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Water Quality Index Assessment Tool of Surface & Subsurface Water Quality: An Overview

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Abstract:- Water is a vital resource for the survival of mankind. The rapid urbanization, industrialization and uncontrolled use of chemicals in agriculture, deteriorate the quality of water and showed adverse effect on the aquatic environment. As a result, a huge population of human kind suffered with water borne diseases because of using the contaminated water. There are many parameters available, based on that the water suitability can be evaluated for potable use. Generally, the chemicals which present in water bodies such as Ca (Calcium), Mg (Magnesium), Chlorides (Cl^-), Sulphates (SO_4^{2-}), Total Hardness, Fluoride, Nitrate, Total Dissolved solids and the physical properties such as temperature, Electrical Conductivity etc are analyzed. On the basis of above mentioned physico-chemical parameters the goodness of water can be indexed by using the Tool Water Quality index (WQI) assessment which expressed quality of water in terms of some index number. Water quality index number stored all the information related to the water in single value. Various researchers have developed water Quality index region wise and proposed models for the anticipation of quality of water. This paper is focused upon the various ways for the detection of Water Quality index.

Keywords:- *Water Quality Standard, Water Quality Index, Physico- Chemical Analysis.*

I. INTRODUCTION

Water is an asset to the living creatures, it is essential for the survival on earth. Existence of human kind is associated by the presence of water which is available in rivers, lakes, oceans etc. In all over the world most of the fresh water are getting polluted and decreases the portability of water. Polluted water carries a different types of pollutants in dissolved and particulate forms that directly influences on the system including the lithology of the basin, anthropogenic inputs, atmosphere inputs and climatic conditions. All living things on the earth surface need water for their growth and survival. However, chemically pure water never exists in nature in any form. In General, pure water is said to have minimum concentration of suspended & dissolved solids and obnoxious gases and minimum in biological life. The quality of water totally depends on geological environment, recovery , utilization as per need and various human activities like domestic, commercial or industrial, mining operations, effluent discharges, soil erosion, agriculture etc and is dependent on land cover, climate, land slope, and soil resilience. If the water is impure it is very tedious to recapture the quality of water easily. It becomes necessary to provide suitable treatment to water so as to destroy the effects of pollutant and microbes which reduces the potential hazard of health of human body. For drinking purpose the quality of water must be better, while for industry & agriculture purpose flexibility can be entertained. In modern scenario domestic, industrial water supply, irrigation requirement of the water is being served by the surface and subsurface water. In recent decades huge population enhancement has resulted in growing demand of fresh water. As per WHO, the use of unsafe water is the cause of 80% diseases in human being. The physical, chemical and biological parameters helps in assessment of water quality. To maintain the desired concentration of minerals in water, the various authorities in the world like World Health Organization, the European Union, Bureau of Indian Standards, the United States Environmental protection agency, have mentioned drinking water standards. Quality of water is a parameter which describes the water suitability for particular purpose.

Water Quality Index (WQI) depicts the water quality which involves citizens and policy manufactures. WQI is combined influence of the different water quality parameters on overall water quality.WQI is a Mathematical tool that converts the huge data of water quality into a single numerical value based on various water quality indices. It's purpose is to provide the data for water quality into information that is useful and easily understandable by public. It is compulsory to continuous maintain the quality of water and various ways of devices for protection of its quality.

II. LITTERATURE REVIEW

- *General*

The assessment of WQI is depending upon the importance of a variety of parameters suitability for human uses. Water Quality index helps in knowing subsurface and surface contamination also utilized in the execution of water quality upgrading programme. Various technical papers on assessment of water quality have been referred from which some papers are discussed in this section.

(M. Prasad, 2019) have worked on assessment of ground quality from Oblulavaripalli Mandal, YSR district, in Andhra Pradesh India. Water quality index is found by observing twenty ground water samples from bore wells in obulavaipalli district and then physico-chemical analysis was performed. Electrical conductivity, total dissolved solids, total alkalinity, magnesium, pH, calcium, chloride,

sulphate and fluoride were considered for analysis. The observed results revealed that 30 % of the sample fall under excellent category, 40 % sample under good category and another 30% is under poor category based on water quality parameters checks. Overall water quality of locality is found to be unhealthy for consumption.

Yulu Tian, Yuan Jiang et al (2019), have worked on the water quality index of upper and middle stream of Luanhe River, Tianjin city, Northern China. For this purpose,12 water quality parameters and 85 sampling sites was selected in July (2017), October (2017) and April (2018). The calculated WQI ranged from 37.6 to 90.0 indicates bad to excellent water quality. The main factor which degrade the water quality is inorganic and organic pollutants and the agriculture relevant variables. In this region, generally in summer season the WQI value is higher than other season.

Shrikant Mukate, Vasant Wagh et al (2019), for drinking suitability they have developed the new integrated water quality index model. The Integrated Water Quality Index (IWQI) is categories as (<1)excellent,(1-2) good,(2-3) marginal,(3-5) poor, and (>5) unsuitable.The results indicates 2 % sample is in excellent category, 39 % are good,43 % are marginal, 8% are poor, and rest 8 % unsuitable for drinking. The outcoming of the work is analyzed at 20 % deficit of its maximum permissible limit. The present work also states that industrial effluents of west region is mostly influenced by anthropogenic inputs from while south west region is influenced by agriculture runoff. This IWQI method has been applied by the Inverse distance Weightage technique in Arc GIS 9.3 software. For interpretation of IWQI, Chincholi industrial area of Solapur city, Maharashtra is selected ,49 groundwater samples collected for analysis in pre monsoon season of 2014. Total 9 parameters are considered for physico-chemical analysis such as pH, TDS, Ca, Mg, Na, K, Cl, SO_4, and NO_3. For laboratory experiment, the standard procedure prescribed by American public health association (APHA) is followed. It uses the desirable and permissible limit described by various authorities such as Bureau of India standards. The results reveals that sample number 38, 41 and 44 exceeds the concentration of Ca,Mg, Cl, NO_3, and TDS, above the permissible limits which are located near industrial area. The major advantage of IWQI is to identify excessive and deficient ions in the water. In conventional WQI the DL or PL as upper limit is considered as good but in IWQI both the DL and PL limits are considered. The IWQI is unbiased and easy to use.

Majid Radfard, Mozhgan seif et al (2019), carried out estimation of drinking water quality index in water resource with the help of Artificial Neural Network (ANN) and ArcGis software in Bardaskan city, Iran. For sampling of water 30 villages were considered. Water samples were tested for eighteen physico-chemical parameters such as Calcium hardness, turbidity, Total Hardness, pH, temperature, Total dissolved solids, electrical conductivity, alkalinity, magnesium, calcium, potassium, sodium, sulphate, bicarbonate, fluoride, nitrate, nitrite and chloride. The results reveals that the drinking water quality index is 3.3 % fall in the category of excellent, 60% in good, 23.3% in poor and 13.3 % in very poor category. It uses the Adaptive Network Based Fuzzy Inference (ANFIS), approach for WQI determination.

A.S. Ejoh, B.A. Unuakpa et al (2018),carried work on the water quality of Ubogo and Egini rivers, Udu laga, Nigeria. For analysis, 16 physico-chemical parameters were selected. The sampling was performed in period of February to July 2010. The water is mostly acidic in nature in both the river. The BOD range of 1.20-2.20 mg/l was found.

Salam Hussein Ewaid & Salwan Ali Abed (2017), have developed water quality index for Al- Gharraf River, Southern Iraq which is the main branch of Tigris River. The sampling was done in 2015-16 and 11 Physico-chemical were considered for analysis such as BOD, TDS, the concentration of hydrogen ions, dissolved oxygen, turbidity , phosphate, nitrates , chlorides, total hardness, electrical conductivity & alkalinity. This paper also indicates the effect of ecological factors on surface water quality. For sampling purpose, 5 stations were chosen in the period of Dec 2015 to January 2016. The WQI was calculated by weighted arithmetic water quality method. The lowest WQI value of 43 was recorded for station 1 which states good quality of water. The WQI values for station 2, 3, and 4 were 67.2, 64.1 & 73.5 respectively, which indicates poor quality of water. The general WQI is 67.3 for selected river which indicates poor water quality.

Hung Pham et al (2017) have used water quality index and Multivariate Statistical Techniques that are used to depict the surface water quality of the Upper Part of Dong Nai River Basin, Vietnam. The main objective of this paper is to determine the effect of anthropogenic sources of pollutants on water quality parameters. Total 42 samples were collected from upper part of Dong Nai River Basin during the period of 2012-2016 and eight physico-chemical parameters are selected for WQI. This paper also deals with the use of multivariate statistical technique such as Hierarchical Cluster Analysis (HCA), One Way Analysis Of Variance (ANOVA) and Spearman Correlation analysis (SCA). The results show that surface water of the river was moderately polluted.

Mohd Saleem, et al (2016), have worked on analysis of groundwater quality by using water quality index, of greater noida region , Uttar Pradesh India. Ten different locations were selected for analysis in 2015. For analysis of water quality Nine physico-chemical parameters are selected such as calcium, Magnesium, chloride, Sulphate, Total Hardness, Fluoride, Nitrate , Total Dissolved Solids .The Water Quality index value was found to be in the range of 16.49- 64.65 in which 90 % sample fall under good category.

Manish Dubey, et al (2016), have worked on characterization of Groundwater quality using water quality index in Gwalior city, Madhya Pradesh, India. Eight

locations of Gwalior city are selected for sampling Purpose in which 48 ground water samples are collected and samples are collected through the deep bore well in Dec-May 2016. The calculated water quality index falls in the range of 50.86 to 64.28 in winter season and 52.23 to 74.89 in summer season which indicate poor quality of water. The high value of WQI is due to higher concentration of calcium, magnesium, hardness, fluorides, solids, and ions in the ground water.

Deepraj Kevat, et al (2016), have developed water quality index of Saank River, Morena Madhya Pradesh. Four Locations of Saank river were selected for sampling purpose and sampling was performed for the duration of Dec 2015 to June 2016. Twelve number of sample were collected in summer, winter & monsoon season from four sites. The experiment was performed according to standard method as per APHA. The parameter consider for analysis are pH value, Electrical conductivity, Total dissolved solids, alkalinity, Total Hardness, Sulphate, Nitrate, Chloride, Turbidity, Phosphate, Dissolved Oxygen, BOD, COD, Coliform test (MPN). The water quality index of Saank River was very poor which is not fit for drinking purpose. Therefore, to improve the water quality index of Saank River stringent pollution control activity shall be under taken.

K.Yogendra and E.T. Puttaiah (2008), have worked on 'determination of water quality and suitability of an urban waterbody in Shimoga town, Karnataka'. The main aim of this paper is to find out the water quality index on the basis of different physico-chemical parameter. The water quality index was determined in different seasons i.e. rainy season, winter season, & summer season for a period of April-2006 to March- 2007. The calculated water quality index is 96,101.7 and 106.3 in different season which indicate poor quality of water.

M. Saeedi, et al (2008), have studied on development of ground water quality index in Qazvin Province in central western of Iran. The aim of this paper is to develop a groundwater quality index which indicates the best quality of water within the Qazvin province.

III. ASSESSMENT OF WATER QUALITY

The various parameters analyzed for assessment of water quality are described below.

- **pH:** It indicates the negative log of hydrogen ion concentration present in the water sample. The scale of pH varies 0 to 14, where value pH=7 represent neutral water, above 7 represent basic water and below 7 represent basic water. Measurement of pH is done with the help of pH meter. Standard limit of pH for drinking water is 6.5-8.5. Due to biological activity in water and reaction of carbon dioxide, the pH value changes for a solution.

- **Electrical Conductivity (**EC**):** It indicates the current carrying capacity of water sample. It also helps to check the purity of water sample. The instrument used for its measurement is called as electrical conductivity meter. The value of EC increases, if the concentration of dissolved salts increases in the water sample.

- **Total Dissolved Solids:** It is the concentration of minerals, salts, and metal which are dissolved in the water sample. It directly degrade the quality and hampers water treatment process. As per BIS, the permissible limit is 500 mg/l. TDS enters into the ground water through the percolation and infiltration from soil strata. Diseases such as arthritis, accumulation of stone in kidney and other various heart diseases etc. are being caused by high TDS value.

- **Total Hardness:** It is measure of presence of calcium and magnesium ions in the water sample. EDTA method is used for its determination. The high value of hardness causes scaling of boilers, lesser formation of foam, kidney problem in human etc. The Standard limit of hardness is 200 mg/l as per BIS.

- **Turbidity:** Presence of suspended particles in water which obstruct the route of light is called turbidity. It represents cloudiness of water that is invisible to the necked eye. Silt, clay, organic matter and dissolved particles makes water turbid. The instrument used for measurement of turbidity is Nephlometer Turbidity Meter (NTU). According to BIS, the permissible limit of turbidity is 5 NTU.

- **Sulphate:** The sulphate ions are present in natural water which are in soluble form. The measurement of sulphate ions is done with the help of UV Spectrophotometer. The acceptable limit of sulphate is 200 mg/l as per BIS standard.

- **Alkalinity:** It is the measure of capability of water to neutralize acid. Alkalinity is measured by titration method in the laboratory. It is present in water due to weak acid. The acceptable limit of alkalinity is 200 mg/l as $CaCO_3$.

- **Chloride:** It is found as salts of calcium, magnesium, and Potassium ions in water sample. It is determined in the laboratory by argentometric method. The acceptable limit of chloride is 250 mg/l and permissible limit is 1000 mg/l. It may corrode the water supply and sewage pipes made of concrete.

- **Dissolved Oxygen:** The survival of aquatic animals is dependent on dissolved oxygen in water .Minimum DO level to be maintained in natural water body is 4 mg/l .The wastewater which is released from industrial outlets may reduce DO level in natural water. It directly affects the health of water bodies.

- **Biochemical Oxygen Demand:** It is the oxygen requirement of microorganism for the decomposition of organic matter present in the water sample. The standard limit of BOD for drinking water is negligible. The significance of BOD is to determine the efficiency of treatment plant by considering influent and effluent BOD values. As per WHO, the acceptable limit of BOD is 6 mg/l.

❖ *Water Quality Index (WQI) & its Rating:*

A. National Sanitation Foundation Water Quality index (NSFWQI) :

This methodology take into account the 9 water quality parameters like temperature, pH, turbidity, fecal coliform, dissolved O_2, biochemical oxygen demand, total phosphates , nitrates and total solids. The recorded values of water quality data is transferred to a weighting curve chart and numerical value of Qi is determined. The equation used for determination of water quality index is :

$$\mathbf{WQI} = \sum_{i=1}^{n} \mathbf{QiWi} /\mathbf{100}$$

Where,
Qi = Sub-index for ith water quality parameter
Wi = Weight related to the ith water quality parameter
n = Water quality parameters in total numbers

The rating of water quality as per NSFWQI method is:

WQI Value	Rating of Water Quality
0.91-1.00	Readily acceptable
0.71-0.90	Acceptable
0.51-0.70	Moderately Acceptable
0.26-0.50	Poor
0-0.25	Adverse

Table 1

B. Canadian Council of Ministers of the Surroundings Environment Water Quality Index (CCMEWQI):

This method has formulated by Canadian jurisdictions for assessment of water quality information for both public and management. The Canadian water quality index method is also suitable for protection of aquatic life and recommended by various agencies in the various countries. In this method the sampling protocol requires atleast four parameters. The mathematical expression for CCMEWQI is given by

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

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.

(a) Excursion_i = (Failed test value_i / Objective_j)– 1
(b) normalized sum of excursions (nse) = $\sum_{i=1}^{n} \frac{\textbf{excursions}}{\textbf{No.of tests}}$
(c) F_3 = [nse / 0.01 nse + 0.01]

The rating of water quality as per **CCMEWQI** method is :

WQI Value	Rating of Water Quality
0.95-1.00	Readily acceptable
0.80-0.94	Acceptable
0.60-0.79	Moderately Acceptable
0.45-0.59	Poor
0-0.44	Adverse

Table 2

C. Oregon Water Quality Index (OWQI) :

Oregon's stream water quality parameters is suitable to the geographic regions, which consider the eight water quality variable for analysis such as temperature, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), ammonia and nitrate nitrogen, total phosphorous, total solids, and fecal coliform. The mathematical equation for this method is given as

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

Where,
n = number of sub indices
SI = sub index of the ith parameter

The rating of water quality as per **OWQI** method is:

WQI Value	Rating of Water Quality
90-100	Readily acceptable
85-89	Acceptable
80-84	Moderately Acceptable
60- 79	Poor
0-59	Adverse

Table 3

D. Weighted Arithmetic Water Quality Index Method :

The degree of purity is being considered for water quality by considering the commonly used water quality variables. It has been mostly used by various scientists. The following equation has been used for calculation of WQI :

$$\mathbf{WQI} = \sum \boldsymbol{QiWi} / \sum \boldsymbol{Wi}$$

The quality rating scale is evaluated using the following equation.
Qi= [V_i- Vo / Si – Vo] * 100
Where,
Vi = Estimated value of ith parameter in the analysed water
Vo = ideal value of the parameter

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Vo = 0 { Except pH = 7.0 and Dissolved Oxygen = 14.6 mg/l }
Si = Standard value of the ith parameter
Wi = unit weight for each quality parameter

$$Wi = k / Si$$

K= Proportionality constant and is calculated by the following expression = $\frac{1}{\sum (\frac{1}{Si})}$

The rating of water quality as per **Weighted arithmetic water quality index** method is :

WQI Value	Rating of Water Quality	Grading
0-25	Excellent water quality	A
26-50	Good water Quality	B
51-75	Poor water quality	C
76-100	Very Poor water quality	D
Above 100	Unsuitable for drinking purpose	E

Table 4

IV. CONCLUSION

Determination and maintenance of water quality is attained by surface and subsurface water quality monitoring by evaluating various physico-chemical parameters and their integration effect. Spreading awareness in public about the water quality parameters is basic aim of this paper. The water pollution can be minimized by housekeeping and management practices of the waste generated in the city. The quality of water is dependent on the nature of the pollutant present in the water bodies. The water quality index is very helpful tool that reduces the complexity created due to different water quality parameters, which provides a single number that tells the whole story of water bodies. Water quality index ensure a single value of water quality that reduces the number of parameters into a mathematical expression which result into easy interpretation of water quality monitoring data.

The Weighted Arithmetic water quality index method is mostly used to determine water quality index as it require less number of parameter in comparison to other. The effort also made to provide the information of various water quality indices used for assessment of water quality and various research done for development of this indices by various government agencies. There is no index developed globally which is universally accepted. The search is still going on.

As per arithmetic water quality index method rating if the value of WQI is 0-25 which comes under excellent category and is suitable for drinking and cooking purpose. If the value of WQI is not in good and excellent category, proper treatment must be provided to water body to safeguard the health of public. Various researches show the value of WQI is better in dry season as compare to wet season.

REFERENCES

[1]. A.S. Ejoh, B. U. (2018). Dataset on the assessment of water quality and water quality index of Ubago and Egini rivers, Uda LGA, Delta State Nigeria. *Data in Brief* , 1716-1726.

[2]. Abed, S. H. (2017). Water quality index for AL-Gharraf River, Southern Iraq. *Egyptian Journal of Aquatic Research* , 117-122.

[3]. APHA1989. *Standard methods for the examination of water and waste water, 17th Ed. Washington DC.*

[4]. BIS(2012). *Drinking water specification IS No. 10500. Bureau of Indian Standards.*

[5]. Deepraj Kevat, M. D. (2016). Assessment of Water Quality Index of Saank River , Morena, Madhya Pradesh. *International Jounal of Science, Engineering and Technology Research (IJSETR)* , 2563-2567.

[6]. Hamed Soleimani, O. N. (2018). Data on drinking water quality using water quality index (WQI) and assessment of groundwater quality for irrigation purposes in Qorveh & Dehgolan, Kurdistan Iran. *Data in Brief* , 375-386.

[7]. Hung Pham, M. M. (2017). Assessment of Surface Water Quality Using the Water Quality Index and Multivariate Statistical Techniques - A Case Study : The Upper Part of Dong Nai River Basin, Vietnam. *Jounal of Water Sustainability, Volume 7, Issue 4* , 225-245.

[8]. ICMR1975. *Manual of standards of quality for drinking water supplies. Indian Council of Medical Research.*

[9]. K. Yogendra, E. P. (2008). Determination of Water Quality Index and Sustainability of an urban Waterbody in Shimoga Town, Karnataka. *12th World lake Conference*, (pp. 342-346).

[10]. Kosha A. Shah, G. S. (2017). Evaluation of water quality index for River Sabarmati, Gujarat,India. *Appl water Science (Springer)* , 1349-1358.

[11]. M. Prasad, V. S. (2019). Data on water quality index development for groundwater quality assessment from Obulavaripalli Mandal, YSR district A.P. india. *Data in Brief* .

[12]. Majid Radfard, M. S. (2019). Protocol for the estimation of drinking water quality index in water resources : Artificial neural network (ANFIS) and Arc- Gis). *MethodsX* , 1021-1029.

[13]. Manish Dubey, D. K. (Volume 5, Issue 8, August 2016). Quality Characterization of Groundwater using water Quality Index in Gwalior city, Madhya Pradesh, India . *International journal of Science, Engineering and Technology Research* , 2578-2584.

[14]. Mohd Saleem, A. H. (2016). Analysis of groundwater quality using water quality index: A case study of greater Noida (Region), Uttar Pradesh (U.P), India. *Cogent Engineering* .

[15]. Mohesn Saeedi, O. A. (2009). Development of groundwater quality index. *Environmental Monitoring and Assessment* .

[16]. Salam Hussein Ewaid, S. A. (2017). Water Quality index for Al-Gharraf River, Southern Iraq. *Egyptian jounal of Aquatic Research* , 117-122.

[17]. Sanigdha Acharya, S. K. (2018). Assessment of groundwater quality by water quality indices for irrigation for irrigation & drinkimg in South West Delhi, India. *Data in Brief* , 2019-2028.
[18]. Shrikant Mukate, V. W. (2019). Development of new integrated water quality index model to evaluate the drinking suitability of water. *Ecological indicators* , 348-354.
[19]. world health, o. *WHO (1993) Guidelines for drinking water quality 1 Recommendations, 2nd edn. World Health Organization, Geneva.*
[20]. Yulu Tian, Y. J. (2019). Using a water quality index to assess the water quality of the upper and middle streams of the Luanhe River, northern China. *Science of the Total Environment* , 142-151.