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The Influence of Flood and the Variation in Water Quality Index in River Periyar, Kerala, India.

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Abstract: *Periyar is the longest river in Kerala state. The river overflowed during August 2018 due heavy rainfall and releasing of water from the reservoir of Mullaperiayar Dam. This resulted in flood along the bank of the river and also extended to the nearby areas.Thus it was essential to monitor the quality of the river in order to ensure quality water for domestic and agricultural purposes. The aim of the study was to assess some physico-chemical parameters of river Periyar and present the Water Quality data of the river before and after flood. The Canadian Council of Ministry of Environment Water Quality Index(CCMEWQI)was applied on the analytical result of the parameters to obtain the Water Quality Index which in turn is used to rank the river. The result of the average Water Quality Index showed that three stations out of the ten stations were ranked 'Marginal' and the remaining stations were ranked 'Poor' in water quality. The overall Water Quality Index showed 'Poor' in quality.Managing and protecting water is essential for sustaining life. A continuous water quality monitoring program and proper water safety plan are essential to preserve and improve the water quality.*

Keywords: *Periyar, Water Quality Index (WQI), Canadian Council of Ministry of Environment Water Quality Index(CCMEWQI).*

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I. Introduction

Periyar is the longest river in Kerala state. The river provides water for irrigation and domestic use all along its course. It is also the main drinking water resource of Cochin corporation, Aluva and Paravur town. The river has been subjected continuous discharge of effluents from ever-growing industries in the Eloor- Edayar belt. So, continuous evaluation of water quality is much important.

The deterioration of water in physical and chemical properties is often slow and not readily noticeable as the water system adapt to the changes until an apparent alteration of the water occurs [1]. Flood is one of the most important disaster in the world. Flood mainly occurs due to heavy rainfall, high tide etc, which can have sudden effects on physicochemical parameters of river.

From 8 August 2018, sever floods affected Kerala, due to unusually high rainfall during monsoon season. The very sudden release of water from the Mullaperiyar Dam was one of the reasons for devastating flood in Ernakulam district, Kerala. Mullaperiyar Dam is an artificial reservoir created across the river Periyar. Releasing of water from the dam caused flooding along the bank of river and the flood extended to nearby areas due to over flow of river.

It becomes imperative to monitor the quality of the river in order ensure availability of quality water for drinking and agricultural purposes. The influence of flood and the variation in Water Quality Index of river Periyar before and after flood was the main focus of the study.

II. Material and Methods

The paper presents the variations in water quality index of Periyar river before and after flood. Water quality of Periyar river was calculated for 10 stations during May 2018 to October 2018 (pre-flood periods May, June, July and post-flood periods August, September, October). Fourteen parameters such as pH, Electrical Conductivity, Total Dissolved Solids, Total hardness, Dissolved Oxygen, Chemical Oxygen Demand, Calcium, Magnesium, Iron, Chloride, Sulphate, Nitrate-N, Fluorides and Phenol were used for calculation.

Physico-chemical analysis

Water samples was collected in one liter polyethylene bottles and preserved till the analysis was completed. Parameters like pH, Electrical conductivity, Total Dissolved solids were estimated using digital

meters soon after the collection of sample. Dissolved oxygen was measured by using Winkler's method with azide modification. Chemical oxygen demand was determined by using Potassium dichromate digestion. Total hardness and Calcium was estimated by titration against EDTA. Gravimetric method was used for Magnesium estimation. Iron was measured using Phenanthroline spectrophotometric method. Argentometric titration was used for chloride estimation. Sulphate was estimated using Nephelometric turbidity meter. Nitrate-N was determined using UV Spectrophotometer. SPADNS method for fluoride estimation and Phenol was analysed using amino-antipyrene and chloroform extraction method. All parameters analysed was carried out following standard techniques reported by American Public Health Association [2].

Table 1: Details of Sampling stations

Station Code	Station	Details
PR1	Edamula	Upstream of the river, Industrial area.
PR2	Pathalam	Downstream of regulator, Industrial area.
PR3	Pallikadavu	Near the bank of Edayar region, Industrial area.
PR4	Manjumal	Industrial region
PR5	Eloor Methanam Kadavu	Industrial region
PR6	Eloor Depo kadavu	Industrial region
PR7	Eloor Muttinakam	Industrial region
PR8	Kuzhikandam Thodu	Industrial region
PR9	Eloor Ferry Right	Confluence point of the two branches of river, Industrial area
PR10	Varapuzha	Tributaries of Periyar river joins.

To analyse the Water Quality Index and to categorize the water quality of the Periyar river, we used the Water Quality Index developed by Canadian Council of Ministry of Environment (CCME) [3]. The variables selected were assigned a limit based on the Bureau of IndianStandards for drinking water standards.

The CCME WQI is based on the following three attributes of water quality, that relate to water quality objectives:

1. **Scope** - The percentage of water quality variables that do not meet objectives in at least one sample during the time period under consideration

F1= (Number of failed variables / Total number of variables) x 100 (1)

2. **Frequency** - The number of individual measurements that do not meet objectives

F2 = (Number of failed test/ Total number of tests) x 100 (2)

3. **Amplitude** - The amounts by which measurements that do not meet the objectives. Amplitude is calculated in three steps.

The number of times by which an individual concentration is greater than (or less than, when the objective is a minimum) the objective is termed an "excursion" and is expressed as follows.

Excursion = (failed test value$_i$ / objective$_j$)-1; (3)

when the variable should not be higher than the objective

Excursion = (objective$_j$ / failed test value$_i$)-1; (4)

when the variable should not be lower than the objective

The collective amount by which individual tests are out of compliance is calculated by summing the excursions of individual tests from their objectives and dividing by the total number of tests (both those meeting objectives and those not meeting objectives). This variable, referred to as the normalized sum of excursions, or *nse*, is calculated as:

Nse = $\sum_{i=1}^{n}$(excursion \ total no. of tests) (5)

F3 is then calculated by an asymptotic function that scales the normalized sum of the excursions from objectives (*nse*) to yield a range between 0 and 100.

F3 = Nse / (0.01nse+0.01); (6)

CCME WQI =100- {$\sqrt{(F1^2+F2^2+F3^2)}$/1.732} (7)

Once the CCME WQI value has been determined, water quality is ranked by relating it to one of the following categories:

Excellent: (CCME WQI Value 95-100) – water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels.

Good: (CCME WQI Value 80-94) – water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.

Fair: (CCME WQI Value 65-79) – water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.

Marginal: (CCME WQI Value 45-64) – water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.

Poor: (CCME WQI Value 0-44) – water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

Table 2: List of Parameters and their Standards given by (BIS: 10500-1991)

Serial. No.	Parameters	Standard Value
1	pH	6.5-8.5
2	Electrical Conductivity	0.5-1.5µS/cm
3	Total dissolved solids	500mg/l
4	Total hardness	300mg/l
5	Dissolved oxygen	500mg/l
6	Chemical oxygen demand	250mg/l
7	Calcium	75mg/l
8	Magnesium	30mg/l
9	Iron	0.3mg/l
10	Chloride	250mg/l
11	Sulphate	200mg/l
12	Nitrate-N	45mg/l
13	Fluorides	0.6-1.2mg/l
14	Phenol	0.001mg/l

III. Result and Discussion

Water Quality Index for each of the ten stations along the river was determined for six months (which CCME WQI is often calculated) using the physicochemical parameters listed in Table 5. The average ranking value with respect to their Water Quality Index are presented in Table 6. During the pre-flood period, the Water Quality Index Value of the river at the station Pathalam was 45.05. The value showed that the water can be ranked as 'Marginal', and 'Poor' at all other stations. During the post-flood period, the Water Quality Index values at Pathalam, Manjumal and Varapuzha showed 49.6,46.70 and 52, which feel under the 'Marginal' ranking of Water Quality. Respective ranks of all other stations remained the same for all the other stations.

The average WQI (Table 6) of the river (which range from 29.95 to 47.32) indicate that the water quality for drinking purposes can be ranked as 'Marginal' at Pathalam, Manjumal and Varapuzha, the value decreased to below 45 making the water to be 'Poor' for the remaining stations.

The decrease in value to be below 44 is a reflection of different type of pollutants entering the river due to various anthropogenic activities. Pollutant such as discharge of untreated or partially treated effluent by various industries at the bank of river may contribute for the poor water quality [4].

Table 3: Mean Water Quality Parameters of the river Periyar during Pre-flood period.

PARAMETERS / STATION CODE	pH	EC µS/cm	TDS mg/l	TH mg/l	DO mg/l	COD mg/l	Ca mg/l	Mg mg/l	Fe mg/l	Cl mg/l	SO4 mg/l	NO3-N mg/l	F mg/l	Phe mg/l
PR1	5.8	0.5	235.6	20.6	6.4	680.9	3.4	2.83	0.66	16.5	3.05	0.44	0.22	0.58
PR2	5.6	0.07	361.3	49.6	6.2	988.3	6.5	10.1	0.68	26.6	39.1	0.69	0.32	0.09
PR3	5.2	0.07	696	77.4	6.2	287.6	7.2	9.46	1.99	69.3	13.4	0.75	0.37	0.21
PR4	5.5	0.10	518.3	98.7	6.9	431.6	11.1	17.6	0.71	194.2	80.7	0.64	0.22	0.10
PR5	5.4	0.08	466	92.6	4.7	399.8	10.8	15.5	1.70	200.16	65.2	0.43	0.31	0.16
PR6	5.6	0.10	506.6	370.4	5.1	393.6	2.7	18.7	2.2	371.7	307.7	1.15	0.37	1.11
PR7	5.3	0.24	427.6	145.3	5.8	375	2.49	40.4	1.6	195.13	70.7	0.67	0.31	1.08
PR8	5.1	0.06	416.6	3158.3	5.1	372.9	1.5	37	1.74	422.8	200.5	0.571	0.40	0.95
PR9	5.2	0.08	430	391.2	7.8	430	4.46	21.5	0.83	192.8	132.9	1.38	0.36	0.7
PR10	5.4	0.10	512	271.8	5.7	290	6.17	32.2	0.47	202	140.5	1.29	0.39	0.10

Table 4: Mean Water Quality Parameters of the river Periyar during Post-flood period

PARAMETERS / STATION CODE	pH	EC µS/cm	TDS mg/l	TH mg/l	DO mg/l	COD mg/l	Ca mg/l	Mg mg/l	Fe mg/l	Cl mg/l	SO_4 mg/l	NO_3-N mg/l	F mg/l	Phe mg/l
PR1	6.3	0.06	208.6	15.19	6.5	175.7	3.4	3	0.32	30.5	2.66	0.26	0.15	0.49
PR2	6.2	0.09	348.3	44.75	5.7	649.7	4.43	7.6	0.28	78.9	36.4	0.37	0.2	0.17
PR3	6.4	0.09	401	66.26	5.7	177.9	6.8	8.3	1.05	98.4	6	0.39	0.24	0.63
PR4	5.6	0.12	567.3	91.13	6.4	397.2	9.6	16.06	0.43	227.3	41.5	0.40	0.20	0.05
PR5	5.9	0.11	538.3	83.43	3.3	327.9	9.6	13.9	1.32	233.3	27.5	0.34	0.22	0.13
PR6	6.0	0.11	562	301.8	4.2	348.6	2.5	17.22	1.78	420.7	291.9	0.85	0.22	1.05
PR7	6.3	0.41	602	95.7	5.1	340.03	0.8	34.5	1.22	244.9	60.7	0.51	0.16	0.45
PR8	6.8	0.61	564.6	3096	4.8	406	1.3	29.8	1.24	400.1	172.4	0.66	0.35	0.7
PR9	6.6	0.35	590.6	311.22	6.3	458.2	3.9	19.11	0.35	217.9	89.7	1.39	0.23	0.39
PR10	6.8	0.6	464.3	219.31	4.7	287.9	6.1	25.9	0.20	195.1	104.5	0.86	0.22	0.04

EC- Electrical conductivity, TDS- total dissolved solids, TH- Total Hardness, DO_ dissolved oxygen, COD- Chemical Oxygen Demand, Ca- Calcium, Mg- Magnesium, Fe- Iron, Cl- chloride, SO_4- Sulphate, NO_3-N- Nitrate-Nitrogen, F- Fluoride and Phe- Phenol.

The 'Poor' water quality rating observed is also supported by the analytical results of the physicochemical parameters (Table 3 & 4) chosen for WQI calculation. pH value is a significant indicator which determine the suitability of water for various purposes [5&6]. The value of pH varied from 5.8 (Edamula) to 5.1(Kuzhikandam Thodu) during the pre-flood period. During post-flood period, slightly high pH was reported throughout the stations. All samples were found to be slightly acidic.

Table 5: Variations in WQI and ranking at each stations during Pre and Post flood period

Serial No.	**Station**	**Pre-flood period**		**Post-flood period**	
		Water Quality Index	**Ranking**	**Water Quality Index**	**Ranking**
1	Edamula	39.30	Poor	39.8	Poor
2	Pathalam	45.05	Marginal	49.6	Marginal
3	Pallikadavu	39.44	Poor	41.07	Poor
4	Manjumal	41.90	Poor	46.70	Marginal
5	Eloor Methanam Kadavu	42	Poor	43.10	Poor
6	Eloor Depo kadavu	34	Poor	33.60	Poor
7	Eloor Muttinakam	36.8	Poor	35.40	Poor
8	Kuzhikandam Thodu	28.10	Poor	31.80	Poor
9	Eloor Ferry Right	35.6	Poor	34.50	Poor
10	Varapuzha	40.9	Poor	52	Marginal
Overall Water Quality Index		38.309	Poor	40.75	Poor

Table 6: Average WQI and Ranking

Serial No.	**Station**	**Average WQI**	**Ranking**
1	Edamula	39.55	Poor
2	Pathalam	47.32	Marginal
3	Pallikadavu	40.25	Poor
4	Manjumal	44.3	Marginal
5	Eloor Methanam Kadavu	42.55	Poor
6	Eloor Depo kadavu	33.8	Poor
7	Eloor Muttinakam	36.1	Poor
8	Kuzhikandam Thodu	29.95	Poor
9	Eloor Ferry Right	35.05	Poor
10	Varapuzha	46.45	Marginal
Overall Water Quality Index		39.53	Poor

Electrical conductivity is an index o represent total concentration of salts. The observed values for electrical conductivity in all the stations were within the permissible level by (BIS:10500-1991) during the study. Total Dissolved Solid is a vital parameter which imparts an unusual taste to water and lessen its usage as potable water [7]. The highest value (696 mg/l) was observed in pre-flood period at Pallikadavu and lowest value (208.6 mg/l) was observed in post-flood period at Edamula.

Total hardness varied during both the period. Comparatively, high hardness content was recorded in Eloor Depo kadavu, Kuzhikanadm and Eloor Ferry during both the period. Dissolved Oxygen is considered the most important parameter for assessing water quality [8]. During the post-flood period, high values (6.5,6.4,6.3 mg/l) were observed in Edamula, Manjumal and Eloor ferry. However, 7.8 mg/l was observed from Eloor Ferry during pre-flood period. Calcium, Sulphate, Nitrate-N and Fluoride were observed within the threshold value during the entire study.

The observed values for Chemical Oxygen Demand was well above the permissible limit for all the sampling stations during the pre-flood period. The COD varied during post-flood period. The maximum and minimum maximum value (649.7 and 175.7 mg/l) were observed at Pathalam and Edamula, respectively.

The concentration of Iron, Chloride, Magnesium and Phenol exceeded the permissible level recommended by BIS 10500-1991 for drinking water at the two period. The highest average concentration was recorded as 1.99 mg/l for Fe, 422.8 mg/l for Cl, 40.4 mg/l for Mg and 1.11 mg/l for pre-flood period. During the post-flood period, the highest average value i.e. 1.78 mg/l for Fe, 420.7 mg/l for Cl, 29.8 mg/l for Mg and 1.05 mg/l for phenol were recorded. The high value recorded in all stations of the river were due to industrial discharge of effluent, disposal of domestic wastes, runoffs, and atmospheric deposition [1& 4].

Calcium, Sulphate, Nitrate-N and Fluoride were observed within the threshold value during the entire study. The maximum value (11.1 mg/l for Ca, 307.7 mg/l for SO_4, 1.38 mg/l for NO_3-N and 0.40 mg/l for Fluoride) and minimum value (1.5 mg/l for Ca, 3.05 mg/l for SO_4, 0.43 mg/l for NO_3-N and 0.22 mg/l for Fluoride) during the pre-flood period. The highest value (9.96 mg/l for Ca, 291.91 mg/l for SO_4, 1.39 mg/l for NO_3-N, and 0.35 mg/l for Fluoride) and lowest value (0.8 mg/l for Ca, 2.66 mg/l for SO_4, 0.26 mg/l for NO_3-N and 0.15 mg/l for Fluoride) for the post-flood period.

IV. Conclusion

Canadian Council of the Ministers of Environment (CCME) Water Quality Index of Periyar river was calculated for 10 stations before and flood (Pre-flood and Post-flood period). The average index values of the most stations were ranging from 29.95 to 47.32. There should be caution in using the river for drinking since the study revealed that the overall water quality index was poor. The presence of industries around the bank of the river impacted negatively on the river. More so, the study showed that application of Water Quality Index is a useful tool in assessing the overall quality of river. Managing and protecting water is essential for sustaining life. A continuous water quality monitoring program and proper water safety plan are essential to preserve and improve the water quality.

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