and not more than 5 percent of samples show values more than 4 times the tolerance limits. There should be no visible discharge of domestic and industrial wastes into Class A waters. In case of Class B and C the discharge shall be so regulated / treated as to ensure maintenance of the stream standards.

Table.2. Biological water quality criteria for various uses of fresh waters, as laid down by the Central Pollution Control Board

Range of Saprobic Score (BMWP)	Range of Diversity Score	Water quality Characteristic	Water quality Class	Indicator Colour
7 and more	0.2 – 1	Clean	A	Blue
6 – 7	0.5 – 1	Slight Pollution	B	Light Blue
3 – 6	0.3 - 0.9	Moderate pollution	C	Green
2 – 5	0.4 and less	Heavy pollution	D	Orange
0 – 2	0 - 0.2	Severe Pollution	E	Red

Table.3. Logical functions of PWQC and BWQC

S.No						Overall Quality
	I	II	III	IV	V	
1	A	A	A	A	A	A
2	B	A	A	A	A	B
3	C	A	A	A	A	C
4	D	A	A	A	A	D
5	E	A	A	A	A	E
6	B	B	B	B	B	B
7	C	B	B	B	B	C
8	D	B	B	B	B	D
9	E	B	B	B	B	E
10	C	C	C	C	C	C
11	D	C	C	C	C	D
12	E	C	C	C	C	E
13	D	D	D	D	D	D
14	E	D	D	D	D	E
15	E	E	E	E	E	E

[The highest class which exhibits (PWQC & BWQC) in a sampling station will consider as the overall quality of the particular locality]

III. RESULT AND DISCUSSION

A. Human activities observed along the river and its bank areas

The following human activities were observed during study period: in-stream activities like bathing, washing, religious, rituals, sand mining, fishing, infiltration wells (drinking water supply) livestock cleaning, agricultural and habitation encroachment; bank activities like reserved habitation (forest), tourism, cultivation, agricultural, open defecation, cremation, brick works, bridge construction, habitation (human settlements), recreational, vehicle cleaning yards, cattle dunk drying, garbage and solid waste dumping, etc. Beside these human activities, the river ecology is significantly affected by direct discharge of untreated sewage and domestic wastes at several places after the sampling station T1.

B. Primary Water Quality of the river Tamirabarani and its Tributaries

Based on the primary water quality criteria the sampling stations during the study was categorized into class "A" (21.67 %), class "B" (51.67 %), class "C" (20 %), class "D" (3.33 %) and class "E" (3.33 %) respectively at the river Tamirabarani out of 60 samplings whereas the tributaries showed class "A" (18.18 %), class "B" (12.72 %), class "C" (7.27 %), class "D" (38.18 %) and class "E" (23.63 %) respectively out of 55 samplings. PWQC showed upto severe pollution level, higher BOD content, less DO level and the presence of coliform organisms in the sampling localities determines the water quality of the river Tamirabarani and its tributaries whereas remaining parameters (pH, NH_4-N, EC, SAR and B) showed the concentrations within the class "A" quality criteria levels. Physicochemical variables during the study were summarized at Table.4 and Table.5 with the standard deviation for 5 quarter studies and the water quality classes were summarized at Table.6 and Table.7 respectively.

Table.4. Physicochemical characteristics of river Tamirabarani

	pH	EC	DO	NH_4-N	BOD	B	TC	SAR
T1	7.61±0.46	59.87±21.38	7.24±0.80	0.01±0.03	1.24±0.55	BDL	102.8±144.108	0.97±0.612
T2	7.54±0.21	86.10±53.38	7.04±0.52	0.03±0.03	1.65±1.00	BDL	51.4±67.367	1.31±0.635
T3	7.63±0.36	123.24±64.22	6.59±1.00	0.07±0.05	2.42±1.18	BDL	135.4±129.251	1.17±0.31
T4	7.81±0.35	142.72±89.44	6.56±0.34	0.01±0.03	2.04±1.08	BDL	52.8±49.1091	1.48±0.680
T5	7.80±0.33	147.73±85.07	6.64±0.99	0.03±0.03	1.85±1.08	BDL	52.6±66.169	1.25±0.237
T6	7.88±0.25	156.06±84.08	6.81±0.65	0.04±0.03	1.59±0.67	BDL	63±61.758	1.34±0.515
T7	7.79±0.46	199.801±11.53	6.96±1.20	0.09±0.05	1.80±1.43	BDL	124±130.190	1.43±0.469
T8	7.97±0.26	206.71±96.50	6.76±0.84	0.17±0.10	3.69±0.42	0.0006±0.0013	942.8±1471.207	1.65±0.608
T9	7.77±0.46	208.67±88.62	6.11±0.45	0.09±0.06	2.77±0.66	0.0003±0.0007	182.6±144.374	1.61±0.501
T10	7.94±0.40	264.28±117.63	6.18±1.40	0.06±0.04	2.37±1.02	BDL	69±63.93	1.86±0.478
T11	7.90±0.27	277.91±109.08	6.03±1.03	0.08±0.06	2.18±1.10	BDL	112±131.109	1.64±0.558
T12	8.05±0.20	408.1±294.01	5.95±1.04	0.13±0.08	2.55±2.47	BDL	150±119.792	2.50±1.008

Table.5. Physicochemical characteristics of tributaries

	pH	EC	DO	NH_4-N	BOD	B	TC	SAR
S1	6.73±0.15	26.86±5.51	7.76±0.80	Nil	0.24±0.09	BDL	Nil	0.58±0.26
S2	6.71±0.12	32.73±6.84	7.12±0.48	Nil	0.24±0.09	BDL	Nil	0.54±0.24
M1	6.97±0.20	43.21±3.62	6.12±0.52	Nil	2.55±0.70	BDL	7±2.12	0.71±0.13
M2	7.48±0.14	88.52±15.08	6.20±0.86	0.06±0.00	3.24±0.72	BDL	64.4±81.77	0.77±0.13
K1	7.84±0.14	151.33±53.36	3.95±2.64	0.06±0.00	5.00±0.23	BDL	56.67±46.19	1.54±0.79
K2	7.84±0.31	87.47±23.42	5.56±0.59	0.11±0.00	4.54±0.23	BDL	49±51.61	1.05±0.38
G1	7.55±0.19	264.85±102.27	5.76±0.64	0.09±0.06	4.98±0.70	BDL	90.4±101.41	1.00±1.03
G2	7.57±0.18	108.95±41.72	5.80±0.75	0.07±0.03	5.02±0.79	BDL	73.6±81.66	1.12±0.53
P1	7.90±0.24	161.52±56.38	5.27±0.31	0.06±0.00	3.71±1.15	BDL	38.67±12.06	0.87±0.93
P2	7.80±0.35	98.32±41.93	5.56±0.38	0.14±0.04	4.21±0.39	BDL	90.2±102.05	1.07±0.77
C1	8.26±0.11	1217.68±252.01	10.90±2.39	0.15±0.10	8.31±0.78	BDL	101±79.69	8.92±5.04
C2	8.17±0.05	484.56±54.80	5.52±0.18	0.14±0.07	5.18±0.23	BDL	87.2±57.79	5.42±1.92

(Values were mean of 5 quarter periods ± SD)

Table.6. Overall water quality calculated from PWQC and BWQC for the river Tamirabarani

Site ID	Primary Water Quality					Biological Water Quality					Overall Quality				
	I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V
T1	A	A	B	A	B	A	A	A	A	A	A	A	B	A	B
T2	B	A	A	A	C	B	B	C	A	B	B	B	C	A	C
T3	C	B	B	C	B	C	C	D	C	D	C	C	D	C	D
T4	B	A	B	B	C	B	C	C	B	C	B	C	C	B	C
T5	C	A	A	B	B	C	C	C	B	C	C	C	C	B	C

T6	**B**	**A**	**A**	**B**	**B**	**C**	**C**	**C**	**C**	**C**	**C**	**C**	**C**	**C**	**C**
T7	**C**	**B**	**A**	**B**	**B**	**C**	**C**	**C**	**D**	**D**	**C**	**C**	**C**	**D**	**D**
T8	**D**	**C**	**C**	**C**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**
T9	**B**	**B**	**B**	**B**	**C**	**D**	**D**	**C**	**D**	**D**	**D**	**D**	**C**	**D**	**D**
T10	**B**	**B**	**B**	**C**	**B**	**C**	**C**	**C**	**C**	**D**	**C**	**C**	**C**	**C**	**D**
T11	**C**	**B**	**B**	**B**	**B**	**C**	**D**	**C**	**C**	**D**	**C**	**D**	**C**	**C**	**D**
T12	**E**	**B**	**B**	**B**	**B**	**D**	**D**	**D**	**D**	**D**	**E**	**D**	**D**	**D**	**D**

A-Clean, B-Slightly Polluted, C-Moderately polluted, D-Heavily polluted, E-Severely polluted

Table.7. Overall water quality calculated from PWQC and BWQC for tributaries

Site ID	**Primary Water Quality**					**Biological Water Quality**					**Overall Quality**				
	I	**II**	**III**	**IV**	**V**	**I**	**II**	**III**	**IV**	**V**	**I**	**II**	**III**	**IV**	**V**
S1	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**
S2	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**
M1	**B**	**B**	**B**	**B**	**C**	**A**	**A**	**A**	**A**	**A**	**B**	**B**	**B**	**B**	**C**
M2	**D**	**C**	**B**	**B**	**C**	**A**	**A**	**A**	**A**	**A**	**D**	**C**	**B**	**B**	**C**
K1	**D**	**Nil**	**Nil**	**E**	**D**	**A**	**Nil**	**Nil**	**B**	**C**	**D**	**Nil**	**Nil**	**E**	**D**
K2	**D**	**D**	**D**	**D**	**D**	**B**	**B**	**C**	**B**	**C**	**D**	**D**	**D**	**D**	**D**
G1	**D**	**D**	**D**	**E**	**E**	**A**	**A**	**C**	**B**	**B**	**D**	**D**	**D**	**E**	**E**
G2	**D**	**D**	**D**	**E**	**E**	**C**	**B**	**B**	**C**	**C**	**D**	**D**	**D**	**E**	**E**
P1	**D**	**Nil**	**B**	**D**	**Nil**	**B**	**Nil**	**B**	**C**	**Nil**	**D**	**Nil**	**B**	**D**	**Nil**
P2	**D**	**D**	**C**	**D**	**D**	**C**	**C**	**C**	**C**	**C**	**D**	**D**	**C**	**D**	**D**
C1	**E**	**Nil**	**E**	**E**	**E**	**C**	**Nil**	**D**	**C**	**C**	**E**	**Nil**	**E**	**E**	**E**
C2	**E**	**E**	**D**	**E**	**E**	**D**	**D**	**D**	**D**	**D**	**E**	**E**	**D**	**E**	**E**

A-Clean, B-Slightly Polluted, C-Moderately polluted, D-Heavily polluted, E-Severely polluted, Nil-Nil flow

C. Biological water quality of the river Tamirabarani and its tributaries

Altogether, 58 different families were recorded with a total number of 3372 individuals during the study (Table.8). Results clearly indicates that water quality of the river Tamirabarani and its tributaries were under class "A" at 10 % (out of 60 samples) of the sampling sites of the main river and 40 % of its tributaries and at stations T1, S1, S2, M1 and M2 throughout the study period; stations T2 and K1 also showed class "A" quality during IV and I quarterlies. Slightly pollution (class "B") quality of water was recorded at stations T2 (I, II and V quarterlies), T4 (I and IV quarterlies) and T5 (IV quarter) of the main river and G1 (II and IV quarterlies), G2 (I, II and IV quarterlies), K1 (IV and V quarterlies), K2 (II and III quarterlies) and P1 (I and III quarterlies) respectively (Table.4 and Table.5).

Table.8. List of observed macroinvertebrate families at river Tamirabarani and its Tributaries

Order	**Family**	**Order**	**Family**
Ephemeroptera	**Baetidae**	**Coleoptera**	**Gyrinidae**
	Ephemeridae		**Dytiscidae**
	Heptageniidae		**Hydrophilidae**
	Leptophlebiidae		**Dryopidae**
	Potomanthidae		**Psephenidae**
	Ephemerellidae		**Elmidae**
	Caenidae	**Diptera**	**Culicidae**
Plecoptera	**Perlidae**		**Tipulidae**
Trichoptera	**Polycentropodidae**		**Simuliidae**
	Rhyacophilidae		**Ceratopogonidae**
	Hydroptilidae		**Chironomidae**
	Hydropsychidae	**Gastropoda**	**Viviparidae**
	Philopotamidae		**Bithyniidae**
	Sericostomatidae		**Planorbidae**
	Lepidostomatidae		**Lymnaeidae**
	Glossosomatidae		**Unionidae**
	Calamoceratidae		**Physidae**
Hemiptera	**Corixidae**		**Valvatidae**
	Gerridae		**Ancylidae**
	Nepidae (ranatra)		**Hydrobiidae**
	Pleidae		**Thiaridae**
	Hydrometridae	**Odonata**	**Aeshnidae**
	Veliidae		**Lestidae**

	Belastomatidae		**Libellulidae**
	Naucoridae		**Corduliidae**
Lepidoptera	**Pyralidae**		**Calopterygidae**
Megaloptera	**Sialidae**		**Coenagrionidae**
Hirudinidae	**Hirudidae**	**Crustacea**	**Palemonidae**
Oligochaetae	**Oligochaetae**		**Potamonautidae**

Maximum sites record with moderately polluted quality of water at main river flow and its tributaries representing 45 % and 30 % respectively. The class "C" quality was observed at sampling points T2 (III quarter), T3 (I, II and IV quarterlies), T4 (II, III and IV quarterlies), T5 (I, II, III and V quarterlies), T6 (I-V quarterlies), T7 (I, II and III quarterlies), T9 (III quarter), T10 (I, II, III and IV quarterlies), and T11 (I, III and IV quarterlies) respectively of the main river. Tributaries showed class "C" quality of water at sampling sites G1 (III and V quarterlies), G2 (III and V quarterlies), K2 (I, IV and V quarterlies), P1 (IV quarter), P2 (I-V quarterlies) and C1 (I, IV and V quarterlies) respectively during the study.

Heavily polluted quality of water was recorded at 35 % of the sampling sites of the river Tamirabarani and 11.67 % of the tributaries during various quarterlies and at various sampling sites like T3 (III and V quarterlies), T7 (IV and V quarterlies), T8 (I-V quarterlies), T9 (I, II, IV and V quarterlies), T10 (V quarter), T11 (II and V quarterlies) and T12 (I-V quarterlies) of the river Tamirabarani and C1 (III quarter) and C2 (I-V quarterlies) of tributaries. Reference points showed clean quality of water throughout the study.

During the late northeast monsoon period (IV quarter); water quality was improved at upstream stretches whereas downstream areas after station T6 showed increased pollution level due to higher urban runoff, agricultural runoff and higher habitation discharges along the course of the river flow further the quality of the river was worsening during the V quarter study.

D. Bio-mapping of river Tamirabarani and its tributaries

Bio-mapping of the river was assigned through overall classification (Table.6 and Table.7) with the help of both biological and primary water quality of the river Tamirabarani and its tributaries based on the quality criteria prescribed by CPCB. Quarterly variations in the quality of water were expressed in GIS compatible map (Plate.2 and Plate.3).

Plate.2. Quarterly variations in the water quality of river Tamirabarani and its Tributaries

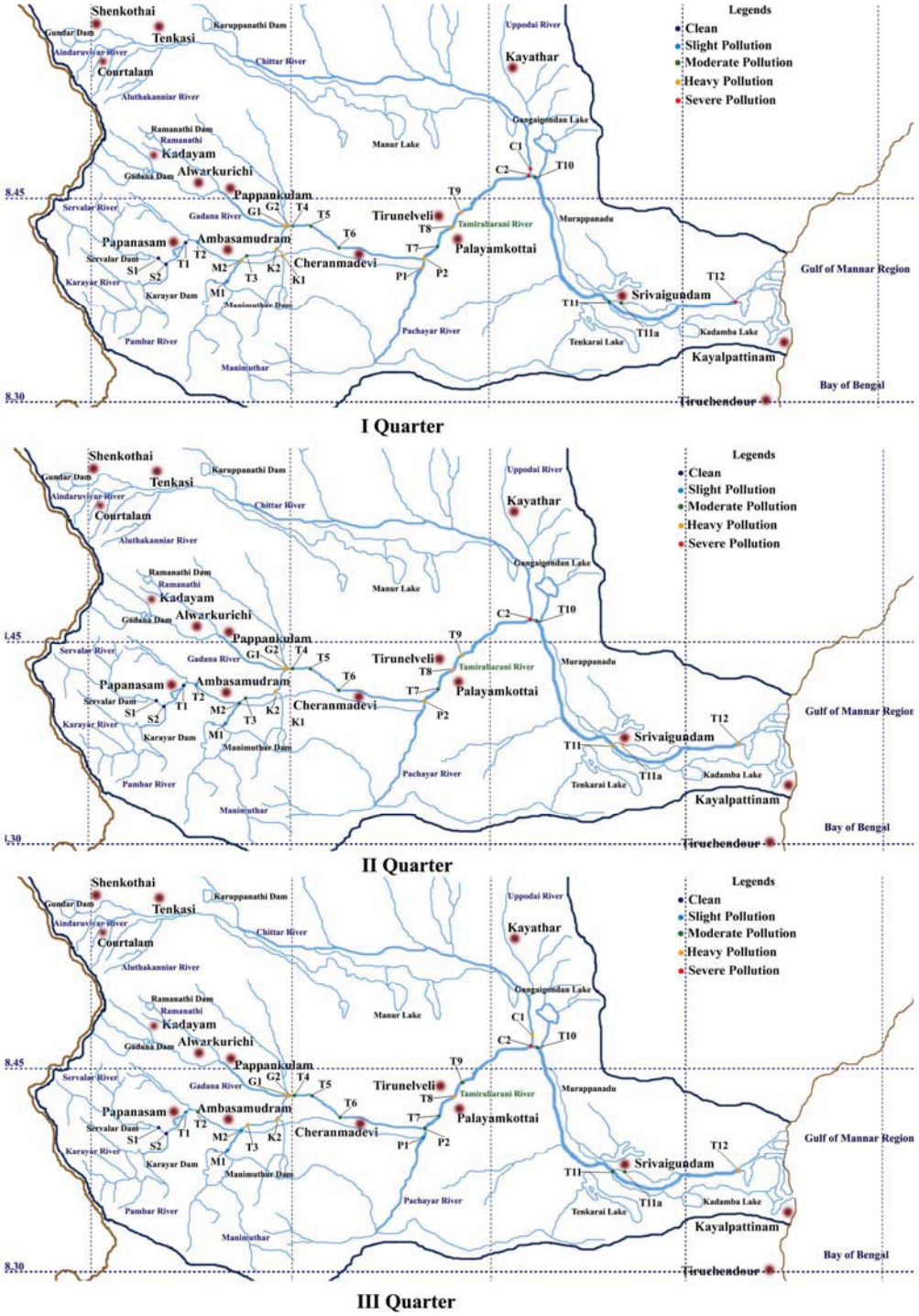

Plate.2. Quarterly variations in the water quality of river Tamirabarani and its tributaries

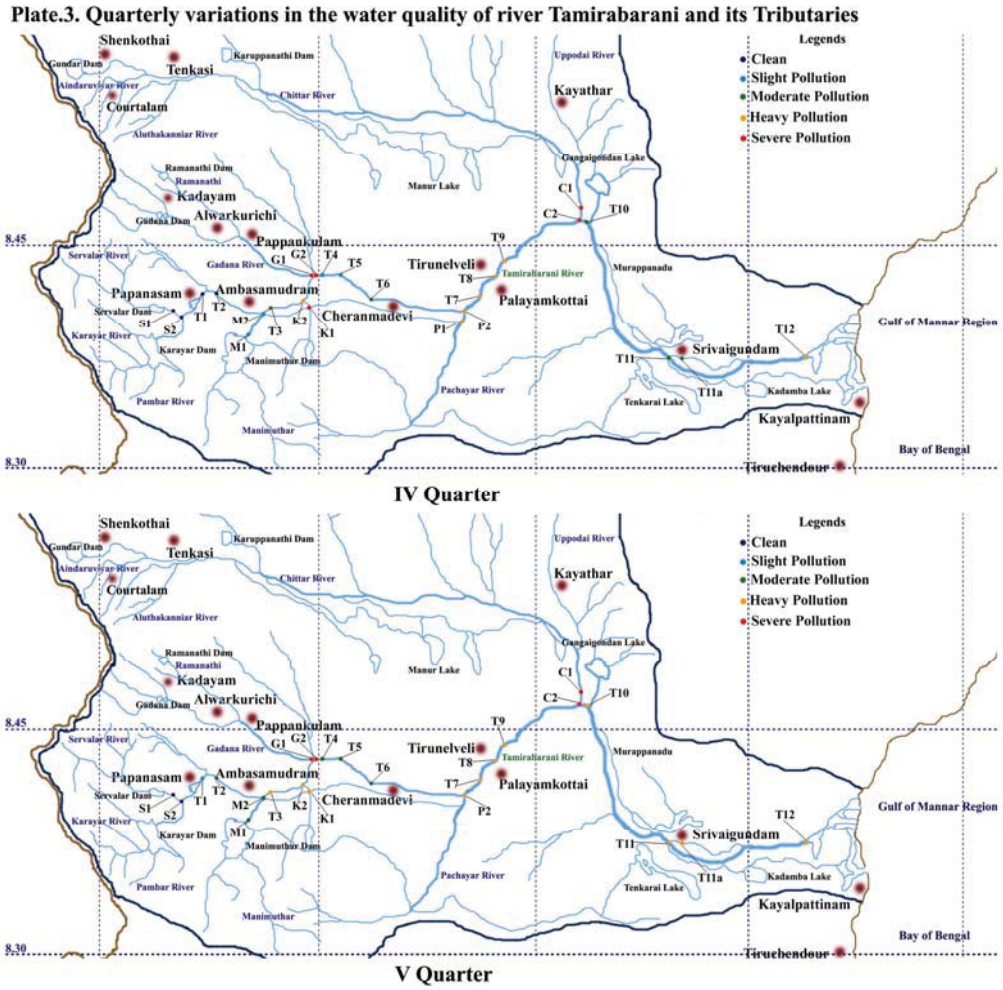

Plate.3. Quarterly variations in the water quality of river Tamirabarani and its tributaries

Comparative study between the biological water quality and primary water quality reveals significant similarities in the results at river Servalar whereas remaining stations showed slight to moderate level of variations between biological and primary water quality. Most of the sampling period, higher coliform content, BOD and COD levels of the river determines the quality of the river, whereas biomonitoring studies (BWQC) showed less polluted level when compared with the primary water quality. Quality of water was worsening at downstream areas when compared with the upstream areas; same trend of results was observed during 2003-04' at river Brahmaputra [27]. Open defecation at several stretches of the river Tamirabarani and its tributaries increases the coliform content as well as decreases the quality of aesthetic environment; previous study by Semwal and Akolkar [28] at Himalayan rivers also showed similarities in results.

IV.CONCLUSION

Based on the primary water quality and biological water quality criteria coloured bio-map of the river Tamirabarani was prepared for the spatial water quality determination and to determine tributaries contribution at various places of the main river flow. Out of 12 sampling stretches and 5 quarter period of study along the river 6.67 % of the sampling sites showed class "A" quality; 11.67 % of the sites showed class "B" quality, 46.67 % of the sampling sites showed class "C" quality, 33.33 % of the sites showed class "D" quality and the remaining 1.67 % of the studied sites showed class "E" quality. Out of six tributaries with 12 sampling sites and 5 quarter period of study 18.18 % of the studied locations showed class "A" quality, 12.73 % of the sites showed class "B" quality, 7.27 % of the sites showed class "C" quality, 38.18 % of the sampling locations showed class "D" quality whereas 23.64 % of the studied sites showed class "E" quality of water. Urban and suburban reaches of the river contribute significant level of pollutants at sites T3, T6, T7, T8, T9, T10 and T12 respectively. Even though the main river flow has its

high potential of self purification the contaminant contribution by the tributaries, urban and sub-urban reaches diminishes the quality of the water at downstream areas. The results of the present study concludes that the bio-mapping technique is an ideal tool for the enumeration of the water quality of the river basin and to create appropriate management measures to restore the originality of the river basin.

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