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A Comprehensive Review on Qualitty Assessment and Mangement of Water

Dr Vijay Singh Gehlot[1], Dr Suresh Kachhawha[2], Dr Tarun Gehlot[*3], Aman Khan[4], Atul Tudawat[5]

[1]Principle, Mahatma Gandhi govt school Mahila bag Jodhpur
[2]CMS, Quality Control Department, Indian Railway Jodhpur
[3*]Assistant Professor (Civil Engineering), CTAE Jodhpur
[4]Final Year Student, B. Tech (Ag. Eng.), CTAE Jodhpur
[5]Second Year Student, B. Tech (Ag.Eng.), CTAE Jodhpur

***Corresponding Author:**
Dr Tarun Gehlot
Assistant Professor (Civil Engineering), CTAE Jodhpur
Email ID: tarungehlot1103@gmail.com

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ABSTRACT

The most significant factor in forming the terrain and controlling the climate is water. It is among the most significant substances that have a significant impact on life. The physical, chemical, and biological properties of water are typically used to characterize its quality. Water quality is declining and aquatic biota is being depleted as a result of extensive and diverse contamination in aquatic environments brought on by rapid industrialization and the careless use of chemical pesticides and fertilizers in agriculture. Water-borne illnesses affect the human population as a result of drinking tainted water. As a result, it is essential to periodically check the water quality. Temperature, pH, turbidity, salinity, nitrates, and phosphates are among the parameters that may be measured. Water quality may also be determined by evaluating the aquatic macroinvertebrates. This paper reviews the assessment methods and management for quality of water.

Keyword: *Alkalinity, Dissolved Oxygen (D.O.), Eutrophication, Biochemical Oxygen Demand (BOD), Water Quality Index (WQI)*

1. INRODUCTION

Water is life; it is a colourless, Odourless, and tasteless liquid that is necessary for all plant, animal, and human growth and development. Water is also an essential necessity for maintaining human economic activity. In addition to supporting a variety of activities, water is regarded as a heavenly gift by many faiths and serves as a key symbolic component in ceremonies all over the world. The existence of all civilizations has depended on the availability of water in the appropriate amount and quality, at the appropriate time and location. In the history of humanity, no other natural resource has had such a profound impact. The pressures on fresh water resources are increasing as the human population rises, people express a desire for a higher quality of life, and economic activity continues to develop in scope and diversity [1].

According to the Yajurveda, water is the elixir of life, the source of energy that keeps life on Earth going, and one of the elements that controls how the cosmos evolves and functions. Water cannot be replaced; without it, people and other living things perish, farmers cannot produce crops, and businesses cannot function. Therefore, in addition to maintaining the hydrological, biological, and chemical processes of ecosystems, a sufficient and continuous supply of high-quality water must be maintained for the rise of human progress. Without a doubt, the most valuable natural resource on the planet is water. It keeps life going. Water's distinct physical and chemical characteristics have made it possible for life to emerge there. This viewpoint is demonstrated by the following quotation from Szent-Gyorgyi (1958):

“Water functions in varieties of ways within the cell cannot be disputed. Life originated in water, is thriving in water, water being it’s solvent and medium. It is the matrix of life”.

2. PREVIOUS RESARCH STUDIES

Groundwater extraction is increasing as a result of India's socioeconomic position gradually changing. There will inevitably be more people looking for ground water as more advanced drilling and pumping equipment becomes available. The effects of overuse of groundwater are already evident. Even during the monsoon season, little streams are drying up because there are not enough catchments, and people are drilling deeper and deeper borewells in both rural and urban regions. In other circumstances, a lot of rain may fall, but it cannot be stored for household use. In the highlands, relatively little rainwater seeps into the soil to irrigate the springs due to deforestation and decreased ground cover. The ground's ability to hold specified amounts of water is further diminished by soil erosion. However, it also faces water scarcity!

Since dependence, the government has been concerned with improving people's health and quality of life. Numerous steps were taken in the policy-making process, which resulted in a number of programs in this area. The most significant aspects in enhancing the health of the populace in any nation are the availability of clean drinking water and sanitary facilities. Eighty percent of infections are caused by unsanitary environments and contaminated drinking water, according to a World Health Organization (WHO) assessment. An estimated 1.5 million-Man days are lost annually as a result of water and sanitation-related illnesses. The issue is further complicated and made worse by long-standing cultural customs, illiteracy, and ignorance. As a result, India has made the provision of clean drinking water a top priority.

In 1972–734, the Indian government launched the Accelerated Rural Water Supply Programme (ARWSP) to hasten the coverage of troubled communities. When the progress of providing clean drinking water to the designated issue village was deemed inadequate, the ARWSP was reinstated in 1977–1978 after the Minimum Needs (MNP) was implemented in 1974–1975 and the ARWSP was withdrawn as a result [2].

One of the five societal missions, the National Drinking Water Mission, was established in 1986. The Rajiv Gandhi National Drinking Water initiative (RGNDWM) was the new name given to the initiative in 19915. Through the efforts of the mission and ARWSP, the Indian government continues to place the rural drinking water sector at the top of its priority list. It is also included in point No. 7 of the twenty-point program of 1986 and the state-funded MNP. India relies largely on groundwater supplies. Through more over 17 million energized wells, this source is thought to supply between 80 and 90 percent of rural households' water needs, 50 percent of urban and industrial demand, and 50 percent of irrigated land. (GoI/World Bank 1997a & 1997b). However, only around 5% of the entire amount of water drawn from the ground is used for residential purposes.

2.1 DRINKING WATER: CURRENT PROBLEM AND PERSPECTIVE

Water scarcity in the nation has posed a major danger to the environment and the lives of women and children.

- During the crucial summer months, drinking water is unavailable due to excessive groundwater exploitation.
- Approximately 5% of rural residents lack regular access to clean drinking water, and many more faces the prospect of progressively dwindling access in the near future. Large amounts of water are being gathered and delivered over long distances by tankers and pipelines as a result of water shortages in towns and villages.
- Elevated fluoride, arsenic, and iron levels produce serious environmental health issues, and in the case of iron, people just dislike drinking the water due to its taste and odour[3].
- Over-extraction of groundwater has caused sea water to seep into coastal aquifers, making water supplies increasingly salinized and unfit for cultivation and drinking.
- According to World Bank estimates, the yearly cost of environmental degradation in India is US$9.7 billion, or 4.5 percent of GDP. The health effects of water contamination account for 59% of this.
- According to current estimates, the yearly cost of environmental degradation in India is US$9.7 billion, or 4.5 percent of GDP. The health effects of the water population account for 59% of this.
- According to current estimates, India would experience water stress by 2017, with per capita availability dropping to 1600 cubic meters. Only 10% of the 20000 crore litres of sewage produced by cities is treated. High rates of water-related illnesses and fatalities will result from inadequate drinking water and sanitation facilities. It is estimated that overapplication and seepage via unlined field canals lose 60% of irrigation water.

India's National Water Policy acknowledges the need of giving its citizens access to clean drinking water. "Human and animal drinking water needs should be the first charge on available resources," it says. Article 24 of the Convention on the Rights of the Child (CRD), which the Indian government has ratified, particularly guarantees this right to children. It has been suggested that water be viewed as an "economic resource" that is necessary for growth and development rather than merely as a "economic good." However, for a variety of reasons, many elements of the National Water Policy, laws, and regulations, as well as the rights of children under the CRC, have not been able to be implemented in the Indian setting.

2.2 KEY COMPONENTS OF THE GROUND WATER MODEL BILLS

- Control and/or restriction of groundwater extraction in any region that a Ground Water Authority has informed and considered essential [4].
- To extract and utilise ground water in the notified regions, a permission is required.
- Both new and current users must register in the designated places.
- keeping an eye on and upholding the Ground Water Authority's rules and regulations.

The Panchayati Raj Institutions were given authority over drinking water and sanitation in 1992 by the 73rd amendment to the constitution. The fundamental justification is that water boards and public health engineering divisions were overstaffed, centralized, and unaccountable to customers. As the local level tier, Gramm Panchayats are now expected to be in charge of selecting technology, financing expenses, and managing and maintaining rural sanitation and water supplies. The community would own the assets. Gramm Panchayats are now virtually exclusively carrying out development programs that have been delegated to them by the state and federal governments, although this process is still in its very early stages in the majority of states. Nonetheless, the state governments continue to provide the bare minimum of free water delivery in rural regions, and the governments continue to exert influence over the day-to-day operations of the panchayats due to their continued control over the subsidies given to them.

2.3 WATER QUALITY PARAMETERS:

The acceptable limitations for various characteristics established by different authorities must be reached by the water used for residential purposes, particularly for drinking. The table below lists the many metrics used to characterize the water quality.

Table- 1: The standard values for different parameters of water quality, as laid down by USPH[12] (United State Public Health) and ICMR.

Parameters	USPH Standards (1980)	ICMR Standards (1975)
Colour	Colourless	….
Odour	Odourless	….
pH	6.0 – 8.5	6.5 – 9.2
Total Hardness	….	600
Dissolved Oxygen (D.O.)	4.0 – 6.0 (ppm)	5.0 – 6.0 (ppm)
Total dissolved solids	500	1500
Suspended solids	5.0	…..
Chloride	250	1000
Fluoride	1.5	….
Sulphate	250	1000
Nitrate + Nitrite	<10	….
Phosphate	0.1	….
Cyanide	0.05	0.01
Sulphide	0.1 (ppb)	….
Lead	<0.05	0.01
Iron	<0.3	….
Manganese	<0.05	….
Copper	1.0	….

Cadmium	0.01	….
Arsenic	0.05	0.2
Mercury	0.001	….
Calcium	100	200
Magnesium	30	100
Zinc	5.5	….
Chemical Oxygen Demand	4.0	….
Biochemical Oxygen Demand	5.0	….
E. coli/100ml	100	….

All the units, except otherwise mentioned and pH, are in ppm, i.e., parts per mission on mg/1

Table-2: Drin king Water Standards of BIS[13] and WHO[14].

Parameters	**BIS (IS:10500: 1991)**		**WHO (1996)**	
	Desirable Limits	**Permissible limits**	**Desirable Limits**	**Permissible limits**
Colour Hazen Unit	5	25	5	50 Unit
Odour	Unobjectionable	…	….	….
Taste	Agreeable	No relaxation	…..	….
pH	6.5-8.5	….	….	6.5-9.2
BOD mg/1	….	…..	…..	6
COD mg/1	….	…..	…..	10
Total Hardness $CaCO_3$ mg/1	300	600	100	500
Chloride mg/1	250	1000	200	600
Fluoride 100 mg/1	1.0	1.5	1.0	1.5
Sulphate mg/1	200	400	200	400
Nitrate mg/1	45	100	45	45
Lead mg/1	0.05	No relaxation	…	0.05
Iron mg/1	0.3	1.0	0.3	1.0
Manganese mg/1	0.1	0.5	0.1	0.5
Copper mg/1	0.05	1.5	0.05	0.02
Nickel mg/1	0.02	No Relaxation	…	0.02
Cadmium mg/l	0.01	No Relaxation	…	0.005
Mercury mg1/1	0.001	No Relaxation	….	0.001
Arsenic mg/1	0.05	No Relaxation	…	0.05

Calcium mg/1	75	200	75	200
Magnesium mg/1	30	100	50	150
Zinc mg/1	5.0	15	5.0	15
Ammonia mg/1	…	0.5	…	0.5
Phenolic Compound mg/1	…	0.005	…	0.002
Total alkalinity mg/1	200	600	120	250
Cyanide mg/1	…	0.05	…	0.05
Turbidity (NTU)	5	25	5	25
Total dissolved solid mg/1	500	1000	500	1000
Chromium mg/1	0.05	No Relaxation	0.05	0.05
Sodium mg/1	…	200	…	200
Potassium mg/1	…	….	…	12
E. coli	…	10/100 ml	…	10/100 ml

2.4 PARAMETERS INCLUDED IN WATER QUALITY ASSESSMENT:

Bore well monitoring in Indore necessitates sampling a wide range of parameters. The following parameters were examined in this evaluation [5]:

pH: For many practical applications, the pH of a solution is calculated as the -ive logarithm of H_2 ions. The pH range is 7 to 14 (alkaline), 0 to 7 (acidic), and 7 (neutral). The pH range of drinking water is typically between 4.4 and 8.5. Typically, the pH scale falls between 0 and 14.

Turbidity: Turbidity is the suspension of particles in water that obstruct light flow. There are several different types of suspended particles that generate turbidity. Turbidity may be evaluated using either turbidimetry, which measures how it affects light transmission, or nephelometry, which measures how it affects light scattering. The acceptable and allowed limits, according to IS: 10500-2012, are 1 and 5 NTU, respectively.

T.D.S.: Using filtrate and the previously described process, the difference between total solids and suspended solids is utilised to identify the filterable solids. Conductivity measurements in water samples may also be used to estimate it. According to IS: 10500-2012, the acceptable and allowed values are 500 and 2000 mg/l, respectively.

Elec. Conductivity: The ability of water to conduct an electrical current change depending on the kinds and quantity of ions present in the solution. On the other hand, distilled water has a conductivity of less than 1umhos/cm. The existence of ions, their mobility, valence, and relative concentration, as well as the liquid's temperature, all affect this conductivity. The majority of inorganic acid, base, and salt solutions conduct rather well.

Total hardness: In accordance with IS: 10500-2012 The acceptable and desirable limits for hardness are 200 and 600 mg/l, respectively. Hardness has an impact on boilers, hot water systems, and kitchenware by causing scale. Scum from soap Calcium and magnesium that have been dissolved from soil and aquifer minerals that comprise dolomite or limestone are the sources. Reverse osmosis and softener ion exchangers are used to treat hard water. According to the equivalent $CaCO_3$ content, drinking water hardness has been categorized as follows: soft (less than 60 mg/l), medium (60–120 mg/l), hard (120–180 mg/l), and very hard (more than 180 mg/l).

sulphate: The majority of the sulphate ions found in natural water are soluble in water. The oxidation of their ores produces a large number of sulphate ions, which are also found in industrial waste. The UV Spectrophotometer is used to test the amount of sulphate. According to IS: 10500-2012, the permissible limit for sulphate is between 200 and 400 mg/l[8].

Nitrate: Raw water contains nitrate, which is primarily a form of the N2 molecule (in its oxidizing state). Animal waste, deteriorating vegetables, chemical and fertilizer industries, and household and industrial effluent all contribute to the production of nitrate. The UV Spectrophotometer is used to test the amount of nitrate. According to IS: 10500-2012 The ideal nitrate level is 45, and the allowable limit cannot be lowered.

Total alkalinity: The sum of the elements in the water that tend to raise the pH to the alkaline side of neutrality is known as total alkalinity. It is generally represented in milligrams per litre of calcium carbonate (mg/l as CaCo3) and is tested by titrating with standardized acid to a pH of 4.5. Hydroxides, phosphates, and carbonate are common substances that raise the alkalinity of water. Carbonate buffering can be found in large amounts of glacial till and limestone bedrock.

Chloride: Chlorides are present in all natural and raw water types. It originates from industrial processes, agricultural operations, and chloride stones. Human activity is the reason for its high concentration. According to IS: 10500-2012, the permissible maximum for chloride is 1000 mg/l, but the desirable level is 250 mg/l.

Fluoride: Fluoride has natural forms such as rock phosphate, triplite, phosphorite crystals, and fluorspar (fluorite). The local temperature and the presence of accessory minerals in the rock minerals assemblage that the ground water circulates through are two examples of variables that affect fluoride concentration. According to IS: 10500-2012, the acceptable limit for fluoride is between 1 and 1.5 mg/l.

Boron: Boron is found in nature as boric acid and its salts. Through weathering, it is liberated from rocks and soils and eventually finds its way into water. Additionally, when residential landfills are not properly sealed, it enters the soil and groundwater. It functions as a common indicator chemical that shows additional dangerous drugs are present. According to IS: 10500-2012, the permissible maximum for boron is 1 mg/l, whereas the desirable level is.5.

Phosphate: A vital nutrient for plants, phosphorus primarily regulates the development of aquatic plants in freshwater environments. Due to the poor solubility of native phosphate minerals and the soils' capacity to hold phosphate, ground water often has a minimal phosphorus content.

Chemical Oxygen Demand (COD); The oxygen needed for the chemical oxidation of organic materials with the aid of a potent chemical oxidant is measured by the Chemical Oxygen Demand (COD). Because of the breakdown of bacteria, high COD can lead to oxygen deprivation, which is harmful to aquatic life. The benefit of COD determination over BOD determination is that the former may be completed in around five hours, while the latter requires five days.

Zinc: The earth's crust contains around 0.05 g/kg of zinc. Sphalerite (ZnS), its most common mineral, is typically combined with additional Sulphide elements. Abdominal discomfort, electrolyte imbalance, vomiting, and dehydration are all signs of zinc poisoning in humans. There have been reports of zinc chloride-induced acute renal failure.

2.5 WATER QUALITY INDEX (WQI)

WQI is a dimensionless number that combines multiple water-quality factors into a single number

by normalizing values to subjective rating curves. Factors to be included in WQI model could vary

depending upon the designated water uses and local preferences. Some of these factors include DO, pH, BOD, COD, total coliform bacteria, temperature, and nutrients (nitrogen and phosphorus), etc. These parameters occur in different ranges and expressed in different units. The WQI takes the complex scientific information of these variables and synthesizes into a single number. Calculation of WQI: The Water Quality Index (WQI) was calculated using the Weighted Arithmetic Index method. The quality rating scale for each parameter Qi was calculated by using this expression [6]:

Quality rating, Qi = 100 [(Vn -Vi) / (Vs -Vi)]

Where, Vn: actual amount of nth parameter,

Vi: the ideal value of this parameter,

Vi = 0 except for pH and D.O.;

Vi = 7.0 for pH; Vi = 14.6 mg/L for D.O.,

Vs: recommended WHO standard of corresponding parameter

Relative weight (Wi) was calculated by a value inversely proportional to the recommended standard (Si) of the corresponding parameter.

Wi = 1 ⁄ Si

Generally, WQI are discussed for a specific and intended use of water. In this study the WQI for human consumption is considered and permissible WQI for the drinking water is taken as 100. The overall WQI was calculated by using Equation [9]:

Water Quality Index =Σ(Qi)Wi ⁄ Σ Wi

The WQI ranges have been defined as:

- 90-100: Excellent
- 70-90: Good
- 50-70: Medium
- 25-50: Bad
- 0-25: Very Bad

By this way it defines water quality.

2.6 REQUIREMENT OF FRESH WATER IN INDIA:

In our nation, the agricultural sector uses the most water. The climate and crop type have an impact on how much water is needed for irrigation. Domestic needs, the production of thermal electricity, and industry come next. It is anticipated that the overall demand for water would triple by 2025 compared to 1974. Compared to 1974, the industrial sector will need almost 20 times as much water, and the electricity generating sector will need roughly 15 times. The table below provides an estimate of India's water requirements [10].

Table 3 – Estimate of water Requirement in (Cubic Kms) India

Water Needed for	1974	2000	2025
Irrigation	350.0	630.0	770.0
Thermal Power Generation	11.0	60.	160.0
Industries	5.5	30.	120.0
Domestic Needs	8.8	26.6	39.0
Livestock Management	4.7	7.4	11.0
Total	380.0	754.0	1100.00

3. CONCLUSIONS

One of the main causes of water pollution in Indian cities is the discharge of industrial effluents into bodies of water. Therefore, in order to take the proper actions for managing water resources, it is essential to continuously and periodically assess the quality of the water, especially in areas with industrial settlements [7]. Similarly, sewage disposal has grown to be a significant issue in India. Nearly three-fourths of river water contamination is caused by sewage effluents from towns and clogging riverbanks. Cholera, TB, gastroenteritis, hepatitis, and other illnesses and epidemics are caused by the mixing of sewage into waterways. Given the aforementioned situation and current events, it is beneficial to do a research on the water quality at Satna and the adjacent areas, paying particular attention to its physical, chemical, and biological properties. The residents of Satna (M.P.) will benefit from this endeavor in evaluating the quality of the water they drink. The goal of the current study is to track the level of pollution in Satna's drinking water and the surrounding areas, with a focus on physico-chemical characteristics. Some vulnerable Satna sample sites, including as industrial, urban, mining, rural, and agricultural areas, as well as rivers, will be selected for monitoring in the current study. There are 42 out of 30 sample points in ground water in 10 samples, 10 samples in rural and agricultural areas, 10 samples in mining areas, and 12 samples in surface water in 6 industrial areas and 6 river samples. The study's design calls for monthly sample collection for the whole year, beginning in January 2011 and ending in January 2012. Every sample is examined for the following biological parameters: pH, DO, BOD, COD, fluoride, chloride, sulphate, phosphate, and the presence of certain heavy metals, such as Hg, Pb, Fe, Cu, and Mn, as well as the MPN index per 100 milliliters a year, samples must be taken once a month in non-reactive plastic containers that have been acid cleansed. There would be three distinct seasons during the research period. They are cold (October to January), rainy (June to September), and summer (February to May). The analysis's findings will be displayed seasonally. For each season, the average reading for each parameter over four months would be considered.

WQI is a simple tool that gives a single value to water quality taking into consideration a specifc number of physical, chemical, and biological parameters also called variables in order to represent water quality in an easy and understandable way. Water quality indices are used to assess water quality of different water bodies, and different sources. Each index is used according to the purpose of the assessment. The study reviewed the most important indices used in water quality, their mathematical forms and composition along with their advantages and disadvantages. These indices utilize parameters and are carried out by experts and government agencies globally. Nevertheless, there is no index so far that can be universally applied by water agencies, users and administrators from different countries, despite the efforts of researchers around the world (Paun et al. 2016). The study also reviewed some attempts on different water bodies utilizing different water quality indices, and the main studies performed in Lebanon on Lebanese rivers in order to determine the quality of the rivers (Table 6)

In other research, authors compared many WQIs to check the difference of water quality according to each index. Each index can provide different values depending on the sensitivity of the parameter. For that reason, WQIs should be connected to scientific advancements to develop and elaborate the index in many ways (example: ecologically). Therefore, an advanced WQI should be developed including first statistical techniques, such as Pearson correlation and multivariate statistical approach mainly Principal Component Analysis (PCA) and Cluster Analysis (CA), in order to determine secondly the interactions and correlations between the parameters such as TDS and EC, TDS and total alkalinity, total alkalinity and chloride, temperature and bacteriological parameters, consequently, a single parameter could be selected as representative of others. Finally, scientific and Table technological advancement for future studies such as GIS techniques, fuzzy logic technology to assess and enhance the water quality indices and cellphone-based sensors for water quality monitoring should be used.

Declaration

Conflict of interest: All authors declare that they have no any conflict of interest

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