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Assessment of Water Quality Index of River Teesta in East District, Sikkim, India

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Abstract - *The objective of this study was to calculate the Water Quality Index of Teesta River which flow through Sikkim, India. In this study water quality parameters (physico-chemical parameters) was analyzed for the month of June and October 2018 at the laboratory of State pollution Control Board, Sikkim. The different parameters analyzed are pH, Turbidity, DO, BOD, Electrical Conductivity, Hardness, Alkalinity TDS, Chloride and Calcium. The laboratory analysis was done according to the procedures as given by American Public Health Association (APHA). The water samples for this study were taken from nine sampling station along the River Teesta in East District of Sikkim. The calculation of the Water Quality Index (WQI) was done using Weighted Arithmetic Index Method. As per the results of the calculation of Water Quality Index the WQI value for the month of June and October ranged between138-421and 85.13-391.55. The highest value of WQI was recorded at Singtam and Majhitar during June and October 2018 respectively. The station where WQI was recorded highest falls in densely populated region and also falls in the industrial belt in East Sikkim. Hence, the river needs proper management and treatment to conserve the Water Quality and to control pollution.*

Key Words: **East Sikkim, River Teesta, Physico-chemical parameters, Water Quality Index, Weighted Arithmetic Index Method.**

1. INTRODUCTION

Water is the most vital fluid which all organisms on the Earth are dependent on. It may be noted that man's early habitation and civilization sprang up along the banks of rivers. Although the surface of our planet is nearly 71% water, only 3% of it is fresh. Of these 3% about 75% is tied up in glaciers and polar icebergs, 24% in groundwater and 1% is available in the form of fresh water in rivers, lakes and ponds suitable for human consumption (Dugan, 1972). Now increasing population and exploded growth of industrialization has been leading to degradation of Water Quality. With these reasons said the rate of water pollution has been increasing and is becoming a threat to the environment. The Water Quality Indices (WQI) has been the easiest way to communicate on the quality of water. Water pollution is one of a threat to mankind that can lead to serious health issues and also destroy the agri-fields as the same water in the river is used for irrigation purposes in different parts of India and also the world. It is an established fact that water quality is closely related to the surrounding environment and prevalent land use (APHA, 1992). In order to keep the environment safe the physico-chemical parameters must be kept monitored and controlled. A Water Quality Index summarizes a large amount of data into simple terms. Water Quality Index in fact is a single number that reveals the overall quality of water. WQI can be used as a tool in comparing the water quality of different sources and it gives the public a general idea of the possible problems with water in a particular region.

River Test originates from Pahunri Glacier which feeds Tso Lhamu Lake located in North district of Sikkim at an altitude of 5330 m (17,490ft). The river Teesta flows to the Indian states of Sikkim, West Bengal and the country of Bangladesh finally emptying into Bay of Bengal. In Sikkim it covers a length of 309 km with Rangpo being its last point after that it enters West Bengal meeting Rangit River. The river then travels southwards flowing into West Bengal. The river after travelling through the gorges and rocks finally meets the plain when it reaches Sevoke, 22km before Siliguri. In Sevoke the river is spanned by Coronation Bridge which links Sikkim and North-Bengal to the Northeastern States of India. The river than merges up with River Brahmaputra after it bifurcates in the city of Jalpaiguri in North Bengal. The River Test then flows through the town of Cooch Behar and moves to Fulchori in Bangladesh and meets Jamuna River and finally drains into Bay of Bengal.

Based on the importance of fresh water to the surrounding livelihood, agriculture, fisheries, irrigation, etc. Water Quality assessment of River Teesta is very much in need. The Water Quality Assessment of River Teesta is very important due to the rise in the anthropogenic activities that has been leading to the degradation of water quality. This research will also be helpful in planning various water management programs for saving the River Teesta.

1.1 MATERIALS AND METHODS

The present work is divided in three categories:

i) Firstly, the initial survey in order to find the sampling stations for collecting the water samples.

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ii) Secondly, the water sample collection has been done from the sampling stations.

iii) Lastly, the collected Samples were analyzed in the laboratory of State Pollution Control Board, Sikkim.

1.2 SAMPLING STATIONS

The details of the sampling stations along with the geographical coordinates are tabulated in Table 1 below:

Table 1: Details of the Sampling Station.

Sl.No	Sampling Stations	Latitude	Longitude
1	Burtuk	27°35’40”N	88°61’58” E
2	Adampool	27°30’69”N	88°58’48”E
3	Sangkhola	27°24’93”N	88°52’96”E
4	32 number	27°26’29”N	88°56’59”E
5	Martam	27°26’20”N	88°55’56”E
6	Singtam	27°13’64”N	88°39’31”E
7	Bardang	27°21’62”N	88°43’06”E
8	Majhitar	27°18’76”N	88°49’97”E
9	Rangpo	27°17’61”N	88°52’87”E

The water samples from the sampling stations were collected during the month of May and October-November of the year 2018. The dates of collection of Samples were 6th June-15th June and 10th October to 5th November, 2018 respectively. Water samples were collected by using plastic bottle from study site of River Teesta. pH of water was measured by pH meter. Turbidity or transparency of water was taken by turbidity meter, total alkalinity, BOD and total hardness were determined by titration method (APHA, 2005). The Dissolved Oxygen determination was done by Wrinkler’s method with Azide modification (APHA, 2005). The elements like calcium, magnesium and chloride were analyzed by titration method (ALPHA, 2005) .

2. CALCULATION OF WATER QUALITY INDEX:

In this current study, Water Quality Index (WQI)is calculated by using the Weighted Arithmetic Water Quality Index which was originally proposed by Horton (1965) and developed by Brown et al (1972). The weighted arithmetic water quality index (WQI) is in the following form:

$$\mathbf{WQI = \Sigma w_i q_i / \Sigma w_i}$$

Where, w_i= Relative weight

q_i= Water quality rating

The unit weight (w_i) of the various water quality parameters are inversely proportional to the recommended standards for the corresponding parameters. According to Brown et al (1972), the value of q_i is calculated using the following equation:

$$\mathbf{q_i = 100\,[(V_i - V_{id}) / (S_i - V_{id})]}$$

Where, V_i= Observed value

S_i= Standard permissible value

V_{id}= Ideal value

All the ideal values (V_{id}) are taken as zero for drinking water expect pH and Dissolved Oxygen (Triphaty and Sahu, 2005).

For pH, the ideal value is 7.0 (for natural/pure water) and a permissible value is 8.5 (for polluted water). Therefore, the quality rating for pH is calculated from the following equation:

$$\mathbf{q_{ph} = 100\,[(V_{pH} - 7.0/(8.5-7.0)]}$$

Where, VpH= observed value of pH

For dissolved oxygen, the ideal value is 14.6 mg/L and the standard permissible value for drinking water is 5 mg/L. Therefore, its quality rating is calculated from the following equation:

$$q_{DO} = 100\ [(V_{DO} - 14.6)/(5.0-14.6)]$$

Where, VDO =observed value of dissolved oxygen.

Table 2 below shows a classification of water quality, based on its quality index of Brown et al (1972), Chatterji and Raziuddin (2002) etc.

Table -2: Classification of Water Quality based on weighted arithmetic WQI method:

WQI	STATUS
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
Above 100	Unsuitable for Drinking

3. RESULTS AND DISCUSSION

Table -3: Data of parameters for the month of June 2018

Parameters	SITES								
	S1	S2	S3	S4	S5	S6	S7	S8	S9
pH	8.5	7.5	7	6.2	8	6	6	5.9	7
Turbidity	140	130	160	160	155	170	164	170	160
DO	13	16.2	19.2	21	20	22	22	25	23
BOD	6.5	8.5	12	16	8	14	16	18	15
Conductivity	280	235	240	260.8	220	200	240	260	240
Hardness	80	85	90	99	82	98	100	110	110
Alkalinity	100	102	106	110	102	105	108	110	110
TDS	120	110	140	170	150	180	120	140	120
Chloride	30	30	35	40	30	32	30	40	38
Calcium	32	32	36	36	36	20	30	35	30

Table -4: Data of parameters for the month of October 2018

Parameters	SITES								
	S1	S2	S3	S4	S5	S6	S7	S8	S9
pH	7.5	7.2	72	6.5	8.5	6.28	6.8	6	6.2
Turbidity	100	120	155	140	105	142	135	150	160
DO	15	18	23	21	15	26	20	25	23
BOD	10	12	15	12	9	18	14	18	19
Conductivity	300	250	249	230	300	200	200	210	260
Hardness	80	87	89	82	60	100	100	120	110
Alkalinity	70	95	80	80	50	110	100	120	130
TDS	145	140	170	130	180	123	130	100	140
Chloride	30	26.4	30	60	40	25.5	35	30	35
Calcium	35	34	32	32	32	17.2	36	40	32

Table -5: Calculation of WQI for month of June 2018

Parameters	Sites	Observed Value(Vi)	Standard Value(Si)	Unit Weight(wi)	Quality Rating(qi)	Weighted value (wi*qi)
pH	S1	8.5	8.5	0.1176	100	11.76
	S2	7.5	8.5	0.1176	33.333	3.92
	S3	7	8.5	0.1176	0	0
	S4	6.2	8.5	0.1176	53.333	6.272
	S5	8	8.5	0.1176	66.666	7.84
	S6	6	8.5	0.1176	66.667	7.84
	S7	6	8.5	0.1176	66.667	7.84
	S8	5.9	8.5	0.1176	73.333	8.624
	S9	7	8.5	0.1176	0	0
Turbidity	S1	140	25	0.04	560	22.4
	S2	130	25	0.04	520	20.8
	S3	160	25	0.04	640	25.6
	S4	160	25	0.04	640	25.6
	S5	155	25	0.04	620	24.8
	S6	170	25	0.04	680	27.2
	S7	164	25	0.04	656	26.24
	S8	170	25	0.04	680	27.2
	S9	160	25	0.04	640	25.6
DO	S1	13	5	0.2	106.67	-21.333
	S2	16.2	5	0.2	106.667	21.3333
	S3	19.2	5	0.2	306.667	61.3333
	S4	21	5	0.2	426.667	85.3333
	S5	20	5	0.2	360	72
	S6	22	5	0.2	493.333	98.6667
	S7	22	5	0.2	493.333	98.6667
	S8	25	5	0.2	693.333	138.667
	S9	23	5	0.2	560	112
BOD	S1	6.5	5	0.2	130	26
	S2	8.5	5	0.2	170	34
	S3	12	5	0.2	240	48
	S4	16	5	0.2	320	64
	S5	8	5	0.2	160	32
	S6	14	5	0.2	280	56
	S7	16	5	0.2	320	64
	S8	18	5	0.2	360	72
	S9	15	5	0.2	300	60
Conductivity	S1	280	250	0.004	112	0.448
	S2	235	250	0.004	94	0.376
	S3	240	250	0.004	96	0.384
	S4	260.8	250	0.004	104.32	0.41728
	S5	220	250	0.004	88	0.352
	S6	200	250	0.004	80	0.32
	S7	240	250	0.004	96	0.384
	S8	260	250	0.004	104	0.416
	S9	240	250	0.004	96	0.384
Hardness	S1	80	300	0.0033	28.3333	0.0935

	S2	85	300	0.0033	30	0.099
	S3	90	300	0.0033	33	0.1089
	S4	99	300	0.0033	27.3333	0.0902
	S5	82	300	0.0033	32.6667	0.1078
	S6	98	300	0.0033	33.4667	0.11044
	S7	100.4	300	0.0033	36.6667	0.121
	S8	110	300	0.0033	36.6667	0.121
	S9	110	300	0.0033	36.6667	0.121
Alkalinity	S1	100	200	0.005	50	0.25
	S2	102	200	0.005	51	0.255
	S3	106	200	0.005	53	0.265
	S4	110	200	0.005	55	0.275
	S5	102	200	0.005	51	0.255
	S6	105	200	0.005	52.5	0.2625
	S7	108	200	0.005	54	0.27
	S8	110	200	0.005	55	0.275
	S9	110	200	0.005	55	0.275
TDS	S1	120	500	0.002	24	0.048
	S2	110	500	0.002	22	0.044
	S3	140	500	0.002	28	0.056
	S4	170	500	0.002	34	0.068
	S5	150	500	0.002	30	0.06
	S6	180	500	0.002	36	0.072
	S7	120	500	0.002	24	0.048
	S8	140	500	0.002	28	0.056
	S9	120	500	0.002	24	0.048
Chloride	S1	30	250	0.004	12	0.048
	S2	30	250	0.004	12	0.048
	S3	35	250	0.004	14	0.056
	S4	40	250	0.004	16	0.0 64
	S5	30	250	0.004	12	0.048
	S6	32	250	0.004	12.8	0.0512
	S7	30	250	0.004	12	0.048
	S8	40	250	0.004	16	0.064
	S9	38	250	0.004	15.2	0.0608
Calcium	S1	32	75	0.013	42.6667	0.55467
	S2	32	75	0.013	42.6667	0.55467
	S3	36	75	0.013	48	0.624
	S4	36	75	0.013	48	0.624
	S5	36	75	0.013	48	0.624
	S6	20	75	0.013	26.6667	0.34667
	S7	30	75	0.013	40	0.52
	S8	40	75	0.013	53.33	0.69329
	S9	35	75	0.013	46.66	0.60658

Table -5: Calculation of WQI for month of October 2018

Parameters	Sites	Observed Value(Vi)	Standard Value(Si)	Unit Weight(wi)	Quality Rating(qi)	Weighted value (wi*qi)
pH	S1	7.5	8.5	0.1176	33.3333	3.92
	S2	7.2	8.5	0.1176	13.3333	1.568

	S3	7.2	8.5	0.1176	13.3333	1.568
	S4	6.5	8.5	0.1176	-33.333	-3.92
	S5	8.5	8.5	0.1176	100	11.76
	S6	6.28	8.5	0.1176	48	5.6448
	S7	6.8	8.5	0.1176	13.333	1.568
	S8	6	8.5	0.1176	66.667	7.84
	S9	6.2	8.5	0.1176	53.333	6.272
Turbidity	S1	100	25	0.04	4	0.16
	S2	120	25	0.04	4.8	0.192
	S3	155	25	0.04	6.2	0.248
	S4	140	25	0.04	5.6	0.224
	S5	105	25	0.04	4.2	0.168
	S6	142	25	0.04	5.68	0.2272
	S7	135	25	0.04	5.4	0.216
	S8	150	25	0.04	6	0.24
	S9	160	25	0.04	6.4	0.256
DO	S1	15	5	0.2	26.666	5.33333
	S2	15	5	0.2	26.666	5.33333
	S3	23	5	0.2	560	112
	S4	21	5	0.2	426.66	85.3333
	S5	15	5	0.2	26.666	5.33333
	S6	26	5	0.2	760	152
	S7	20	5	0.2	360	72
	S8	25	5	0.2	693.33	138.667
	S9	23	5	0.2	560	112
BOD	S1	10	5	0.2	200	40
	S2	12	5	0.2	240	48
	S3	15	5	0.2	300	60
	S4	12	5	0.2	240	48
	S5	9	5	0.2	180	36
	S6	18	5	0.2	360	72
	S7	14	5	0.2	280	56
	S8	18	5	0.2	360	72
	S9	19	5	0.2	380	76
Conductivity	S1	300	250	0.004	120	0.48
	S2	250	250	0.004	100	0.4
	S3	249	250	0.004	99.6	0.3984
	S4	230	250	0.004	92	0.368
	S5	300	250	0.004	120	0.48
	S6	200	250	0.004	80	0.32
	S7	200	250	0.004	80	0.32
	S8	210	250	0.004	84	0.336
	S9	260	250	0.004	104	0.416
Hardness	S1	80	300	0.0033	0.26667	0.00088
	S2	87	300	0.0033	0.29	0.00096
	S3	89	300	0.0033	0.29667	0.00098
	S4	82	300	0.0033	0.27333	0.0009
	S5	60	300	0.0033	0.2	0.00066
	S6	100	300	0.0033	0.33333	0.0011
	S7	100	300	0.0033	0.33333	0.0011
	S8	120	300	0.0033	0.4	0.00132

	S9	110	300	0.0033	0.36667	0.00121
Alkalinity	S1	70	200	0.005	0.35	0.00175
	S2	95	200	0.005	0.475	0.00238
	S3	80	200	0.005	0.4	0.002
	S4	80	200	0.005	0.4	0.002
	S5	50	200	0.005	0.25	0.00125
	S6	110	200	0.005	0.55	0.00275
	S7	100	200	0.005	0.5	0.0025
	S8	120	200	0.005	0.6	0.003
	S9	130	200	0.005	0.65	0.00325
TDS	S1	145	500	0.002	29	0.058
	S2	140	500	0.002	28	0.056
	S3	170	500	0.002	34	0.068
	S4	130	500	0.002	26	0.052
	S5	180	500	0.002	36	0.072
	S6	123	500	0.002	24.6	0.0492
	S7	130	500	0.002	26	0.052
	S8	100	500	0.002	20	0.04
	S9	140	500	0.002	28	0.056
	S1	30	250	0.004	12	0.048
Chloride	S2	26.4	250	0.004	10.56	0.04224
	S3	30	250	0.004	12	0.048
	S4	60	250	0.004	24	0.096
	S5	40	250	0.004	16	0.064
	S6	25.5	250	0.004	10.2	0.0408
	S7	35	250	0.004	14	0.056
	S8	30	250	0.004	12	0.048
	S9	35	250	0.004	14	0.056
Calcium	S1	35	75	0.013	46.666	0.60667
	S2	34	75	0.013	45.333	0.58933
	S3	32	75	0.013	42.666	0.55467
	S4	32	75	0.013	42.666	0.55467
	S5	32	75	0.013	42.666	0.55467
	S6	17.2	75	0.013	22.933	0.29813
	S7	36	75	0.013	48	0.624
	S8	40	75	0.013	53.333	0.69333
	S9	32	75	0.013	42.6667	0.55467

The Water Quality Index was then calculated by using the formula of Weighted Arithmetic Index formula for the month of June and October as follows:

Water Quality index for the month of June:

WQI(site1)=$\sum wiqi//\sum wi$= 82.9355/0.5889 =140.83

WQI(Site 2)= 81.43/0.5889 =138.27

WQI(Site 3)= 136.427/0.5889= 231.6

WQI(Site 4)= 168.63/0.5889 =286.34

WQI(Site 5)= 138.08/0.5889 =234.47

WQI(Site6)= 189.301/0.5889 =321.44

WQI(Site 7)= 198.13/0.5889 =336.44

WQI(Site 8)= 248.02/0.5889 =421.15

WQI(Site 9)=199.02 /0.5889 =337.95

Similarly, the Water Quality Index for the month of October 2018, is as follows:

WQI (Site1)=∑wiqi//∑wi= 50.608/0.5889=85.93

WQI (Site 2)=56.184= /0.5889 =95.40

WQI (Site 3)= 174.88/0.5889= 296.96

WQI (Site 4)= 138.55/0.5889 =235.26

WQI (Site 5)= 54.43/0.5889 =92.43

WQI (Site6)= 230.584/0.5889 =391.550

WQI (Site 7)=127. 70/0.5889 = 216.844

WQI (Site 8)= 219.86/0.5889 =373.34

WQI (Site 9)=195.35 /0.5889 =331.72

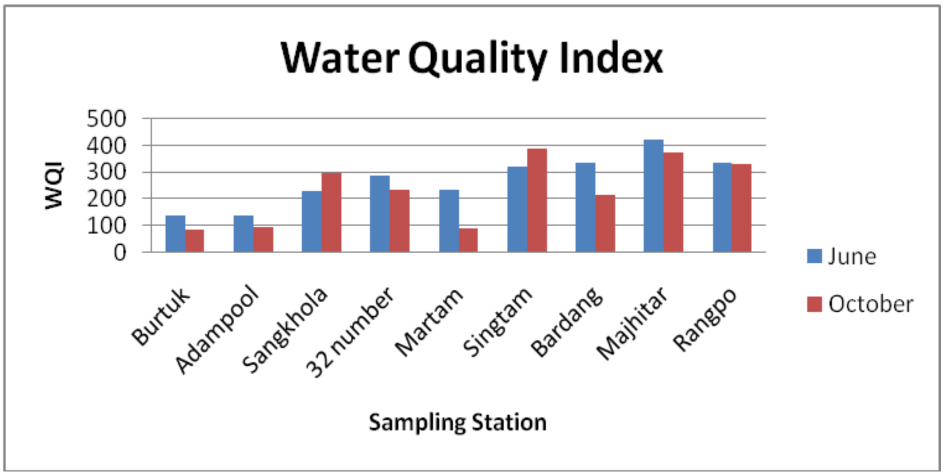

Figure-1 Graphical Representation of WQI for June 2018 and October 2018

4. CONCLUSIONS

The objective of the study was to calculate the Water Quality Index (WQI) of Teesta River which flow through the state of Sikkim in order to assess its suitability for drinking purposes. The water quality index (WQI) of the river was assessed for East District for the month o June and October 2018 as presented in Figure1 above using the data tabulated in table 3 and table 4. The WQI for the month of June and October was found out to be the highest in Site 8 during both June and October with the value of 421.15 and 373.34 respectively.

The obtained value is a clear indication that water from Teesta River is unsuitable for drinking purposes and must therefore be treated before use to avoid water related diseases. And it is also need for regular monitoring of water quality in order to detect the changes in physicochemical parameters. Thus it is suggested that proper waste management should be taken up.

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