Water Quality Index for Water Bodies: A Review

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Abstract— Water quality index delivers a single digit that states whole water quality at a certain time and location based on several water quality parameters. These indices are better to understandable and useable for public and concerning water management bodies. These indices give general idea of possible problems in the water to public where they live. It can be used to look trends over a period of time on an each location. It is a number ranging from 0 to 100; higher number indicates better quality and sometimes higher number indicates poor quality. The whole story of water quality can't tell by a single number.

Key words: Physico-Chemical Parameters, Water Quality Index (WQI), Water Bodies

I. INTRODUCTION

Currently, clean water is essential for several purposes for healthy living. Rivers are most significant role play in our daily life that is important for human development but it is being polluted by indiscriminate discharge of domestic, industrial waste and anthropogenic activities by human, which affects its physic-chemical and biological quality of water. It is necessary to evaluate the water quality index at regular frequency of period that gives the quality level of index which gives the general idea about the quality of water. Concept of WQI was introduced in Germany in 1848.Later on various indexes are associated with mainly in qualitative nature.

The general water quality was developed by Brown in 1970 and improved by Deininger for the Scottish Development Department (1975). Hortan suggested that the various water quality data could be aggregated into an overall index. The concept of water quality index has been developed by various researchers and used in many countries. Most water quality indices rely on normalizing, or standardizing, data parameter by parameter according to expected concentrations and some interpretation of 'good' versus 'bad' concentrations. Parameters are often then weighted according to their perceived importance to overall water quality and the index is calculated as the weighted average of all observations of interest (e.g., Pesce and Wunderlin, 2000; Stambuk-Giljanovic, 1999; Sargaonkar and Deshpande, 2003; Liou et al., 2004; Tsegaye et al., 2006). Stambuk-Giljanovik (2003) compared the performance of several water quality indices for Croatian waters. Liou et al. (2004) developed an index of river water quality in Taiwan that is a multiplicative aggregate function of standardized scores for temperature, pH, toxic substances, organics (dissolved oxygen, BOD, ammonia), particulate (suspended solids, turbidity), and microorganisms (faecal coliforms). The standardized scores for each water quality parameter are based on predetermined rating curves, such that a score of 100 indicates excellent water quality and a score of 0 indicates poor water quality. The index relies on the geometric means of the standardized scores. Tsegaye et al. (2006) developed a chemical water quality index based on data from 18 streams in one lake basin in northern Alabama that summed the concentration of seven water quality parameters (total nitrogen, dissolved lead, dissolved oxygen, pH, and total, particulate and dissolved phosphorus) after standardizing each observation to the maximum concentration for each parameter. Kim and Cardone (2005) developed a water quality index that evaluates changes in water quality over time and space. The Scatter score index identifies increases or decreases in any water quality parameter over time and/or space. It does not rely on water quality standards or guidelines and can include an unlimited number of parameters. It was developed primarily to detect positive or negative changes in water quality around mining sites in the United States, but could be applied to non-impacted sites as well. Sargaonkar and Deshpande (2003) developed the Overall Index of Pollution (OIP) for Indian rivers based on measurements and subsequent classification of pH, turbidity, dissolved oxygen, BOD, hardness, total dissolved solids, total coliforms, arsenic, and fluoride. Each water quality observation was scored as Excellent, Acceptable, Slightly Polluted, Polluted, and Heavily Polluted, according to Indian standards and/or other accepted guidelines and standards such as World Health Organization and European Community Standards. Once categorized, each observation was assigned a pollution index value and the OIP was calculated as the average of each index value. Water quality index is defined as an overall scheme that transforms weighted values of individual water pollution related parameters into a single number or set of numbers. Water quality index is most effective tools to expressing water quality that communicate information of water quality to the concerned citizens and policy makers. Water quality index gives for assessment and management of surface water. Scottish Water quality index is to assess the temporal variations of surface water quality and highlighted water quality index as a component tool to reflect aggregate water quality. To obtain WQI value, some information is lost especially inter relationships among the water quality and variability in water quality concentrations. The WQI can be used to monitor water quality changes in a particular water supply over time.

A general WQI approach is based on the most common factors aggregated by Shweta Tyagi, Bhavtosh Sharma, Prashant Singh, Rajendra Dobha, which are described in the following three steps:

1) Parameter Selection: This is carried out by judgment of professional experts, agencies or government institutions that is determined in the legislative area. The selection of the variables from the 5 classes namely oxygen level, eutrophication, health aspects, physical characteristics and dissolved substances, which have the considerable impact on water quality, are recommended.
2) Determination of Quality Function (curve) for Each Parameter Considered as the Sub-Index: Sub-indices

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transform to non-dimensional scale values from the variables of its different units (ppm, saturation percentage, counts/volume etc.).

3) Sub-Indices Aggregation with Mathematical Expression: This is frequently utilized through arithmetic or geometric averages.

II. LITERATURE REVIEW

Water quality index (WQI) is valuable and unique rating to depict the overall water quality status in a single term that is helpful for the selection of appropriate treatment technique to meet the concerned issues (Shweta Tyagi, Bhavtosh Sharma, Prashant Singh, Rajendra Dobha).Water quality index (WQI) is defined as a technique of rating that provides the composite influence of individual water quality parameter on the overall quality of water (Singh et al. 2013). Water Quality Index, a technique of rating water quality, is an effective tool to assess quality and ensure sustainable safe use of water for drinking (Tiwari et al. 2014). Water quality index is one of the most effective tools to communicate information on the quality of any water body (Rizwan and Gurdeep 2010).WQI is an a superior way to the understanding of water quality issues by integrating complex data and generating a score, which ultimately describes the water quality status (Tiwari et al. 1985; Singh, D. F. 1992; Rao, S.N; 1997; Mishra et al. 2001). One of the major advantages of WQI is that, it incorporates data from multiple water quality parameters into a mathematical equation that rates the health of water quality with number (Yogedra and Puttaiah 2008). The surface water quality in a region largely depends on the nature and extent of the industrial, agricultural and other anthropogenic activities which exist within the catchments (Banejad and olvaie). The control of water quality has become very important in maintaining the sustainability of water resources. However, the main cause of water pollution is human activities (Ashraf et al..2010).

D.S Bhargava (2011) was studies the water quality index of surface water in an industrial area in Kanpur city. He was studies physico-chemical and biological characteristics of water samples at different location of Kanpur city.

He was occurred high values of total coliform and less DO level is responsible for lowering the value of WQI for beneficial uses related to human contact.

Ravi Kumar Ganwar, Jaspal singh, A.P. singh, D.P. singh were studies the water quality index of River Ramganga at Bareilly U.P. India (2013) .They were studies the physic chemical analysis of Ramganga River at three location. They were occured,Ramganga River water is unfit for drinking Purposes.

Kavita Parmar and Vineeta Parmar (2010) were studies the " water quality index for drinking purposes of River Subernarekha in Singhbhum District. They were Analyse the physico- biological characteristics of River and occurred river water turbid in monsoon season. And DO level less in month of August at location no. four.

Avnish Chauhan and Suman Singh were evaluate the water quality index for drinking purpose of Ganga River at Rishikesh, Uttarakhand ,India. They were studies the physico-chemical and biological characteristics of Ganga River water. They were occurred turbidity high in monsoon season and low in summer season and DO is high in winter season. They were occurred WQI in month of June is 1666 which is very high.

III. WATER QUALITY INDEX WORK DONE IN DIFFERENT WATER BODIES

A. *In Rivers*

In the context of river, various water quality indexes are available. Some are given below:

- Ganga River Kanpur
- Ganga River at rishikesh, Uttarakhand
- Yamuna River
- Subernarekha River in singhbhum district
- Ramganga River at Bareily U.P.
- Tigris river, Baghdad, Iraq and many more

B. *In Lakes*

- Dokan lake, Iraq
- Pariyej lake, district kheda, Gujarat
- Dal lake, Kashmir, India and many more

IV. METHODS & METHODOLOGY

Various numbers of water quality indices are globally available:

A. *Weighted Arithmetic Water Quality Index*

This method has been widely used by the various scientists. This method classified the water quality according to degree of purity by using commonly measured water quality variables.

$$WQI= \sum WiQi / \sum Wi$$

The quality rating (Qi) for each parameter is calculated by using this equation:

Qi= 100[(Ve-Vi / Vs-Vi)]

Where,

Ve= experimental value

Vi= ideal value(Zero for all parameters except pH=7 and DO = 14.6 mg/l)

Vs= standard values

Wi= K / Vs

Wi= unit weight for each parameter

K= proportionality constant = $1/\sum(1/Vs)$

The quality rarting table as per WAWQI

Rating of Water Quality	WQI	Grading
Excellent Water Quality	0-25	A
Good Water Quality	26-50	B
Poor Water Quality	51-75	C
Very Poor Water Quality	76-100	D
Unsuitable For drinking Purpose	>100	E

Fig. 1: Grading

1) *Merits*

- Incorporate data from multiple water quality parameters into a mathematical equation that rates the health of water body with number.
- Less number of parameters required in comparison to all water quality parameters for particular use.
- Useful for communication of overall water information to the concerned citizens and policy makers.
- Reflects the assessment and management of water quality.

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- Describes the suitability of both surface and ground water sources for human consumption.

2) *Demerits*

- Water quality may not carry enough information about the real quality situation of the water.
- Many uses of water quality data cannot be met with an index.
- The eclipsing or over emphasizing of a single bad parameter value.
- A single number cannot tell the whole story of water quality parameters that are not included in the index.
- Water quality index based on some very important parameters can provide a simple indicator of water quality.

B. National Sanitation Foundation Water Quality Index (NSFWQI)

The proposed method for comparing the water quality of various water sources is based upon nine water quality parameters such as temperature, pH, turbidity, fecal coliform, dissolved oxygen, biochemical oxygen demand, total phosphates, nitrates and total solids. The water quality data are recorded and transferred to a weighting curve chart, where a numerical value of Qi is obtained. The mathematical expression for NSF WQI is given by

$$WQI = \sum_{i=1}^{n} Wi.Qi$$

Where,
Qi= sub-index for ith water quality parameter;
Wi= weight associated with ith water quality parameter;
n= number of water quality parameters.
For this NSFWQI method, the ratings of water quality have been defined by using following table:

Rating of Water Quality	WQI	Grading
Excellent Water Quality	91-100	A
Good Water Quality	71-90	B
Medium Water Quality	51-70	C
Bad Water Quality	26-50	D
Very bad water quality	0-25	E

Fig. 2: Grading

1) *Merits*

- Index values relate to potential water use.
- Facilitates communication with lay person.
- Summarizes in single index value in an objective, rapid and reproducible manner.
- Evaluation between areas and identifying changes in water quality.

2) *Demerits*

- Loss of data during the handling.
- Represents general water quality, it does not represent specific use of water.
- Lack of dealing with uncertainty and subjectivity present in complex environmental issues.

C. Canadian Council Of Ministers of the Environment Water Quality Index (CCMEWQI)

This method has been developed to evaluate surface water for protection of aquatic life in accordance to specific guidelines. The parameters related with various measurements may vary from one station to the other and sampling protocol requires at least four parameters, sampled at least four times. The calculation of index scores in CCME WQI method can be obtained by using the following relation:

$$WQI=100-\frac{\sqrt{F_1^2+F_2^2+F_3^2}}{1.732}$$

Where, Scope (F_1) = Number of variables, whose objectives are not met.

F_1= [No. of failed variables /Total no. of variables]*100

Frequency (F_2) = Number of times by which the objectives are not met.

F_2 = [No. of failed tests/Total no. of tests]*100

Amplitude (F_3) = Amount by which the objectives are not met.

1) Excursion$_i$ = [Failed test value$_i$ /Objective$_j$]-1
2) Normalized sum of excursions (nse) = $\sum_{i=1}^{n}$ excursions $_i$ /No of tests
3) F_3 = [nse/0.01nse+0.01]

Therefore, five categories have been suggested to categorize the water qualities which are summarized in Table.

Rating of Water Quality	WQI	Grading
Excellent Water Quality	95-100	A
Good Water Quality	80—94	B
Fair Water Quality	60-79	C
Marginal Water Quality	45-59	D
Very bad water quality	0-44	E

Fig. 3: Grading

1) *Merits*

- Represents measurements of a variety of variables in a single number.
- Adaptability to different legal requirement and different water uses.
- Flexibility in the selection of input parameters and objectives.
- Suitable tool for water quality evaluation in a specific location.
- Clear and intelligible diagnostic for managers and the general public.
- Statistical simplification of complex multivariate data.
- Tolerance to missing data.
- Easy to calculate.
- Suitable for analysis of data coming from automated sampling.
- Combine various measurements in a variety of different measurements units in a single metric.

2) *Demerits*

- Loss of information on single variables.
- Loss of information about the objectives specific to each location and particular water use.
- Only partial diagnostic of the water quality.
- Sensitivity of the results to the formulation of the index.
- Easy to manipulate.
- Lack of portability of the index to different ecosystem types.
- No combination with other indicators or biological data.
- The same importance given to all variables.

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– Lack of information on interactions between variables.

D. Oregon Water Quality Index (OWQI)

The original OWQI was designed after the NSFWQI where the Delphi method was used for variable selection. It expresses water quality status and trends for the legislatively mandated water quality status assessment. The index is free from the arbitration in weighting the parameters and employs the concept of harmonic averaging. The mathematical expression of this WQI method is given by

$$WQI=\sqrt{\frac{n}{\sum_{i=1}^{n}\frac{1}{SI_i^2}}}$$

Where, n= number of subindices
SI= subindex of ith parameter

Furthermore, the rating scale of this OWQI has also been categorized in various classes, which are given under Table.

Rating of Water Quality	WQI	Grading
Excellent Water Quality	90-100	A
Good Water Quality	85—89	B
Fair Water Quality	80-84	C
Poor Water Quality	60-79	D
Very poor water quality	0-59	E

Fig. 4: Grading

1) *Merits*

– Un–weighted harmonic square mean formula used to combine sub-indices allows the most impacted parameter to impart the greatest influence on the water quality index.
– Method acknowledgements that different water quality parameters will pose differing significance to overall water quality at different times and locations.
– Formula is sensitive to changing conditions and to significant impacts on water quality.

2) *Demerits*

– Does not consider changes in toxics concentrations, habitat or biology.
– To make inferences of water quality conditions outside of the actual ambient network site locations is not possible.
– Cannot determine the water quality for specific uses nor can it be used to provide definitive information about water quality without considering all appropriate physical , chemical and biological data.
– Cannot evaluate all health hazards(toxics, bacteria, metals, etc).

V. BHARGAVA METHOD

Bhargava has proposed the method of water quality index for beneficial use.

$$WQI_{i=1}^{n} = [\pi \text{ fi (pi)}]^{1/n} \times 100$$

Where, n is the number of variables is considered more relevant to the use and fi (pi) is the sensivity function of the i^{th} variable which includes the effect of weighting of the i^{th} water quality parameter in the use.

The sensitivity function values of 1.00, 0.75, 0.50, 0.25 and 0.01 representing respective values of 100, 75, 50,25and1 (almost zero) have been used for beneficial uses in classes I to V, respectively. The range of WQI values assigned to the various classes for each beneficial use have been in table.

Interpretation of class	Limits of the WQI	Class of the beneficial use
Excellent	WQI≥90	I
Good	90>WQI≥65	II
Satisfactory	65>WQI≥40	III
Poor	40>WQI ≥15	IV
Unacceptable	WQI<15	V

Fig. 5: Grading

VI. NEED OF WATER QUALITY INDEX

– Developed to summarize and present water quality data in an easily expressible and easily understood.
– Developed to address non-technical questions about general water quality.
– Gives a range 0 to 100; lower the number is indicative of better water quality.

Earlier, River Ami was subjected to multiple uses for bathing, irrigation, fisheries, and also for drinking purposes but presently, uses for disposal of sewage and industrial effluents. This study is to calculate the water quality index of Ami River. Ami River is originated from Sikhara Tal near Pre-Hallur (Siddharth nagar) and joins to river Rapti. The serpentine length of Ami river is 126 Km and it's receives the industrial and domestic effluent during the course of 90 kilometers. The sample was collected from mid-stream of river Ami at nine locations which covers the whole river. The collected samples are subjected to test for physico-chemical analysis. The main reason of degradation of water quality of Ami River was due to the improper sanitation, too much anthropogenic activities, and high rate of direct discharge of effluent by industrial and domestic sectors, which is finally, requirement of water quality index.

VII. CONCLUSION

The water quality index integrates complex water quality data into a readily understood scale to help the public and water managers better understand results from water quality monitoring. Indexes scores for complex data may also increase public awareness and understanding of water quality.

The central government and state government is to committed management of water resources and established the treatment plant and research community should be committed to future controlling strategies of effluent discharge into the water bodies. In order to implementation, there is a need to understand how effluent and other discharge to surface water. For the implication of water bodies, we need to more work on water quality index of various water bodies because of Indian rivers, lakes and other water bodies are mostly polluted in that time.

The discussions conclude that wretched condition of surface water quality in the Gorakhpur region and others which is still continuously degrading. Ami River is far beyond the alarming condition that means it is irreparable. There is a need to understand how much treated and untreated effluent discharges to surface water. For save this precious Ami River, a enhance effort and advanced treatment technologies should be immediate action by policy makers, social activists, and most important public involvement. For this reason we are require to calculate water quality index of Ami River which gives the approximate idea about the how much pollution in River.

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