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# Water Quality Index for Assessment of Rudrasagar Lake Ecosystem, India

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**ABSTRACT:** Water quality of lakes, rivers and reservoirs in developing countries like India is being degraded because of the contaminated inflows and surrounding influence. There is a serious need for appropriate water quality monitoring for future planning and management of Lake and other type of water resources. Quality of water in Rudrasagar Lake, Tripura, India has been investigated in this paper. Water Quality Index (WQI) was applied in Rudrasagar Lake India using water quality parameters like pH, Turbidity, Conductivity, Hardness, Alkalinity, Dissolved Oxygen, Biochemical Oxygen Demand and Nitrate. Based on the importance of the parameter for aquatic life the relative weight is assigned to each water quality parameter ranged from 1 to 4. Tests were performed on site using electronic measuring device as well as on Laboratory with samples of water collected from different locations of Rudrasagar Lake. It shows that water quality of Rudrasagar Lake falls within the 'good water' category but marginally. Continuous monitoring of Rudrasagar lake is suggested for proper management.
***Keywords***: Water Quality Index (WQI), Rudrasagar Lake, aquatic life.

## I. INTRODUCTION

The lakes and rivers contribute a lot to human welfare. Lakes and Rivers are the major source of water in several countries all over the world. Lakes have a great significance environmentally due to various reasons such as (i) sources of water for surface and groundwater recharge and discharge (ii) act as flood control and stream flow maintenance, (iii) recreation—education, boating, swimming etc, (iv) pisciculture, (v) wildlife habitat, especially fishes and birds, (vi) emergency water supply for firefighting and (vii) rain water harvesting. Today the lakes and reservoirs are in varying degrees of environmental degradation, due to encroachments, eutrophication(from domestic and industrial effluents) and silt. There has been a quantum jump in population during the last century. But civic facilities were not build at par .As a result lakes and reservoirs became dustbin. Most urban and rural lakes have deteriorated or vanished under this pressure with worldwide environmental concerns [1]. However, in those lakes that could tolerate, drinking water supply is either substantially reduced or is non-potable, flood absorption capacity impaired, biodiversity threatened and there is diminished fish production. The main reasons which resulted in impaired conditions of the lakes may be categorized into two classes namely, (a) pollutants entering from fixed point sources (viz., nutrients from wastewater, from municipal and domestic effluents; organic, inorganic and toxic pollutants from industrial effluents and storm water runoff) (b) pollutants entering from non-point sources (viz., nutrients through fertilizers, toxic pesticides and other chemicals, mainly from agriculture runoff; organic pollution from human settlements spread over the periphery of the lakes and reservoirs).

Rudrasagar Lake is one of the important lake of northeastern part of India. In recent years the lake is also under the capture of civilization resulting deterioration of water body. So to indentify the level of degradation of Lake water , Water quality index (WQI) can be used which is based on aggregate data on water quality parameters. The water quality index (WQI) may also be used in relation to the sustainable management. In an aquatic ecosystem like Rudrasagar Lake water quality is determined by various factors [2].

There are a number of methods to analyze water quality data that vary depending on informational goals, the type of samples, and the size of the sampling area. Research in this area has been extensive, as indicated by the number of methods proposed or developed for classification, modeling and interpretations of monitoring data. One of the most effective ways to communicate information on water quality trends is by use of the suitable indices [3]. Indices are based on the values of various physico-chemical and biological parameters in a water sample. The use of indices in monitoring programs to assess ecosystem health has the potential to inform the general public and decision-makers about the state of the ecosystem. This approach can also help to pro-vide a benchmark for evaluating successes and failures of management strategies at improving water quality [4]. It will indicate what actions should be modified. Numerous studies on water quality assessment have been made, using WQIs. Initially Horton [5] proposed the application of WQI and after that various methods for the calculation of WQI's have been developed. The objective of the present work is to apply the WQI tool to evaluate the water quality of Rudrasagar Lake during the year 2013. The Rudrasagar lakes water may be used as one of the main water sources for the surrounding people.

## II. MATERIALS AND METHODS

### 2.1. Description of the Study Sites

Rudrasagar Lake were studied which is located in the Melaghar of Sonamura Sub-Division of Sipahijala district. The lake forms a geographical area of 2.4 $km^2$ and situated at a distance of about 52 km from Agartala, the state capital of Tripura, India. The lake is situated in between 23° 29' 00" N and 90° 01' 00" E.

The Rudrasagar lake is a natural sedimentation reservoir, which receives flow from three perennial streams namely Kemtalicherra, Noacherra and Durlanaraya cherra .After settling the sediment from the received flow, clear water discharges into the river Gumati through a connective channel namely Kachigang. The lake bed has been formed by silt deposition. Surrounding hillocks are of soft sedimentary formation. Annual rainfall is of the order of 2500 mm. Spread over the months of June to September with 4/5 flood peaks. Substantial base flow in streams rounds the year. The soil in lake area is silty clay loam to clay loam. Lake water depth varies from 2 m to 9m. Fluctuation in water level varies from EL 9m to 16m.The downstream area of the lake is 688 ha with a temperature variation from $37^0$C to $5^0$C and rainfall during May 15 to October 15. The area grows initially based on fishing as main form of livelihood. Later on agricultural activity also started including application of pesticides and fertilizers that drained directly or indirectly to the lake. Besides brick kilns also developed in the area.

### 2.2 Sampling Details and Analysis:

The data recording station is selected mainly through the water navigable areas. Some samples were collected to measure in Laboratory. Some of the water quality parameters have been measured in situ using Multi-parameter water quality checker instruments. The water quality devices have been duly calibrated before the onsite measurements.


**Figure 1. Rudrasagar Lake area showing sampling stations.**

### 2.3. Application of the WQI

This study is an effort to assess the water quality of Rudrasagar Lake, Tripura, India. For this purpose, eight water quality parameters have been selected which are: pH, Dissolved Oxygen, Turbidity, Conductivity, Hardness, Alkalinity, Biochemical Oxygen Demand and Nitrate. Values used for each parameter are the mean value of different points measured under this study. In the formulation of WQI, the importance of various parameters depends on the intended use of water. Water quality parameters are studied from the point of view of suitability for human consumption. The standards values of various parameters for the drinking water used in this study are those recommended by the WHO [6] and BIS[7]. The calculation and formulation of the WQI involved the following steps:

Firstly, each of the ten parameters has been assigned a weight ($AW_i$) ranging from 1 to 4 depending on the collective expert opinions taken from different previous studies. The mean values for the weights of each parameter along with the references used are shown in Table 2. Here, the greatest weight assigned to parameter that has major importance in water quality assessment, while the smallest weight assigned to that parameter that may not be harmful. However, a relative weight of 1 was considered as the least significant and 4 as the most significant.

In the second step, the relative weight (RW) was calculated by using the following equation:

$$RW = \frac{AWi}{\sum_1^n AWi} \quad \text{……….. ……..(1)}$$

where, RW = the relative weight, $AW_i$ = the assigned weight of each parameter, n = the number of parameters. The calculated relative weight (RW) values of each parameter are given in Table 3.

In the third step, a quality rating scale ($Q_i$) for all the parameter except pH and DO was assigned by dividing its concentration in each water sample by its respective standard according to the drinking water guideline recommended by WHO[6], or the BIS drinking water standards [7], the result was then multiplied by 100.

$$Qi = \frac{Ci}{Si} \text{x}100 \qquad \text{……………(2)}$$

$$Q_{ph,do} = \frac{Ci-Vi}{Si-Vi} \text{x}100 \qquad \text{…………(3)}$$

where, $Q_i$ = the quality rating, $C_i$ = value of the water quality parameter obtained from the laboratory analysis, $S_i$ = value of the water quality parameter obtained from recommended WHO or BIS standard of corresponding parameter, $V_i$ = the ideal value which is considered as 7.0 for pH and 14.6 for DO. Equations (2) and (3) ensures that $Q_i$ = 0 when a pollutant is totally absent in the water sample and $Q_i$ = 100 when the value of this parameter is just equal to its permissible value. Thus the higher the value of $Q_i$ is, the more polluted is the water.

Finally, for computing the WQI, the sub indices ($SI_i$) were first calculated for each parameter, and then used to compute the WQI as in the following equations:

$$SIi = RW \text{ X } Q_i \qquad \text{…………………………… (4)}$$

$$WQI = \sum_1^n SIi \qquad \text{……………..(5)}$$

The computed WQI values could be classified as given in table 1.

**Table 1. Classification of WQI values for human consumption.[15]**

| WQI range | Water type |
|---|---|
| <50 | Excellent |
| 50.1 - 100 | Good water |
| 100.1 – 200 | Poor water |
| 200.1 - 300 | Very poor water |
| >300.1 | Unfit for drinking |

**Table 2. Assigned weight values adopted from the literature.[16]**

| Parameters | Reference No | | | | | | | | Mean value |
|---|---|---|---|---|---|---|---|---|---|
| | 3 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | |
| pH (pH unit) | 4 | 1 | 4 | 1 | 1 | 1 | 4 | 1 | 2.1 |
| DO (mg/L) | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4.0 |
| Turbidity (NTU) | 2 | 2 | 2 | - | - | 4 | - | 2 | 2.4 |
| Conductivity (µS/cm) | 2 | 4 | 2 | - | 1 | 4 | 4 | 2 | 2.7 |
| Hardness (mg/L) | 1 | 1 | 1 | - | 1 | 1 | 2 | 1 | 1.1 |
| Alkalinity (mg/L) | 1 | | 1 | - | - | - | 3 | | 1.7 |
| BOD (mg/L) | 3 | 3 | 3 | 2 | 3 | 3 | 4 | 3 | 3.0 |
| $NO_3$ (µg/L) | - | 2 | - | 3 | 2 | 2 | - | 2 | 2.2 |

**Table 3. Relative weight of the water quality parameters.**

| Parameters | Water quality standard | Assigned weight (AW) | Relative weight (RW) |
|---|---|---|---|
| pH (pH unit) | 6.5-8.5(8.0) | 2.1 | 0.109375 |
| DO (mg/L) | 5 | 4.0 | 0.208333 |
| Turbidity(NTU) | 5 | 2.4 | 0.125 |
| Conductivity(µS/cm) | 250 | 2.7 | 0.140625 |
| Hardness(mg/L) | 100 | 1.1 | 0.057292 |
| Alkalinity(mg/L) | 100 | 1.7 | 0.088542 |
| BOD (mg/L) | 3 | 3.0 | 0.15625 |
| NO3 (µg/L) | 50 | 2.2 | 0.114583 |
| Total | | 19.2 | 1 |

## III. RESULTS AND DISCUSSION

Descriptive statistics for all water quality parameters examined are shown in Table 4. It was observed from the computed WQI that the average value is 99.53 for the year 2013 and therefore can be categorized into "Good water" as per Table No 1 but marginally.

In order to reach a better view on the causes of nearly deteriorated water quality in the Rudrasagar lake water, selected results from the determination of water quality parameters are discussed below.

The results of pH varied from 6.2 to 9.0, indicating that the water samples are almost neutral to sub-alkaline in nature.

The observed average DO concentration level of 6.5 mg/L complies with WHO standards and is considered good to sufficient for human consumption and most aquatic biota. Lake waters are till not polluted much as most of the cases BOD value is less than 3 mg/L. Turbidity is widely concerned as an important parameter for drinking water. However, the observed values are not within the permissible level recommended by the WHO for drinking water.

**Table 4. Statistical summary of Rudrasagar Lake water quality data.**

| Parameters | Min | Max | Mean |
|---|---|---|---|
| pH (pH unit) | 6.2 | 9 | 7.6 |
| DO (mg/L) | 4.26 | 8.6 | 6.5 |
| Turbidity(NTU) | 6 | 25 | 10 |
| Conductivity(µS/cm) | 62 | 115 | 78 |
| Hardness(mg/L) | 67 | 91 | 73.3 |
| Alkalinity(mg/L) | 102 | 207 | 135 |
| BOD (mg/L) | 1.21 | 4.1 | 2.3 |
| $NO_3$ (µg/L) | 70 | 112 | 78 |

## IV. CONCLUSION

The calculated Water Quality Index suggests that water quality of Rudrasagar lake was marginally good in the year 2013. Measured Turbidity exceeds frequently from its permissible value and mainly responsible for lowering the quality index. Regular study of such water quality index parameter may guide the authority for taking proper strategy to implement the corrective measures. Finally, it can be concluded that the lake is at the verge of degradation and preventative measures is to be taken by the appropriate authorities.

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