

Water Quality Index as a Reliable Indicator of Water Pollution Level-A Case Study of Rudrasagar Lake, Tripura

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ABSTRACT: Pollution level of any lake water can be easily identified by employing water quality index (WQI) method. WQI can be taken as the single value indicator for studying pollution level of lake water which can be derived from large quantities of water characterization data such as dissolved oxygen (DO), biological oxygen demand (BOD), pH, electrical conductivity, total nitrogen etc. In this paper an attempt is made to study the pollution level of Rudrasagar, a natural lake in western Tripura by following Canadian Council of Ministers of the Environment (CCME) water quality guideline. Measured WQI for this lake water shows presence of insignificant pollutant with some seasonal variation of its value. WQI has a significant role for studying the aquatic environment as well as that of lake surrounding and so it is a very good indicator of resilience and sustainability of lake ecosystem.

KEYWORDS: WQI, CCME, Rudrasagar Lake, lake ecosystem

I. INTRODUCTION

Rudrasagar lake is the only natural lake of western Tripura and it was declared as Ramsar site on 08/11/2005 due to support of its wetland for globally threatened ecological communities and also for the populations of living species for maintaining the biological diversity. So study of water quality of this lake and also implementation of management action plan for improving its water quality is very vital issue.

Regular water quality monitoring of water resources are necessary for sustainability of ecosystem health and hygiene, agricultural use and domestic use. There are various water quality indices and calculation of these indices is based on number of physico chemical and bacteriological parameters. Water quality indices can be classified in four major groups (Jena V, Dixit S and Gupta S et al., 2013) and these are public indices, specific consumption indices, designing and planning indices and statistical indices. Statistical approaches are very much beneficial for finding the significance of parameters used for water quality assessment. (Marta T, Damia B and Roma.T et al., 2010). Several workers (Tiwari and Mishra et al. 1985) has been used WQI for studying the water quality of major Indian rivers. Whereas CCME WQI was used for assessment of water quality of Mackenzie river basin Canada (Lumb et al. 2006). This index method also been used (Sharma et al. 2011) for water quality analysis of river Yamuna in the national capital territory (2000-2009), India. This index can play a vital role for regular monitoring of the water quality. The limitation of the CCME WQI is that it can't include the loss of interactions among the variables chosen for its calculation and also the sensitivity of the results to the formulation of CCME WQI (Zandbergen P.A and Hall KI et al. 1988). The specific variables, objectives and time period used for index calculation may vary from region to region, depending on local conditions and issues. This paper presents water quality of the lake Rudrasagar mainly targeting public sector, experts and policy makers.

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II. MATERIALS AND METHODS

Study Area: Tripura, a landlocked state of North-East India is the third smallest state of India. The actual study site Rudrasagar Lake ($23^{\circ}29' N$ and $90^{\circ}01' E$) is a floodplain wetland of a river called Gomati. The lake is located in the Melaghar Block under Sonamura Sub-Division in the West Tripura District and at a distance of about 50 km from the state capital of Tripura. The Lake is a natural sedimentation reservoir which has three sources of inflow and one outflow. Inflows are Noacherra, Durlavnaraya cherra and Kemtali cherra whereas Kachigang, the only outflow is a connective channel which discharges water into the river Gomati (Pal et al., 2014).

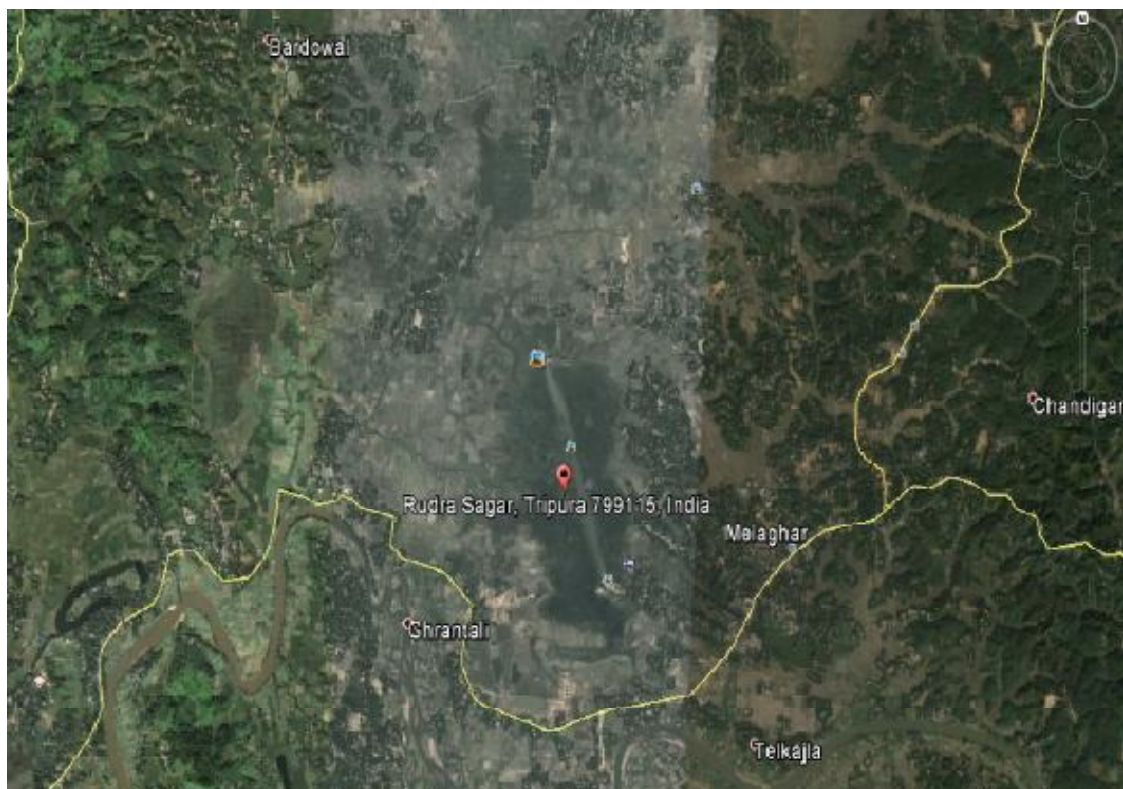


Fig1: Satellite image of Rudrasagar wetland

Sampling Details and Instrumentation: The data recording station is selected considering the maximum water depth along the mid reach and considering the less human intervention. The parameters pH, conductivity, DO, TDS and turbidity of the lake water have been measured using multipurpose water quality analyser devices. Stored data from memory cells of the devices has been transferred to the database of the computer. The water quality analyser devices are usually calibrated before the field work in every sampling day following the laboratory methods (APHA, 1989). The other parameters like alkalinity, chloride, BOD, TN and hardness of water sample have been estimated in laboratory following the standard techniques.

Methodology: Canadian Water Quality Index method has been adopted for studying the water quality of the lake Rudrasagar from the recorded data of ten different parameters. This method was developed by Canadian Council of Ministers of the Environment and was based on water quality index developed by British Columbia in 1995.

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Factors of CCME WQI:

F₁ (Scope):

It has been estimated using the following relation

$$F_1 = \frac{\text{Number of failed variables}}{\text{Total number of variables}} \times 100$$

Where variables indicate those water quality parameters with objectives which were tested during time domain of index calculation

F₂ (Frequency):

It has been estimated using the following relation

$$F_2 = \frac{\text{Number of failed tests}}{\text{Total number of tests}} \times 100$$

F₃ (Amplitude):

It is calculated using the following relation

$$F_3 = \left(\frac{nse}{.01nse + 0.01} \right)$$

$$\text{Where } nse = \frac{\sum_{i=1}^n \text{excursion}_i}{\text{no of tests}} \text{ and}$$

$$\text{excursion}_i = \frac{\text{objective}_j}{\text{Failed test value}_i} - 1, \text{ for the cases where test values must not fall below the objective}$$

$$\text{but, } \text{excursion}_i = \frac{\text{Failed test value}_i}{\text{objective}_j} - 1, \text{ for the cases where test values must exceed the objective.}$$

Final expression for WQI is given by

$$\text{WQI} = 100 - \frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732}, \text{ the term 1.732 is the scaling factor to ensure the index varies from 0 to 100.}$$

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Table 1: Categories of water quality based on WQI value:

WQI Value	Comments about water quality	Description
95-100	Excellent	Conditions very close to natural or pristine levels and water is protected with a virtual absence of threat.
80-94	good	Conditions rarely depart from natural or desirable levels and water is protected with only a minor degree of threat.
65-79	Fair	Water quality is protected but occasionally threatened or impaired
45-64	Marginal	Water quality is frequently threatened or impaired
0-44	Poor	Water quality is almost always threatened or impaired.

III RESULT AND DISCUSSION

For calculating CCMEWQI of lake water field measurement and data collection programmes were performed over the time domain of one complete year (2014) in one month intervals. The details of various parameters measured for this purpose have been displayed in table 2. The measured values of pH, BOD, DO and turbidity of lake water shows some deviation from their objective values and responsible for lowering the value of water quality index.

Table 2: Rudrasagar lake at 2014

Date	pH	Conductivity (µS/cm)	Alkalinity (mg/L)	BOD mg/L	DO mg/L	TDSmg /L	TN mg/L	Chloride (mg/L)	Turbidity (NTU)	Hardness ppm
14 th Jan	5.8	55.45	134.78	2.86	6.5	37.24	5.16	35.24	4.79	72.45
16 th Feb	5.7	70.26	132.45	2.74	7.1	41.25	5.01	36.75	4.89	74.79
16 th Mar	5.6	77.35	131.45	2.65	5.9	46.5		36.88	7.85	
13 th April	6.1	80.25	121.7	3.23*	5.2	46.75	4.25	37.35	11.2	84.36
18 th May	6.5	87.45	115.78	4.12	4.89	51.35	3.76	38.23	16	87.29
15 th June	7.6	106.25	108.68	4.42	4.96	69.75	3.2	39.41	23	89.35
13 th July	7.8	92.5	102.79	3.06	5.15	58.78		37.65	32.5	91.35
17 th Aug	7.4	96.75	97.65	3.23	5.2	61.45	4.25	34.75	16	88.96
14 th Sept	6.9	90.78	103.67	2.95	5.35	54.24	5.23		9	83.78
19 th Oct	6.8	76.34	117.89	2.89	5.75	45.35		31.35	7.5	79.35
16 th Nov	6.4	61.25	123.45	2.15	5.95	40.56	6.17	32.45	4.95	76.45
14 th Dec	6.08	62.95	129.67	1.89	6.98	39.35	5.21	35.41	4.82	75.79
Objective	6 to 9	300	200	3	5	500	45	250	5	200

* Values do not meet the objectives

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Calculation for CCME WQI

$$F1=(4/10)*100=40$$

$$F2=(18/115)*100=15.65$$

The excursion, their normalized sum, and F_3 are calculated as follows

$$\text{Excursion}=(6/5.8)-1=.03 \text{ etc}$$

$$\text{nse} = \frac{.03+.052+.071+.07+.37+.473+.02+.07+.02+.008+.57+1.24+2.2+3.6+5.5+2.2+.8+.5}{115}$$

$$=0.1588$$

$$F_3 = \frac{.1588}{.01(.1588)+.01} = 13.704$$

$$\text{CCMEWQI} = 100 - \frac{\sqrt{40^2 + (15.65)^2 + (13.704)^2}}{1.732} = 73.96$$

IV. CONCLUSION

The calculated CCMEWQI suggests that water quality of Rudrasagar lake was fair in 2014. The calculated value of WQI suggested that water quality condition at this site can be considered suitable for the protection of aquatic life, though sometime the condition may depart from natural or desirable level. Measured Turbidity exceeds several times from its objective value and much responsible for lowering the quality index. Regular study of such water quality index parameter can provide assistance in the field of environmental protection through the implementation of the water Framework Directive on national level.

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