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A Review On Evaluation Of Water Quality Index

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Abstract: Any water quality monitoring study's main goal is to assess the water quality status for specified uses. Water is one of the most valuable natural resources on the planet, and it is critical for the survival of both plant and animals. The quality of water is just as crucial as the amount. [1] Water quality index (WQI) is a useful and unique rating that depicts the total state of water quality in a single term and aids in the selection of appropriate treatment techniques to address the concerns. WQI, on the other hand, illustrates the combined impact of many water quality metrics and communicates water quality information to the public and policymakers. [2] There are a number of criteria that may be used to analyze water quality, but taking into account all of them can add to the complexity of the process. As a result, the development of a Water Quality Index (WQI) is a widely used tool for assessing water quality. The entire tale of water can be told in a single scoring number, which is determined using various ways. It is beneficial to choose a suitable therapy method to address the problem. WQI and its development methods are addressed in this study. The benefits and drawbacks of WQI are also discussed.

***Index Terms* - ground water, water parameters, water quality, water quality index**

I. INTRODUCTION

Water is one of the most vital resources for human life, and its quality is entirely dependent on the geological environment, recovery, and usage as needed, as well as human activities such as household, industrial, or commercial, mining operations, agricultural, and so on [1]. Physical, chemical, and biological factors can be used to assess the water quality of any specific place or source. If the levels of these parameters exceed the set limitations, they are detrimental to human health [2,3,4,5]. As a result, the water quality index (WQI), which is one of the most effective techniques to quantify water quality, has been used to assess the acceptability of water sources for human consumption. WQI makes use of water quality data and assists in the revision of policies developed by various environmental monitoring agencies. It has been established that using individual water quality variables to describe water quality for the general audience is difficult to comprehend [6,7]. There is a method for determining the quality of water in the form of an index based on the following categories:

- Human well-being, which encompasses both health and population.
- Ecosystem health, which includes air and water quality testing

II. WATER QUALITY INDEX

WQI was first developed in the United States by Horton (1965), who chose ten of the most commonly used water quality variables, such as dissolved oxygen (DO), pH, coliforms, specific conductance, alkalinity, and chloride, among others. It has since become widely used and accepted in European, African, and Asian countries. The weight allocated to a parameter represented its importance for a certain application and has a significant impact on the index. Furthermore, a new WQI based on weights to specific parameters was produced by the Brown group in 1970, which was similar to Horton's index. Many changes to the WQI concept have recently been discussed by numerous scientists and experts. The most common factors, which are presented in the following three steps, form the basis of a general WQI approach:

1) Selecting Parameters: This is done by the decision of professional experts, agencies, or government entities, which is based on legislation. It is advised that variables from the five classifications, namely oxygen level, eutrophication, health aspects, physical qualities, and dissolved substances, be chosen because they have a significant impact on water quality.

2) Determination of Quality Function (curve) for Each Parameter Considered as a Sub-Index: Sub-indices convert variables of diverse units (ppm, saturation %, counts/volume, etc.) to non-dimensional scale values.

3)Aggregation of Sub-Indices Using Mathematical Expressions: This is commonly done using arithmetic or geometric averages.

III. ENVIRONMENTAL WATER QUALITY INDEX

In its descriptive categorization of a huge quantity of environmental data, an "environmental water quality index" is used. It is for this reason that it can be valuable to decision-makers. Impact studies employ these indices. Air quality index, water quality index, ecological sensitivity and variety, noise index, visual quality, and quality of life are all included in this. Among the various Water Quality Indexes that are mathematically analyzed, two key ones are explained in detail. The primary goal of the environmental water quality index is to synthesize available data and to disseminate information about the baseline environment's condition. Also, to assess the long-term viability of environmental categories in terms of pollution and to concentrate attention on the most important environmental variables.

A. National Sanitation Foundation Water Quality Index (NSFWQI)

A common water quality index technique was created by picking criteria with considerable care, constructing a standard scale, and assigning weights. The National Sanitation Foundation (NSF) backed the effort, which was dubbed NSFWQI in order to compute the WQI of numerous dangerously polluted water bodies. Temperature, pH, turbidity, fecal coliform, dissolved oxygen, biochemical oxygen demand, total phosphates, nitrates, and total solids are among the nine water quality characteristics included in the proposed technique for assessing the water quality of various water sources [28,36]. The data on water quality is recorded and transferred to a weighting curve chart, from which a numerical value for Qi is calculated. The mathematical expression for NSF WQI is given by

WQI= $\sum QiWi\ n\ i$=1

Where,
Qi =sub-index for ith water quality parameter;
Wi = weight associated with ith water quality parameter;
n = number of water quality parameters

Table 1: Different variables considering for NSFWQI questionnaires no. I

Candidates' variables considered forthe NSE WQI in questionnaire	
Dissolved oxygen	Oil and grease
Fecal coliforms	Turbidity
pH	Chlorides
Biological oxygendemand (5 days)	Alkalinity
Coliform Organisms	Iron
Herbicides	Color
Phosphates	Manganese
Temperature	Fluorides
Pesticides	Copper
Nitrates	Sulfates
Dissolved solids	Calcium
Radioactivity	Hardness
Phenols	Sodium &potassium
Chemical OxygenDemand	Acidity
Carbon chloroformextract	Bicarbonate
Ammonia	Magnesium
Total solids	Aluminum

Table 2: Classification criteria standards based on NSF-WQI with colors suggested for reporting theWQI:

Advantages:
• It summarizes the data pertaining to the studied parameters into a single number in a quick, objective, and repeatable manner.
• The assessment of changes in water quality in various places; • The index value represents the amount of water that might be used.

Disadvantages:
• It does not use a sophisticated scale of water quality metrics;

National Sanitation Foundation WaterQuality Index (NSFWQI)	
WQI VALUE	Rating of WaterQuality
91-100	Excellent water quality
71-90	Good water quality
51-70	Medium water quality
26-50	Bad water quality
0-25	Very bad water quality

• Some of the data is lost during the manipulation process.

B. Canadian Council of Ministers of the Environment Water Quality Index (CCMWQI)

The CCME WQI is a standardized technique developed by Canadian authorities to communicate water quality information to both managers and the general public. Furthermore, WQI was created by a committee under the Canadian Council of Ministers of the Environment (CCME), and it may be used by many water agencies in other nations with minor modifications [8,9,10]. This approach was created to assess surface water for aquatic life protection in compliance with particular requirements. The parameters associated with various measurements may differ from one station to the next, and the sampling methodology calls for at least four parameters to be sampled four times [11,12]. The calculation of index scores in CCME WQI method can be obtained by using the following relation:

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

Where,

Scope (F1) = Number of variables, whose objectives are not met.

F1= [No. of failed variables /Total no. of variables] *100 Frequency (F2) = Number of times by which the objectives are not met.

F2 = [No. of failed tests/Total no. of tests] *100 Amplitude (F3) = Amount by which the objectives are not met.

(a) excursion = [Failed test value$_i$ /Objective$_j$] - 1

(b) normalized sum of excursions (nse) = $\sum_{1=1}^{n}$ excursions /No of tests

(c) F3 = [nse/0.01nse+0.01]

Therefore, 5 categories have been suggested to categorize the water qualities which are summarized below:

Table 3: Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI)

Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI)	
95-100	Excellent water quality
80-94	Good water quality
60-79	Fair water quality
45-59	Marginal water quality
0-44	Poor water quality

Advantages:
- It is very adaptable to various water usage -
- It is simple to compute
- It has a low level of sensitivity to missing data.

Disadvantages
- The relevance of all factors in determining the index is equal.
- It can't be confused with other signs or biological information.
- Only a portion of the water quality is described.
- When there are too few variables to consider, F1 does not operate properly

C. Weighted Arithmetic Water Quality Index

When most common quality variables are measured, this approach is used. The parameters or variables were examined in the lab according to APHA 1995 standard methods. To calculate water quality index following equation is used:

Step1: To calculate a quality rating (Qn):
Quality rating (Qn) = $100 \times \frac{V_n - V_i}{V_s - V_i}$

Where,
Vn = actual value of particular parameter in water sample
Vi = ideal value of parameter (0 for all parameters except pH 7 Milligram per liter)
VS= standard value for the parameter

Step2: To find unit weight (Wn):
Wn= K/ Vs
Where, $K = \frac{1}{\frac{1}{V_{S_1}} + \frac{1}{V_{S_2}} + \cdots + \frac{1}{V_{sn}}}$

Step3: To calculate water quality index (WQI):

$$WQI = \frac{\sum Q_n W_n}{\sum W_n}$$

Water QualityIndex	Descriptionstatus	Category
0 – 25	Excellentquality	A
26 – 50	Good quality	B
51 – 75	Poor quality	C
76 – 100	Very poorquality	D
>100	Unsuitable for drinking	E

Advantages:
• It incorporates the values of numerous physicochemical water quality parameters into a mathematical equation that represents the water ecological condition;
• It reflects the relevance of each parameter in the evaluation and management of water quality.
• It may be used to characterize the acceptability for human consumption of both surface and subsurface water sources.

Disadvantages:
• This index may not give enough information about the true state of water quality;
• This index does not contain all of the factors.

D. OWQI (Oregon Water Quality Index)

The OWQI (Oregon Water Quality Index) is a metric for describing the quality of surface water bodies in Oregon and neighboring states. Temperature, dissolved oxygen (OD), biochemical oxygen demand (BOD), pH, Ammonia, nitrate, nitrogen, total phosphorus, total dissolved solids (TDS), and Coliforms are the eight physical, chemical, and biological parameters employed in this descriptive technique for water quality [13,15]. Starting with the NSF-WQI model, this index was proposed. The difference is in the calculus approach and the parameter weighting, which is not taken into account in this scenario. Below Formula is the mathematical formulation for this strategy, which uses the idea of arithmetical average.

$$OWQI = \sqrt{\frac{n}{\sum_{i=1}^{n}\frac{1}{SI^2}}}$$

where:
n is the numbers of parameters (n=8),
Si is the sub-index of sub-index ith parameter [13,16,17].
The calculus method of the sub-index for each parameter is presented in much more detail in Cude's article, 2001.
The obtained value after the index calculation of the water utilizing the Oregon Water Quality Index method indicates the quality of the analyzed water, as shown in Table below:

Table 4: The corresponding values to water quality in conformity with OWQI:

Oregon Water Quality Index (OWQI)	
90-100	Excellent water quality
85-89	Good water quality
80-84	Fair water quality
60-79	Poor water quality
0-59	Very poor water quality

Advantages:
• The use of weighted harmonic to combine sub-indices allows the most impacted criteria to have the most influence on the OWQI;
• The formula is sensitive to environmental changes and major influences on water quality.

Disadvantages:
• It is unable to offer reliable information on changes in toxics concentrations, habitat, or biology;
• It is unable to assess all toxic elements for health (bacteria, metals, toxics) [13,14].

E. Overall Index of Pollution (OIP):

Sargaonkar and Deshpande (2003) created OIP for Indian rivers based on pH, turbidity, dissolved oxygen, BOD, hardness, total dissolved solids, total coliforms, arsenic, and fluoride measurements and categorization. According to Indian norms and/or other recognized rules and standards such as World Health Organization and European Community Standards, each water quality observation was graded as Excellent, Acceptable, Slightly Polluted, Polluted, and Heavily Polluted. Each observation was given a pollution index value once it was classified, and the OIP was determined as the average of each index value using the following mathematical expression:

$$OIP = \frac{\sum_i P_i}{n}$$

Where ,
Pi = pollution index for ith parameter,
n = number of parameters

F. Bhargava method:

Bhargava (1985) identified four groupings of factors to create this index. There were sets of one type of parameter in each category. The first group comprised coliform organism concentrations, which represented the bacterial quality of drinking water. Toxicants, heavy metals, and other substances were included in the second group. Physical impacts, such as odour, colour, and turbidity, were included in the third group. Nontoxic inorganic and organic compounds such as chloride, sulphate, and others made comprised the fourth category. The sub-indices were calculated, and the simplified WQI model for practical use is as follows:

$$WQI = \sum_{i=1}^{n} f_i(P_i)^{1/n}$$

where n is the number of variables considered more relevant to the use and fi(Pi) is the sensitivity function of the ith variable which includes the effect of weighting of the ith variable in the use. The index was applied to the raw water quality data at the upstream and downstream of river Yamuna at Delhi, India.

G. Smith's index:

Smith (1987) created an index for four different types of water applications, including touch and non-contact. It's a cross between the two popular index kinds, and it's based on both expert judgement and water quality criteria. Delphi was used for selecting parameters for each water type, creating sub-indices, and giving weightages. The final index score was calculated using the minimal operator technique: $I_{min} = \Sigma\ (I_{sub1}, I_{sub2}, I_{subn})$

Where, I_{min} equals the lowest sub index.

H. The River Ganga Index of Ved Prakash et al (1990)

The index was created to assess the water quality profile of the Ganga across its entire length. The index had a weighted multiplication form and was based on the NSFWQI, with minor weightage changes to conform to the Central Water Pollution Board of India's water quality parameters for various kinds of usage.

$$WQI = \sum_{i=1}^{p} Wi\ Ii$$

Where,
Wi is weight associated with ith water quality parameter, Ii denotes sub-index for ith water quality parameter. i = 1, 2,…,n and p denotes number of considered water quality parameters.

Conclusion

Following a review of several water quality indices, it can be concluded that the goal of WQI is to assign a single value to a source's water quality while also reducing a large number of characteristics into a simple expression, allowing for easy interpretation of water quality monitoring data. Furthermore, this is an effort to evaluate the key indices used in assessing water quality risk, as well as information on the indices' composition and mathematical forms. It's the simple interpretation of data from water quality monitoring. As we review the benefits and drawbacks of both the National Sanitation Foundation WQI and the Weight Arithmetic WQI, which are both beneficial for monitoring, assessment, and impact studies for various water bodies in various places throughout the world. It assists various decision-makers in taking appropriate action or determining treatments

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