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Water Quality Index (WQI) Prediction System

C. SENTHIL KUMARAN, MCA., (Ph.D)
(Dean & Head, Associate Professor, Department of Computer Applications)
F. PRAVEEN KUMAR, MCA.,
Christ College of Engineering and Technology
Moolakulam, Oulgaret Municipality, Puducherry – 605010

Abstract

Access to clean and safe water is a fundamental requirement for human health, economic development, and environmental protection [1][2]. In recent years, rapid population growth, expanding industrial activities, and large-scale agricultural practices have imposed excessive stress on natural water resources, leading to serious deterioration of surface water and groundwater quality in many regions [3][4]. Polluted water sources contribute to the spread of water-borne diseases and cause long-term damage to aquatic ecosystems, making water quality assessment an urgent global concern [5].

This study introduces a Water Quality Index (WQI)–based evaluation approach for determining the overall status of water quality by combining multiple physicochemical parameters, including pH, turbidity, total dissolved solids, hardness, chlorides, and dissolved oxygen [6][7]. Each parameter is assigned a weight according to its relative impact on human health and environmental stability. The weighted values are standardized and mathematically combined to obtain a single WQI score [8][9]. Based on this score, water samples are classified into quality categories such as excellent, good, poor, very poor, and unsuitable for drinking [10]. The proposed framework provides a systematic, reliable, and user-friendly method that supports environmental monitoring and evidence-based policy decisions [11][12].

Index Terms

Water Quality Index, Drinking Water Safety, Environmental Assessment, Physicochemical Analysis, Water Resource Management

I. INTRODUCTION

Freshwater plays a crucial role in sustaining human life, supporting agricultural productivity, enabling industrial growth, and maintaining ecological balance [1][13]. However, accelerated urban expansion and economic development have resulted in the overuse and contamination of available water resources [3][4]. Industrial discharges, untreated municipal wastewater, agricultural runoff containing chemical fertilizers and pesticides, and improper waste disposal practices are major contributors to declining water quality [14][15].

Conventional water quality monitoring techniques focus on analyzing individual parameters separately, often producing complex datasets that are difficult for non-experts to interpret [5]. This limitation reduces their effectiveness in large-scale water management and policy formulation. To address this issue, the Water Quality Index (WQI) was developed as an integrated indicator that converts multiple water quality measurements into a single numerical value [6][9]. WQI enhances clarity, supports comparative analysis, and assists decision-makers in implementing sustainable water management strategies [10][16].

II. MAIN OBJECTIVES

The primary aim of this project is to evaluate the overall condition of water resources using the Water Quality Index method [6][9]. The study focuses on assessing critical physicochemical parameters that directly influence water safety and usability.

Another objective is to transform complex laboratory data into a single quantitative index that reflects the general status of water quality [8]. The system also seeks to categorize water samples into standard quality classes such as excellent, good, poor, very poor, and unsuitable for drinking [10][17]. In addition, the project is designed to serve as a practical and economical tool that can assist environmental authorities, researchers, and planners in monitoring water quality trends and

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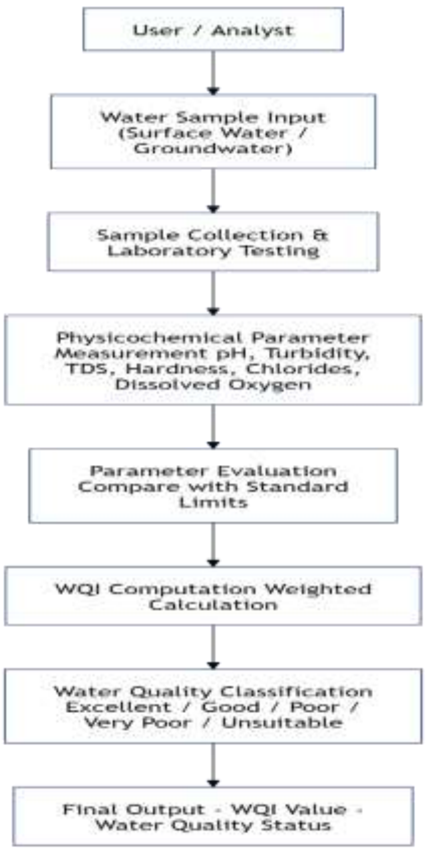
developing appropriate pollution control measures [11][16].

III. SYSTEM OVERVIEW

The proposed WQI framework follows a sequential and well-defined process for water quality assessment [6]. Initially, water samples are collected from selected surface and groundwater sources using scientifically accepted sampling techniques. These samples are then subjected to laboratory testing to measure essential physicochemical characteristics [7][18].

The measured values are evaluated against recommended drinking water standards to determine compliance levels [19]. Each parameter is assigned a weight that reflects its relative importance to human health and environmental quality [8][9]. The weighted values are normalized and mathematically aggregated to calculate the final WQI score [10]. This score provides a concise representation of overall water quality, enabling quick interpretation and comparison across different locations [11][12].



IV. SYSTEM ARCHITECTURE

The WQI-based assessment system is structured into four functional components: sample collection, parameter evaluation, index computation, and result interpretation [6][9]. The sample collection component manages water sampling and laboratory analysis.

The parameter evaluation component compares observed values with prescribed standards to identify deviations [7][19]. The index computation component calculates individual sub-indices and integrates them to generate the final WQI value [8][10]. The result interpretation component classifies water quality into defined categories and presents the findings in a simplified format to facilitate environmental planning and regulatory decision-making [11][16].

V. ALGORITHM

Water Quality Index Computation

The WQI calculation process consists of selecting relevant water quality parameters, assigning appropriate weight factors, determining quality ratings, and combining them into a single index value [6][8]. The mathematical formulation integrates weighted quality scores to represent the cumulative influence of all parameters on water quality [9][10].

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This approach enables consistent comparison of water quality across different sampling locations and time periods while maintaining accuracy and reliability [11][17]. The algorithm ensures repeatability and transparency in the assessment process.

VI. RESULT AND DISCUSSION

The proposed WQI method was applied to water samples collected from various locations with differing environmental and anthropogenic characteristics [7][18]. The computed WQI values revealed significant spatial variation in water quality, largely influenced by pollution sources, land-use patterns, and human activities [14][15].

While certain samples met acceptable drinking water standards, others were classified as poor or unsuitable due to elevated contaminant levels [10][17]. These results highlight the growing impact of human activities on water resources and emphasize the need for continuous monitoring, effective pollution mitigation strategies, and sustainable water governance [12][16].

VII. BENEFITS

The WQI approach converts complex scientific data into a single, easily interpretable value, improving accessibility for both technical experts and the general public [6][9]. It allows rapid identification of water suitability for domestic and drinking purposes [10][17]. Moreover, the system supports environmental planning, regulatory enforcement, and long-term water resource sustainability by providing clear and actionable information [11][16].

VIII. DIFFICULTIES AND CHALLENGES FACED

A major limitation of WQI-based assessment is the subjectivity involved in selecting parameters and assigning weight values [9][10]. Seasonal variations, climatic influences, and spatial heterogeneity can significantly affect water quality results [18][19]. Furthermore, laboratory testing requires specialized equipment, trained personnel, and financial investment, which may restrict large-scale implementation [7][20].

IX. CONCLUSION

The Water Quality Index–based assessment framework offers an effective and systematic method for evaluating overall water quality [6][10]. By integrating multiple physicochemical indicators into a single index, the approach simplifies interpretation and supports informed decision-making [11][12]. The study confirms that WQI is a valuable tool for identifying pollution levels, assessing water usability, and promoting sustainable water resource management and public health protection [16][17].

X. FUTURE ENHANCEMENTS

Future improvements may include the deployment of real-time sensing technologies and IoT-enabled systems for continuous water quality monitoring [20]. Predictive models based on machine learning techniques can be incorporated to forecast future water quality trends [12][17]. Additionally, integrating Geographic Information Systems (GIS) can enhance spatial visualization and strategic planning for water resource management [16][19].

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