Water Quality Assessment And Prediction: A Comparative Analysis

[1]Valarmathi V, [2]Dr.S.Dhanalakshmi

[1]Assistant professor,
[2] Associate professor,
[1]Department of Information Technology and Cognitive Systems
[2]Department of Software Systems
Sri Krishna Arts and Science College,
Coimbatore, Tamil Nadu, INDIA

Abstract: Water is second essential for life on our planet. It is found in our seas, rivers, lakes, ice caps, and glaciers, as well as in our soil as moisture and in the air as water vapour. Without water, life would be impossible. However, the quality of our water is in jeopardy, not only for drinking but also for the water that runs through our oceans to support marine life, fishing and aquaculture industries, and coastal towns near ports where storm water flow is a major issue. Groundwater quality is being impacted by various issues, including poor national land management, irrigation practices, waste management, and rising chemical concentrations, all contributing to pollution in the form of chemical hazard. In this paper, we did a comparative study on various works carried out for water quality assessment, classification and prediction. A detailed study done on various parameters of water and mainly focused the important parameters of water to measure quality of it. Water quality is assessed using the Water Quality Index.
Keywords: Groundwater quality, water quality assessment, classification, prediction, Water Quality Index

1. Introduction

Everyday living, agriculture, industry, and fisheries are just a few examples of many uses for water. It encourages a wide range of human endeavors as well as those of nature and the entire world ecology. Not only necessary components but also other compounds can be found in water.

Dangerous compounds, which are not only unneeded for living things but also have negative health effects, are both essential for maintaining the life of living things. Furthermore, parasites, contagious microbes, and chemical compounds, such as agricultural chemicals, can harm humans and other living things' health. Water also contains these elements. For a variety of reasons, it is vital to create water quality guidelines.

Water, a crucial nutrient for the body, is necessary for human survival. It helps in digestion, nutrient absorption, and toxin and waste removal from the body. Water is also required for cooking.

The majority of fresh water is consumed for agricultural purposes. Precipitation, irrigation, or both can provide water needed for agriculture. Inappropriate irrigation practices lead to salinization, which reduces soil productivity by deteriorating soil texture and water uptake by agricultural crops. In order to avoid salinization, careful attention must be given to irrigation water quality and irrigation technique.Water is a key requirement for fish farming, especially artificial hatching.

Reusing water is consequently essential in this industry, both for economic reasons and to conserve the finite water supply. In order to avoid harming farmed fish or putting the health of humans who eat farmed fish as a protein source at risk, a sufficient degree of water quality must be ensured.

Several industries depend on water for production, making use of features like its solubility, capability for transportation, or ability to exchange heat. Water is mostly used in manufacturing for cooling, processing, cleaning, and boiler make-up.

1.1 Water Related Diseases

There are four groups that water-related illnesses fall under:

- Waterborne infections are spread through consumption of contaminated water.
- Infections that are washable and are brought on by a shortage of water for personal hygiene.
- Diseases caused by communicable bacteria that impact water, such as schistosomiasis.

- Infections caused by aquatic insects like mosquitoes, whose larvae carry a variety of infectious diseases like malaria and dengue fever, among others.

2. Importance Of Water Quality

One of an ecosystem's most crucial health markers is water quality. Because it supports life on land, in the ocean and in other forms, high-quality water is crucial to preserving biodiversity.

Pollution of water quality has many causes. The main contributors to marine pollution include industrial and agricultural activities, fuel leaks, shipping and fishing operations, sewage discharges and global warming.

Water pollution may cause significant issues for both people and the environment when it comes to drinking water, our fishing, aquaculture industries and marine protected areas (MPAs), wastewater treatment facilities, river life, and our coastal port towns. In order to identify potential environmental problems, develop effective preventative measures, and develop systemic solutions for them, it is important to monitor the quality of the water.

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2.1 Parameters And Key Indicators Of Water Quality

It's crucial to comprehend, evaluate and keep track of the basic parameters of the main water quality indicators in order to meet regulations. The main indicators are dissolved oxygen, turbidity, pH, bio indicators, nitrate compounds, and water temperature comprise a wide variety of chemical, physical and biological qualities related to water quality. To evaluate and monitor the quality of the water, water samples are collected, and the resulting information provides data that serves as crucial indicators of pollution and shifts in normative behavior patterns.

Dissolved oxygen, turbidity, bio indicators, nitrates, pH and water temperature are six primary indicators of water quality.

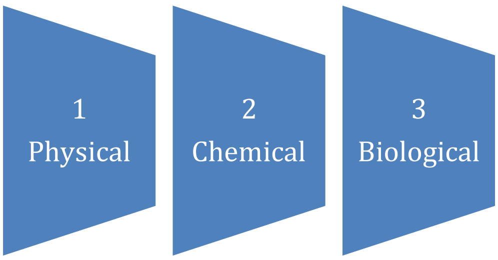

Fig 1 -Basic Water Quality Categories

Table – 1 Basic data on the factors affecting water quality.

Basic Categories	**Factors Affecting Water Quality**	**Measure ment**	**Research Cases**
Physical	Potential Hydrogen (pH)	none	Coastal waterways, rivers, lakes, streams and Waste Water Treatment Plant
	Water Temperature (WT)	◦C	Coastal waterways, rivers, ponds, lakes, catchments and streams
	Electrical Conductivity (EC)	us cm−1	Lakes, Groundwater, Reservoir, Streams and Rivers

	Suspended Solids (SS)	mg/L	Catchments, Coastal waters, Rivers, Streams, and Creeks
	Total Phosphorus (TP)	µg/L	Lakes, Rivers and Waste Water Treatment Plant
	Turbidity (Tur)	FNU	Streams, Rivers
	Salinity (S)	PSU	Coastal waterways, Groundwater
	Boron (B)	mg/L	Rivers
	Total Hardness (TH)	mg/L	Rivers
	Transparence (SD)	cm	Lakes
	Total Suspended Solids (TSS)	mg/L	Rivers
	Total Dissolved Solids (TDS)	mg/L	Drains, Rivers and Groundwater
	Phosphate (P)	mg/L	Experimental system
Chemical	Nitrite (NO2)	mg/L	Groundwater
	Permanganate (COD Mn)	mg/L	Rivers
	Total Nutrients (TN)	mg/L	Waste Water Treatment Plant, Coastal waterways and Lakes
	Dissolved Oxygen (DO)	mg/L	Ponds, Coastal waters, Creeks, Lakes, Waste Water Treatment Facilities, Reservoirs and Rivers
	Biochemical Oxygen Demand (BOD)	mg/L	Water experimental system for rivers, lakes, sewage treatment facilities, and mines
	Chemical Oxygen Demand (COD)	mg/L	Lakes, Rivers, Groundwater, Mine Water, Reservoirs and Waste Water Treatment Plant
	Nitrate (NO3)	mg/L	Catchment, River, Groundwater, Well, and Experimental Aquifer
	Total Organic Carbon (TOC)	mg/L	Rivers
	Ammonia cal Nitrogen (NH3 -N)	mg/L	Lakes, Rivers, Groundwater, and Reservoirs
Biological	Chlorophyll a (Chl-a)	µg/L	Reservoirs, Lakes, surface waters and coastal waters
	Fecal Coliform (FC)	mg/L	Lake

2.2 Requirements For The Quality Of Water For A Range Of Use

Any body of water must be sufficiently clean in order to be utilized to its maximum potential. Water for drinking needs to be incredibly pure. Controlling the water's quality is more crucial due to the rising gap between both the quantity required and the quantity that can be produced.

Every water usage has certain quality requirements. So, it is crucial to comprehend the uses of a water body's flow in order to determine the benchmark for the water's quality standard. The notion of designated best use was first proposed by the Indian Central Pollution Control Board. In light of this, the use of water that requires the best quality of water among all of the others in a given body is the optimal usage.

The top five applications have been established. By using this classification, the managers and planners who are in charge of maintaining water quality can set objectives for the water's quality and develop restoration programmes that are suitable for different water bodies. Referred to from CPCB [1] are Tables 2 and 3.

Table -2. Often used color coding to show the state of the water on maps.

Color of Water	Uses / Description
Blue	Direct drinking, industrial and other uses of this water are all possible.
Green	The water in plants and soil.
White	Atmospheric moisture
Brown or grey	Brown or grey colored effluent can be used to identify different types of wastewater.

Table -3 Best Water Uses Identified.

Class	Best Water Uses Identified	Criteria	
A	Source of Drinking Water before standard treatment but after disinfection	TC	50 or less per 100 ml.
		pH	6.5 to 8.5
		DO	greater than 6 mg/l
		BOD	2mg/l or lower
B	Outdoor bathing	TC	500 or less per 100 ml
		pH	6.5 to 8.5
		DO	greater than 5 mg/l
		BOD	3mg/l or lower
C	Source of drinking water after regular treatment and disinfection	TC	5000 or less per 100 ml.
		pH	6 to 9
		DO	greater than 4 mg/l
		BOD	3mg/l or lower
D	Fisheries and wildlife reproduction	Free Ammonia	-
		pH	6.5 to 8.5
		DO	greater than 4 mg/l
		BOD	2mg/l or lower
E	Controlled waste disposal, industrial cooling and irrigation	pH	6.0 to 8.5
		EC	Maximum 2250
		Sodium absorption Ratio	Maximum 26
		B	Maximum 2mg/l

2. Literature Review

A variety of methods and algorithms were used to assess the quality of surface or ground water. Water quality can be predicted using machine learning, artificial intelligence, and fuzzy logic algorithms.

A new model that incorporates Entropy weight, Set Pair Analysis and Markov chain is utilised to evaluate and forecast the quality of groundwater, claim Fengmei Su et al. in 2019. Short-term groundwater quality predictions made using the SPA-Markov chain model are more accurate. The water quality measurements used for predicting include Cl-, SO42-, TDS, and TH. [2].

AjitPratap Singh et al. developed the fuzzy-based water quality evaluation method in 2019 by combining the triangular membership function with the gaussian membership function. The FCWQI model advises parametric sensitivity for defining the WQI used in surface water quality evaluation. This model evaluates the water quality using the following variables: temperature, pH, Dissolved, BOD, EC, FC, and nitrates. [3].

The results of various studies on water quality are compared in the table.

Table – 4 Comparative Water Quality Analysis.

Author / Year	Research Objective	Benchmark / Dataset	Algorithms / Methods / Models Used	Water Quality parameters used	Performance Metric	Proposed Models and Results Obtained
S.Vijay et al. 2019	To forecast the quality of ground water, physico-chemical properties were used.	Among the towns of the district of Vellore, bore wells.	Naïve Bayes, **C5.0**, and Random forest (Machine Learning classifier algorithm)	Alkalinity, PH, chloride, BOD, sulphate, COD, chloride, EC, TDS and TH	Sensitivity, Kappa, Specificity, and Accuracy	More accuracy is demonstrated by the Naive Bayes and Random Forest algorithms.
Ping Liu et al. 2019	Model for predicting water quality that calls for high-quality data.	Yangzhou's Guazhou Water Source	Deep neural networks, ARIMA, SVR, LSTM, and time-series prediction	Conductivity, Turbidity, CODMn, WT, pH, DO, CODMn, and NH3-N	Precision, ADAM, MSE	Compared to ARIMA and SVR, the dissolved oxygen prediction was more accurate (prediction period length: m = 181).
Uddin et al. 2020	To Assess the quality of surface water using different WQI models.	Ireland's southern Cork Harbour	West-Java, SRDD, Horton, CCME, NSF, Baccarin, and Hanh	Salinity, pH, TP Nitrate, TON TA, DO, Temperature, Chl a,	ACRPS, MSE, ASE, RMSE, and MSE	Combining the EBK interpolation model and the CCME model results in the lowest levels of uncertainty.
Theyazn H. H Aldhyani et al. 2020	WQI and WQC forecast.	https://www.kaggle.com/anbarivan/indian-water-quality-data.	NARNET and LSTM models for WQI prediction Naive Bayes, SVM, and K-NN for WQC forecasting.	Conductivity, pH, BOD, FC, Nitrate, and TC	Precision, sensitivity, and accuracy Correlation, F-score, MSE, RMSE, and R	NARNET model outperformed LSTM. SVM has the highest WQC prediction accuracy (97.01%).
Umair Ahmed et al.2020	WQI and WQC estimation using supervised machine	Pakistani watershed at Rawal	The WQI is estimated using the following algorithms: Ridge Regression, Elastic Net	Total Dissolved Values, pH, Temperature, Turbidity, Nitrate, Fecal Coliform, and	Recall, Accuracy, Precision, F1 Score,	Gradient boosting and polynomial regression produce positive results

	learning methods .		Regression, Lasso Regression, Gradient Boosting, Random Forest, Polynomial Regression, SVM. KNN, Gradient Boosting Classifier, Decision Tree, Gaussian Naive Bayes, Random Forest, Logistic Regression, Stochastic Gradient Descent, SVM, MLP, and Bagging Classifier are some of the algorithms used methods were used to define WQC.	Turbidity	MAE, MSE, RMSE, and R Squared	in the WQI Prediction. In WQC Prediction, MLP fared better.
Rahim Barzegar et al.2020	To forecast variables affecting water quality, construct a coupled CNN-LSTM model.	Greece's little Prespa Lake Real-time dataset	Deep learning (DL) models include LSTM, CNN, and SVR and DT for machine learning.	Oxidation-reduction potential (ORP), EC, WT, pH, DO, and Chl-a	R, RMSE, MAE, percentage of bias PBIAS, ENS, WI, and graphic plots	The hybrid CNN-LSTM model, in particular for the DO levels, successfully caught both extreme and low values of the water quality indicators.
DuieTien Bui et al. 2020	To provide special algorithms for WQI prediction as well as other water science topics in places with highly uneven dispersion of water quality measuring	The Talar and its five principal tributaries .	Four independent RF, M5P, RT, and REPT algorithms as well as 12 hybrid data-mining techniques include BA, CVPS and RFC	pH, PO4, NO3, turbidity, EC, TS, DO, FC, BOD, COD, and TS	Pearson correlation coefficients: R2, RMSE, MAE, NSE, PBIAS, PREI, and R2	In comparison to BA-RT algorithm, RFC-RT has the lowest prediction power. Faecal coliform was the best indicator for calculating WQI.

	stations.					
Anthony Ewusi et al. 2021	Use TDS as a predictor of water quality for management of water quality.	Ghana's Tarkwa	GPR, BPNN and PCR.	EC, As, Cd, CN, Cu-D, pH, TSS, turbidity, and Hg	ENS, MAE, R, R2, RMSE, and Index of Agreement (d)	The average R2, MAE, and RMSE for the GPR model, which provided a better prediction of TDS concentration, were 0.987, 4.090, and 7.910, respectively.

3.1 Index Of Water Quality (WQI)

A single categorising value that describes the pollution level or water quality status of water bodies is provided by the WQI, which is regarded as a mathematical method that significantly simplifies the complex water quality data sets. Moreover, WQI is a single dimensionless number that provides a clear picture of the current state of water quality by combining measurements of a few important variables, such as pH, nitrate, DO and heavy metals.

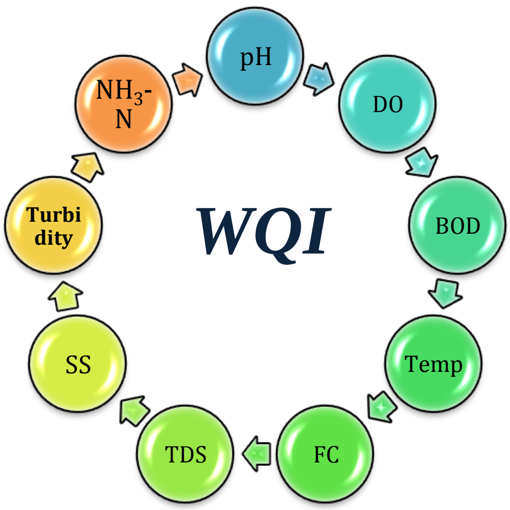

Fig – 2 Most popular measures of water quality.

Conclusion

In this study, we outlined key metrics required to assess water quality. The designated best uses of water and the requirements for water quality for various uses were discussed. Comparative analysis has been done on a variety of classification and evaluation systems for water quality. The kind of pollution affected the water and if it was contaminated are revealed by the results of the criteria used to determine WQI.

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