RESEARCH ARTICLE

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Smart Environmental Monitoring and Management System for Water Quality Using Web-Based Data Analysis

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Abstract

In India, a large population depends on local water bodies such as ponds for daily use, yet the quality of these small, community-level sources is rarely monitored or made publicly accessible, even though contamination from waste disposal, human and animal faecal matter, plastic pollution, and poor sanitation makes timely monitoring essential for reducing public-health and environmental risks. This paper presents a smart environmental monitoring and management system that combines laboratory-based water quality testing with a web-based data-analysis platform. Twenty water samples were collected from ponds and public sources in Berhampur, Odisha, and analysed for pH, dissolved oxygen, chlorinity, salinity, temperature, hydrogen sulphide (H_2S), and microbial contamination. Each sample was compared against WHO and BIS (IS 10500) drinking-water limits and classified, through a rule-based decision procedure, into Safe, Moderate, or Not Safe categories. All records are stored in a structured database and presented through an interactive dashboard that supports historical comparison and public data contribution. Of the 20 samples, 9 (45%) were classified as Safe, 4 (20%) as Moderate, and 7 (35%) as Not Safe. Samples in the Not Safe category showed the highest average chlorinity, salinity, and H_2S values, confirming that chloride load and bacterial activity were the dominant contamination indicators in the study area. The results show that coupling low-cost laboratory testing with an accessible web platform provides a practical and scalable way to monitor local water bodies, raise community awareness, and build a shared dataset for researchers, students, and local communities, while remaining open to future integration of IoT sensors and machine learning.

Keywords: water quality monitoring, smart environment system, web-based data analysis, water pollution, environment monitoring, waste disposal, public health, data management system, data visualization.

Submitted: 11 April 2026
Revised: 18 August 2026
Accepted: 26 August 2026
Published: 09 September 2026

Vol. 2, **No.** 3, 2026.
10.62762/NGCST.2026.715140

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Citation
Samantara, I. K., & Pattanaik, C. (2026). Smart Environmental Monitoring and Management System for Water Quality Using Web-Based Data Analysis. *Next-Generation Computing Systems and Technologies*, 2(3), 109–122.

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1 Introduction

Water quality has a direct impact on human health and environmental sustainability. Water resources are increasingly affected by multiple sources of contamination, including the discharge of untreated or partially treated industrial effluents containing toxic chemicals, heavy metals, acids, and dyes; the release of untreated domestic sewage containing organic matter and detergents; and agricultural runoff carrying fertilizers, pesticides, and other pollutants. These contaminants can degrade aquatic ecosystems and pose potential risks to communities that depend on local water resources for domestic and other daily uses [1, 2]. Meanwhile, continued population growth, urbanization, and infrastructure development have increased pressure on limited freshwater resources, making the monitoring of ponds, rivers, lakes, reservoirs, and other local water bodies increasingly important.

Advances in digital technologies provide new opportunities to improve the collection, management, and communication of environmental information. The concept of smart cities emphasizes the use of digital technologies to support more efficient urban services and environmental management [3], while Internet of Things (IoT) technologies provide a framework for connecting sensing, communication, and data-processing components [4]. Building on these concepts, this study proposes a web-based water quality monitoring and management system that connects laboratory-based water testing with structured digital data management. Users can submit measured water quality parameters from local water sources, after which the platform stores, analyzes, classifies, and visualizes the submitted data in an accessible format. Historical records can also be retrieved and compared to support the observation of water quality changes across locations and over time. By combining laboratory measurements with an accessible web platform, the proposed system aims to facilitate communication of water quality information among researchers, students, and local communities and to support broader participation in community-level environmental monitoring.

The main contributions of this work are summarized as follows:

- A low-cost, laboratory-based testing workflow is presented for characterizing small, community-level water bodies that are usually overlooked by large-scale monitoring efforts.
- A rule-based classification procedure is defined that compares each sample against WHO and BIS (IS 10500) drinking-water limits and assigns it to one of three easy-to-understand categories: Safe, Moderate, or Not Safe.
- A web-based platform with a structured database and interactive dashboard is developed for storing, retrieving, comparing, and visualizing historical water quality records.
- An open, participatory model is proposed in which researchers, students, and local users can contribute their own test results, gradually building a shared regional dataset.

The remainder of this paper is organized as follows. Section 2 reviews related work. Section 3 states the problem, and Section 4 describes the methodology, including the testing procedures and the classification rule. Section 5 presents the collected dataset. Section 6 outlines the scope and objectives, and Section 7 describes the proposed system. Section 8 details the implementation, Section 9 discusses the results and limitations, and Section 10 concludes the paper and highlights future directions.

2 Related Work

Many researchers have worked on improving water quality monitoring using different technologies such as IoT, smart sensors, cloud computing, and machine learning. These studies have helped in collecting water quality data more efficiently and have made environmental monitoring easier. However, many existing systems mainly focus on data collection or prediction and provide limited support for storing and sharing information in a simple way for public use.

Batty et al. [3] defined the concept of smart cities as urban environments in which ICT is merged with traditional infrastructure and coordinated through new digital technologies. Their framework provides a conceptual basis for deploying digital monitoring platforms — such as the web-based system proposed here — as part of broader smart city services. Similarly, Gubbi et al. [4] presented a vision for the Internet of Things (IoT), in which wireless sensor networks enable ubiquitous sensing and actuating, and data are shared across platforms to build a common operating picture of the physical environment. This architecture — connecting field sensors, communication networks, and cloud-based data processing — directly informs the IoT integration planned as a future extension of the proposed system.

Shixian and Rui [5] developed an IoT-based online water quality monitoring system that continuously collects water quality data using sensors. Garrido-Momparler and Peris [1] also proposed a smart sensor and cloud-based system for monitoring water quality. Their work improved data collection and visualization, but the main focus was on sensor technology rather than providing a simple platform for users to manage and access historical water quality records.

Recent studies have also applied machine learning techniques for water quality analysis. Hridoy et al. [2] used advanced machine learning models to classify water quality and predict the Water Quality Index. Their results showed that machine learning can improve prediction accuracy and help in environmental decision-making. Khare and Kushwaha [6] also developed machine learning models for predicting water quality. Although these studies achieved good prediction results, they mainly focused on model performance and did not include a web-based system for storing laboratory results or allowing public participation.

From the above studies, it is clear that many researchers have contributed to water quality monitoring using modern technologies. However, there is still a need for a simple system that combines laboratory testing with an easy-to-use web platform. The proposed work addresses this need by developing a web-based water quality monitoring system that stores historical records, classifies water samples into Safe, Moderate, and Not Safe categories, and presents the information in a simple way for researchers, students, and local communities. The system is also designed so that it can be expanded in the future by integrating IoT sensors and intelligent data analysis. Table 1 summarizes how the proposed system compares with representative existing approaches.

Table 1. Comparison of the proposed system with representative existing approaches.

Study	Data class.	Historical records	Public contrib.	Low cost
Shixian & Rui [5]	✓	–	–	–
Garrido-Momparler [1]	✓	✓	–	–
Hridoy et al. [2]	✓	–	–	–
Khare & Kushwaha [6]	✓	–	–	✓
Proposed	✓	✓	✓	✓

3 Problem Statement

Although several water quality tests and reports are available on the internet, the general public still lacks easy access to water quality data. The data available on the internet contains tests of some famous water resources, whereas the water quality of small local sources — which are sometimes the sole drinking-water supply for certain communities — is largely absent from publicly available online databases. This study addresses this gap by covering different local water resources and presenting the collected data to users in a freely accessible format.

4 Methodology

The proposed system was developed to monitor and analyze the quality of water collected from different locations in Berhampur, Odisha. The study combines laboratory-based water quality testing with a web-based platform for storing, managing, and displaying the results. The complete methodology consists of five major stages: sample collection, laboratory testing, data processing, water quality classification, and web-based data management.

4.1 Data Collection

Water samples were collected from different locations, including ponds, residential areas, and public water sources in Berhampur. The locations were selected to represent different types of water bodies that are commonly used by the local population. Before collecting each sample, clean and sterilized bottles were used to avoid contamination.

Each sample was assigned a unique Sample ID. Along with the sample, information such as collection date, location name, and GPS coordinates was recorded. Basic observations including water colour, odour, temperature, and visible impurities were also noted before laboratory testing. The collected samples were transported carefully to the laboratory to minimize changes in water quality before analysis. The overall data collection process is illustrated in Figure 1.

4.2 Laboratory Water Quality Testing

The collected water samples were analyzed using standard laboratory procedures. Different physical, chemical, and biological parameters were measured to determine the quality of water. Each test was performed carefully following standard laboratory practices to ensure reliable observations.

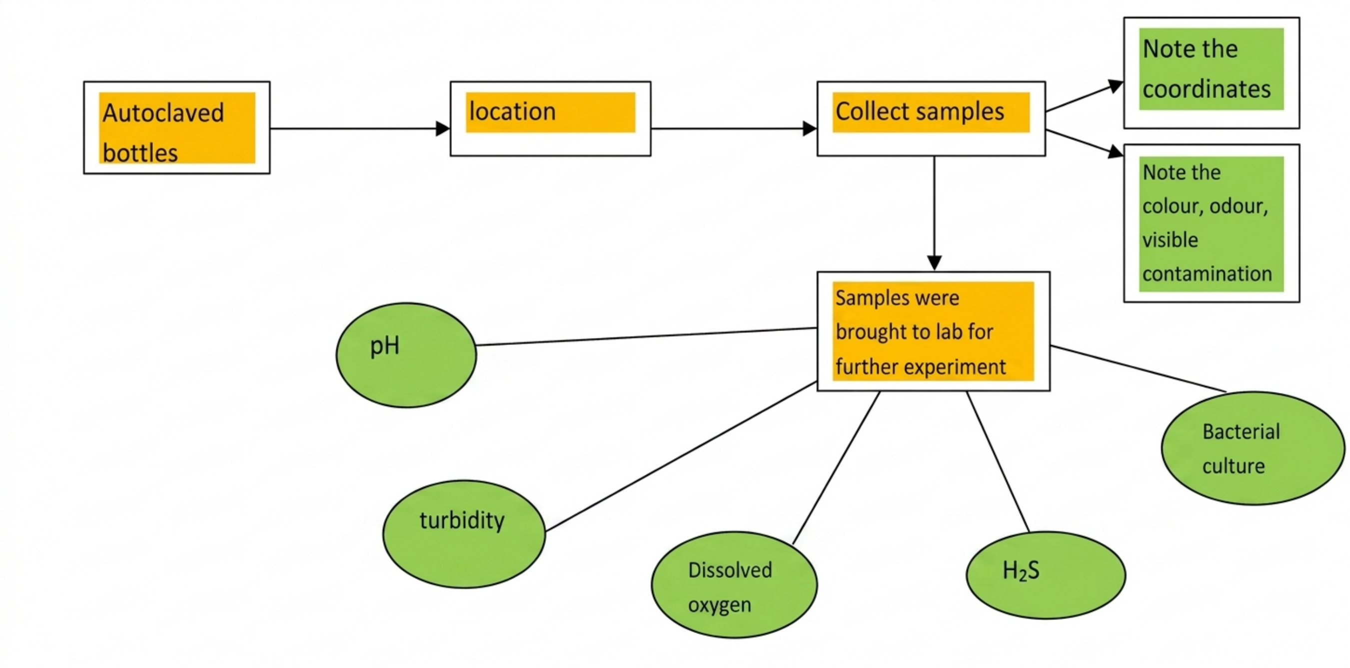


Figure 1. Data collection process.

4.2.1 pH Test

The pH value indicates whether the water is acidic, neutral, or alkaline. A calibrated digital pH meter was used to measure the pH of each sample. According to WHO drinking water standards, a pH value between 6.5 and 8.5 is considered suitable for drinking.

4.2.2 Turbidity Test

Turbidity measures the amount of suspended particles present in water. A turbidity meter was used to measure the clarity of the collected samples. Water with lower turbidity is generally cleaner, while higher turbidity may indicate contamination.

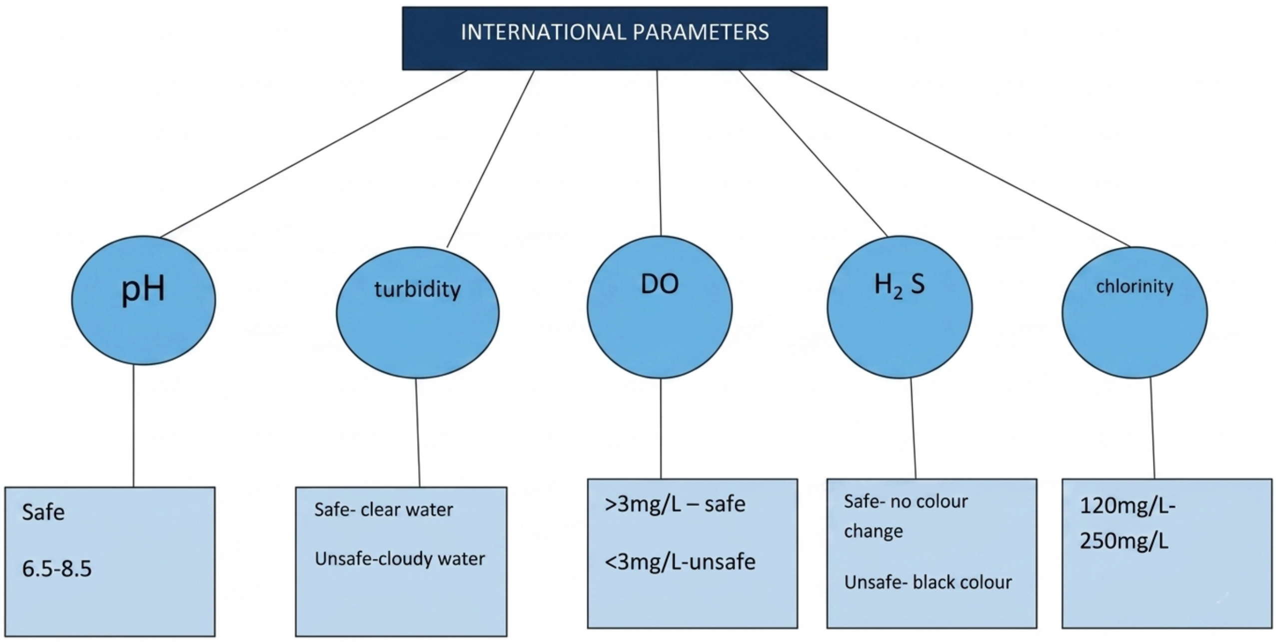


Figure 2. Various international parameters.

4.2.3 *Dissolved Oxygen (DO) Test*

The dissolved oxygen level indicates the amount of oxygen available for aquatic organisms. The DO value was measured using a digital dissolved oxygen meter after ensuring that no air bubbles were present inside the sample container.

4.2.4 *Hydrogen Sulfide (H_2S) Test*

The H_2S test was performed to identify bacterial contamination. Water samples were added to H_2S test bottles and kept undisturbed for approximately 24 to 48 hours. A black colour indicated bacterial contamination, while no colour change indicated that harmful bacteria were not detected. This colorimetric strip test yields a binary result (positive/negative) that serves as the critical microbiological indicator in Algorithm 1. In addition, quantitative H_2S concentrations measured with a digital meter are reported in Table 3 for reference; samples showing only trace quantitative values but a negative strip-test result were not classified as Not Safe on this criterion alone.

4.2.5 *Chlorinity Test*

The chlorinity of water was determined using the silver nitrate titration method with potassium chromate as the indicator. This test estimates the chloride concentration, which is an important indicator of water quality.

4.2.6 *Bacterial Culture Test*

The bacterial culture test was carried out by spreading a small amount of water sample on nutrient agar plates. The plates were incubated under suitable laboratory conditions for 24–48 hours. The appearance of bacterial colonies indicated microbial contamination in the water sample. The standard international reference values for the various parameters measured in these tests are shown in Figure 2.

4.3 Data Processing and Classification

After completing all laboratory tests, the observed values were entered into the developed web application. The system stores all information in a structured database, allowing easy retrieval and comparison of water quality data collected from different locations and different time periods.

The database stores details including Sample ID, location, date of collection, water quality parameters, and the final classification result. Historical records can also be accessed through the website for future reference.

The collected values were compared with standard drinking water guidelines issued by the World Health Organization (WHO) [7] and the Bureau of Indian Standards (BIS IS 10500) [8]. For each parameter, two thresholds are considered: an *acceptable* (desirable) limit and a *permissible* limit beyond which the water is generally unfit for consumption. The reference limits used in this study are listed in Table 2.

Table 2. Reference limits used for classification, based on WHO [7] and BIS IS 10500 [8].

Parameter	Acceptable	Permissible
pH	6.5–8.5	6.5–8.5
Turbidity (NTU)	≤ 1	≤ 5
Dissolved oxygen (mg/L)	≥ 5	≥ 4
Chloride (mg/L)	≤ 250	≤ 1000
TDS/salinity (mg/L)	≤ 500	≤ 2000
H_2S	Absent	Absent
Temperature (°C)	10–20	≤ 25

Based on the comparison, each sample is assigned to one of three categories using the rule-based decision procedure summarized in Algorithm 1. In the algorithm, the variable TDS corresponds to the salinity column in Table 3, as total dissolved solids and salinity are treated as equivalent indicators under the BIS IS 10500 classification [8]. The binary H_2S indicator (positive/negative) in Step 1 of the algorithm refers to the colorimetric strip-test result rather than the quantitative concentration values listed in Table 3. The procedure counts how many parameters violate the acceptable limits and treats the detection of H_2S as a critical (bacterial) indicator:

- **Safe:** All measured parameters fall within the acceptable standard limits.
- **Moderate:** One or more parameters slightly exceed the acceptable limit but remain within the permissible limit, so the water may require treatment before use.
- **Not Safe:** Several parameters exceed the standard limits, or a critical indicator (e.g., a positive H_2S test) is present, indicating possible chemical or microbial contamination.

This classification helps users understand the quality of water in a simple and easy-to-read format. A single composite score, such as the Water Quality Index (WQI), can also be computed from the same parameters to give a continuous quality measure; this

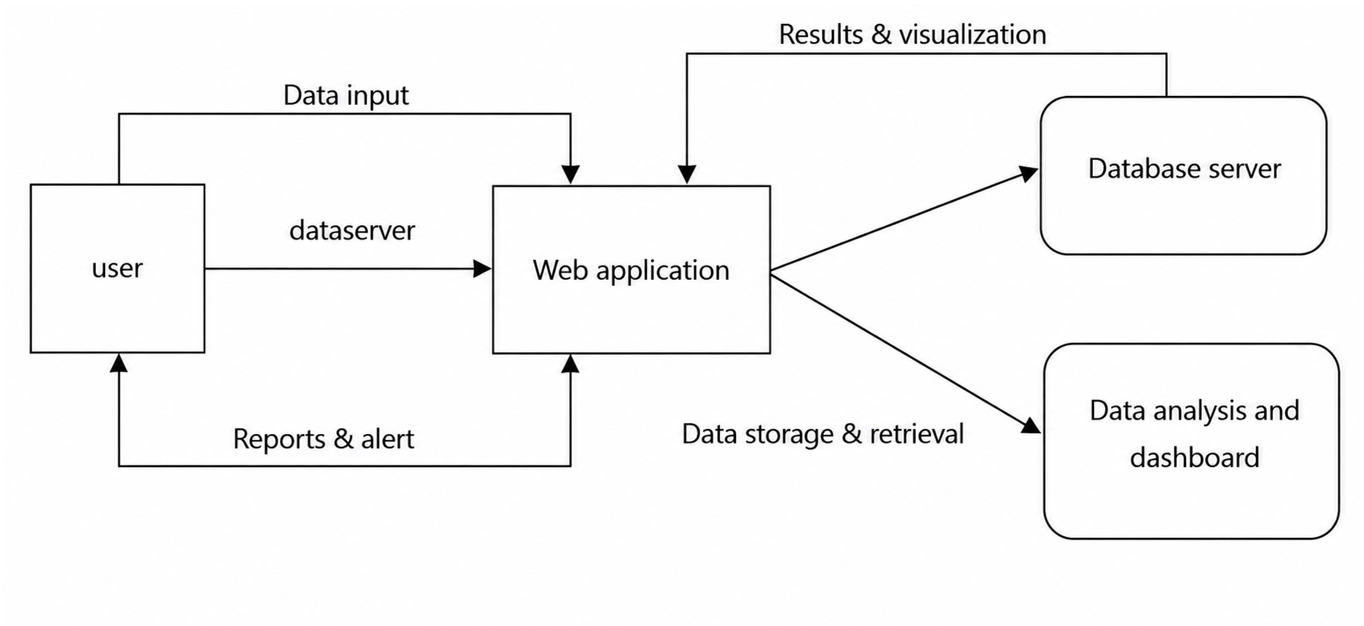


Figure 3. System architecture of the proposed web-based water-quality monitoring platform.

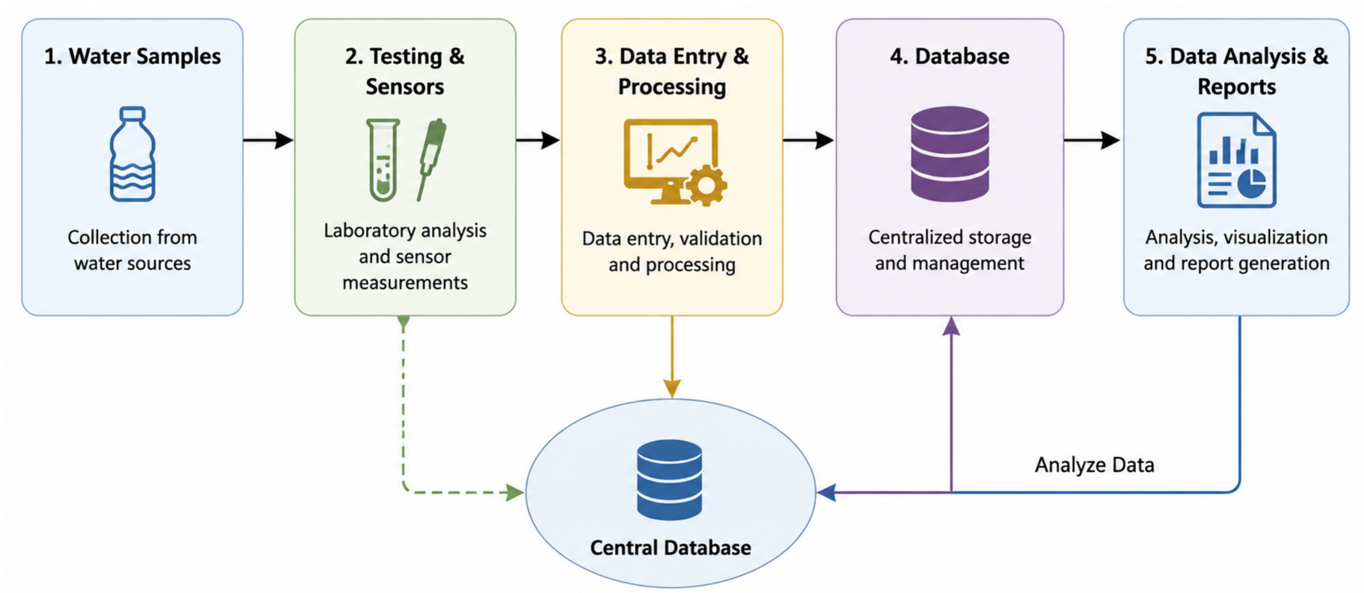


Figure 4. Data flow diagram of the water quality monitoring system. The figure outlines the flow of data within the system, starting with water samples that undergo testing and sensor analysis. The data is then processed, stored in a database, and subsequently analyzed to generate reports.

is discussed further as a planned enhancement in Section 10.

4.4 Web-Based Monitoring System

A web-based application was developed to manage all collected water quality information. The website allows users to upload new laboratory results, store them in a centralized database, and view historical records through an interactive dashboard. The dashboard displays important information such as recently collected samples, water quality status, contamination alerts, and previous testing history. This digital platform makes the collected data easily accessible to researchers, students, and local communities while supporting future environmental monitoring activities. The overall system architecture is shown in Figure 3, the flow of data within the system is presented in Figure 4, and the step-by-step water testing and analysis process is detailed in Figure 5.

5 Water Quality Tests

The sample tests were repeated several times to minimise measurement errors and ensure

Algorithm 1: Rule-based water quality classification based on acceptable and permissible limits defined by WHO [7] and BIS IS 10500 [8].

Data: Measured values $\{pH, Cl, TDS, Tur, H_2S\}$ for a water sample
Result: Water quality class $\in$ {Safe, Moderate, Not Safe}

```
A ← 0;            // number of acceptable-limit violations
// Step 1: Check critical microbiological indicator
if H2S is positive then
|   return Not Safe
end
// Step 2: Check whether any parameter exceeds its permissible limit
if pH < 6.5 or pH > 8.5 then
|   return Not Safe
end
if Cl > 1000 then
|   return Not Safe
end
if TDS > 2000 then
|   return Not Safe
end
if Tur > 5 then
|   return Not Safe
end
// Step 3: Check acceptable-limit violations
if Cl > 250 then
|   A ← A + 1
end
if TDS > 500 then
|   A ← A + 1
end
if Tur > 1 then
|   A ← A + 1
end
// Step 4: Assign the final class
if A = 0 then
|   return Safe
else
|   return Moderate
end
```

reproducibility. The observed values were compared with standard quality guidelines to check whether each parameter was within the acceptable range. The complete set of collected samples along with their measured parameters and classification results is presented in Table 3.

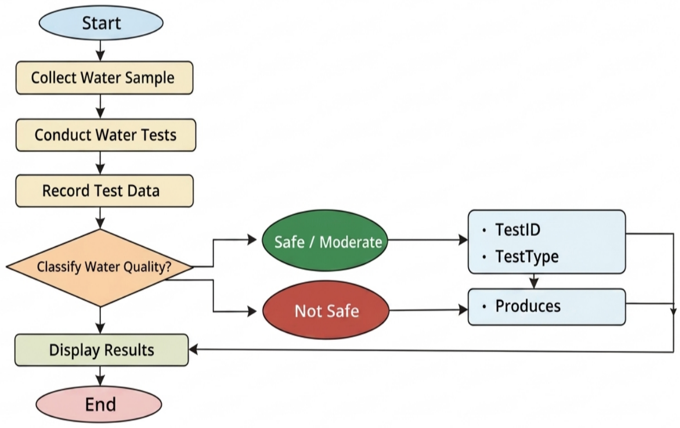


Figure 5. Flowchart of the water testing and analysis process. This flowchart details the step-by-step process for water testing, from sample collection to the final display of results. It includes decision points for classifying water quality as "Safe/Moderate" or "Not Safe," which then produces specific test IDs and types.

6 Scope and Objectives

The study is centered on the development and implementation of a smart environmental monitoring and management system. It primarily focuses on the evaluation of water samples collected from various local sources including ponds, residential areas and public water supplies. By analyzing multiple physicochemical and biological parameters such as pH, turbidity, dissolved oxygen, chlorinity, hydrogen sulfide and microbial contamination, the research aims to provide a comprehensive understanding of water quality. Further, the integration of a web-based system enables structured storage, efficient data management, and easy retrieval of information, facilitating comparative analysis across different locations and time periods. The system is designed to be scalable and adaptable, allowing for future expansion to include additional parameters, geographical areas and users, thereby contributing to improved environmental monitoring and awareness.

The primary objective of this study is to develop an efficient and user-friendly system for monitoring and analysis of water quality. This includes the systematic collection and laboratory analysis of water samples using standard testing procedures to determine key quality parameters. Another important objective is to design and implement a web-based platform that allows for the organized storage, processing, and visualization of collected data. The study also aims to classify water samples into categories such as Safe, Moderate, and Not Safe based on established water quality standards. In addition, the system seeks to

Table 3. Water samples collected from ponds of Berhampur (Odisha): original dataset. Salinity values are expressed in mg/L (equivalent to ppm for dilute aqueous solutions).

S.No.	Sample	DO (mg/L)	Chlorinity (mg/L)	Salinity (mg/L)	pH	Temp. (°C)	H_2S (mg/L)	Result
1	C-1	1.5	100	400	6.5	11	0	Safe
2	C-2	2.0	120	370	7.2	15	0	Safe
3	C-3	1.7	130	120	6.4	20	0	Safe
4	C-4	2.5	260	560	9.6	30	1	Not safe
5	C-5	2.8	270	520	9.7	32	2	Not safe
6	S-1	3	100	2000	10.0	26	0.7	Not safe
7	S-2	4	120	435	11	28	0.4	Safe
8	S-3	2.5	180	500	12	30	0	Safe
9	S-4	1.3	230	400	7.9	11	0	Safe
10	S-5	4	200	500	4.5	15	0.2	Moderate
11	S-6	1.7	270	345	7	18	0.1	Safe
12	S-7	4	265	546	8	30	0.3	Moderate
13	S-8	3	238	576	8.0	26	0.4	Moderate
14	S-9	6	287	765	9	37	0.6	Not safe
15	S-10	1.2	294	400	9	20	0	Safe
16	S-11	7	275	600	10	42	0.9	Not safe
17	S-12	4	179	560	11	27	0.4	Moderate
18	S-13	1	199	300	9	20	0.2	Safe
19	S-14	6	700	800	11	30	0.5	Not safe
20	S-15	5	678	987	14	43	0.6	Not safe

enhance data interpretation and support informed decision making by presenting results in a clear and accessible format. The study intends to provide a low-cost, practical and scalable solution that can be utilized in academic settings as well as by local communities for effective water quality monitoring and management.

7 Proposed System

7.1 System Overview

The proposed system is designed to provide a simple and practical way to monitor and manage water quality using both laboratory testing and a web-based platform. The main idea behind the system is to create a connection between field data collection and digital data analysis.

In this system, water samples are first collected from different locations and tested using standard laboratory procedures. The results obtained from these tests are then entered into the web-based application. The website acts as a central platform where all the collected data is stored, organized and analyzed.

The system is designed in such a way that it can handle data from multiple locations at different time periods. This allows users to not only check the current condition of water but also observe changes over time. The output is presented in a simple format where the water quality is classified as Safe, Moderate, or Not Safe. This approach makes the system useful for students, researchers, and even local people who want to understand the condition of water in their area without needing advanced technical knowledge. The flowchart of the entire proposed solution is shown in Figure 6.

7.2 Features of System

The proposed system includes several important features which make it practical and easy to use, such as:

- **Simple data entry** — users can enter water test values easily through the website interface without any complexity.
- **Centralized data storage** — all test results are stored in one place, making it easy to access and manage.
- **Data classification** — the system automatically classifies water as Safe, Moderate, or Not Safe based on the input values.

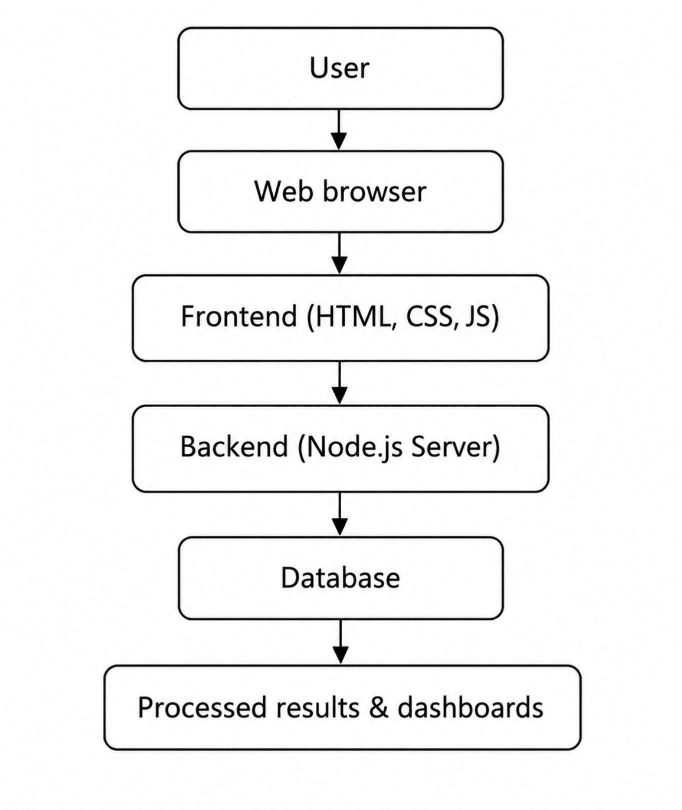


Figure 6. The flowchart of the entire proposed solution.

- **Historical data tracking** — users can view previous records and compare water quality over time.
- **User accessibility** — the platform is designed to be simple so that both technical and non-technical users can use it.
- **Research support** — it allows different users to upload their own data, helping in expanding the dataset for research purposes.

These features make the system not only useful for study but also adaptable for future improvements and wider applications.

8 Implementation

The implementation of the system was carried out using basic and easily available technologies.

8.1 Technologies Used

The web application was developed using HTML and CSS for designing the user interface, which provides a clean and simple layout for users. For handling the backend and storing data, a database system was used to keep all the test records in an organized manner. The system processes the data entered by the user and generates the result based on predefined conditions. The main focus during implementation was to keep the system simple, low cost, and easy to maintain, so that it can be used even in academic projects without requiring advanced resources.

8.2 Database Design

The database plays an important role in storing and managing all the collected water quality data. It is designed in a structured way so that each water sample has its own record. This makes it easier to store the results properly and find the required information whenever needed. The database mainly includes the following components:

- Sample ID
- Location name
- Date of sample collection
- Test parameters (pH, turbidity, DO, chlorinity, H_2S)
- Temperature
- Final result (Safe/Moderate/Not Safe)

Each sample is stored with its corresponding test values and location details. The Sample ID helps to identify each water sample separately and avoids confusion between different records. The stored data can also be used to compare water quality from different locations and at different times. The database makes it easier to retrieve previous test results and display them through the web interface. This also helps in maintaining historical records, which can be useful for observing changes in water quality over time. The structure can be further extended in the future by adding more water quality parameters and records from other locations.

8.3 Web Interface

The web interface connects laboratory data with end users by presenting water quality information in a clear and accessible format. It helps identify contamination levels and support better decision making for water safety. The prototype of the main dashboard is shown in Figure 7.

The web interface is one of the most important parts of this project because it connects the collected data with the users in a simple and understandable way. While designing the website, the main focus was to keep everything clear, easy to use and informative, even for people who do not have a technical background.

The homepage of the system mainly works as a dashboard, where all important information is shown

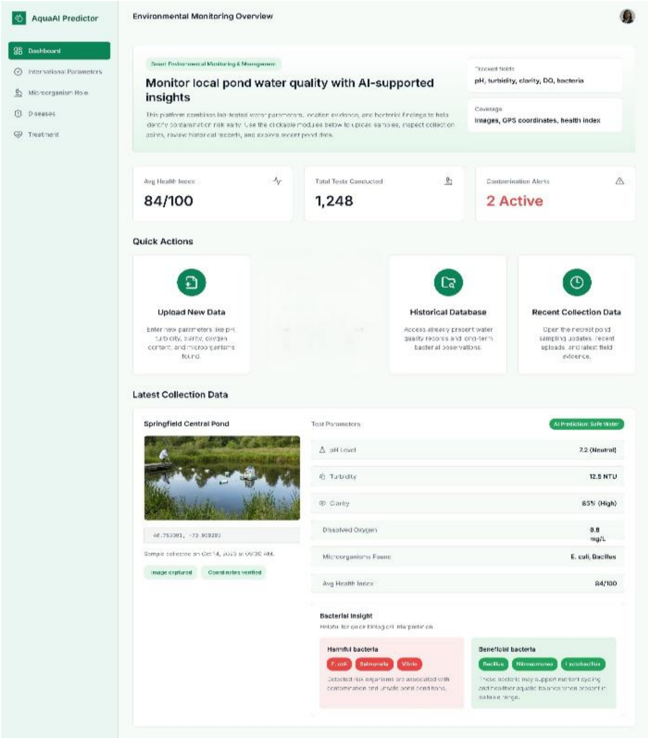


Figure 7. Prototype of the dashboard having the proposed database of the collected pond water quality and many other features.

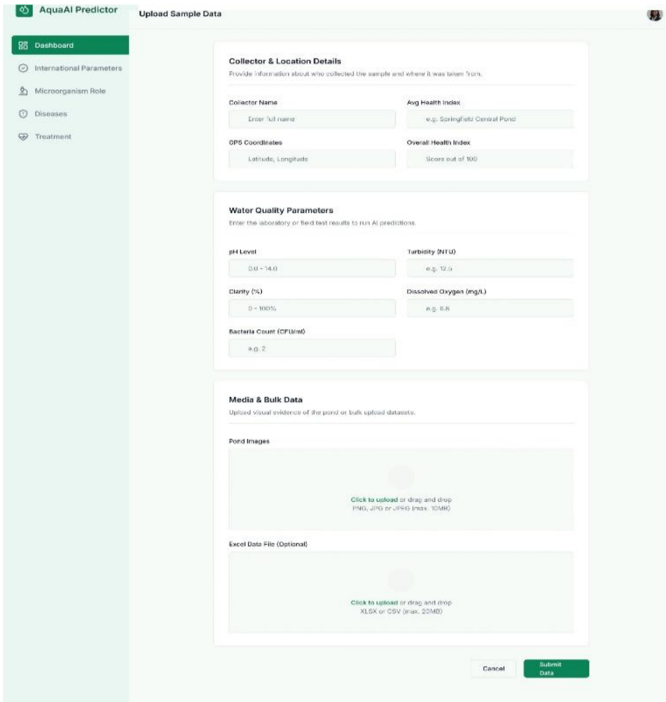


Figure 9. This feature allows the user to input new water quality readings into the system. Data such as pH, temperature and contamination levels are recorded.

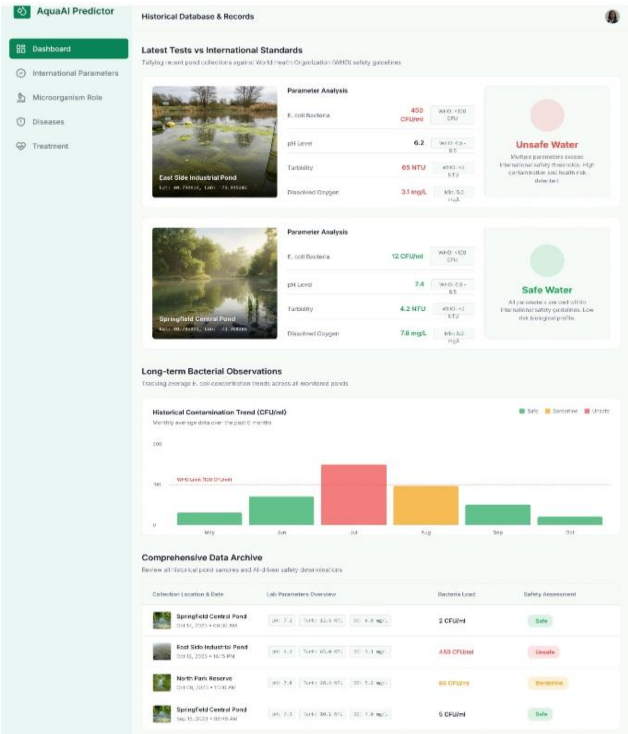


Figure 8. The historic database, storing all previously collected water quality data. It helps in understanding long-term environmental changes.

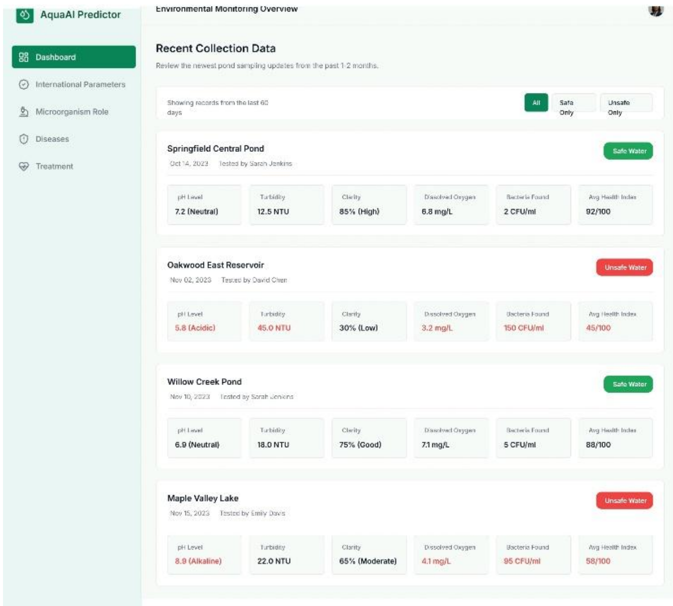


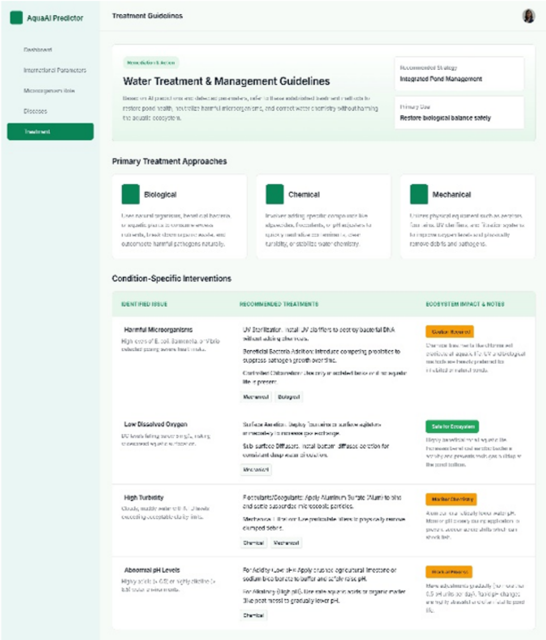
Figure 10. Display of the most recently collected data or water samples and their results. Helps the user quickly assess current water conditions.

at a glance. At the top of the dashboard, there are some key indicators such as average health index, total number of tests conducted, and contamination alerts.

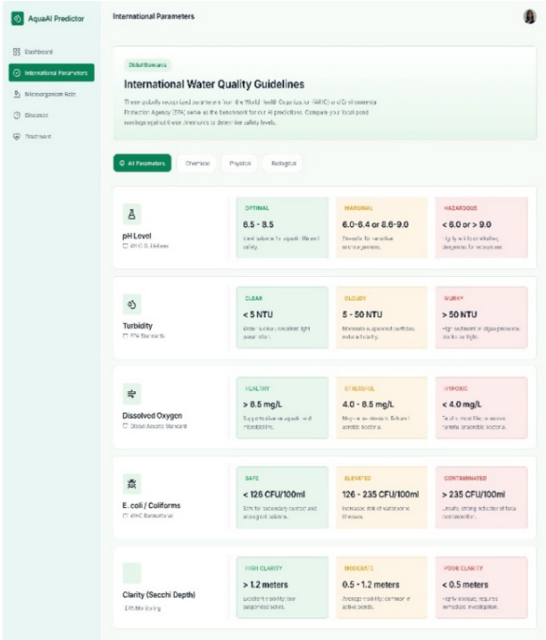
These values help the user quickly understand the overall condition of water quality without going into detailed data.

The three main options are provided in the form of icons, which are:

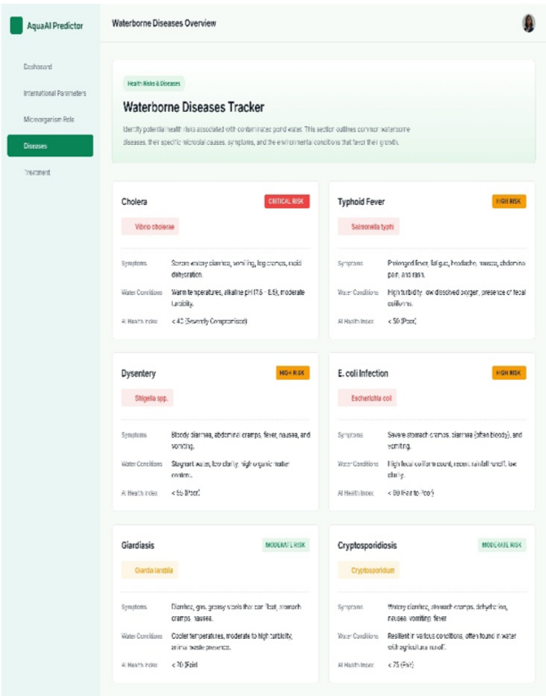
- **Upload new data** — this allows users to enter new



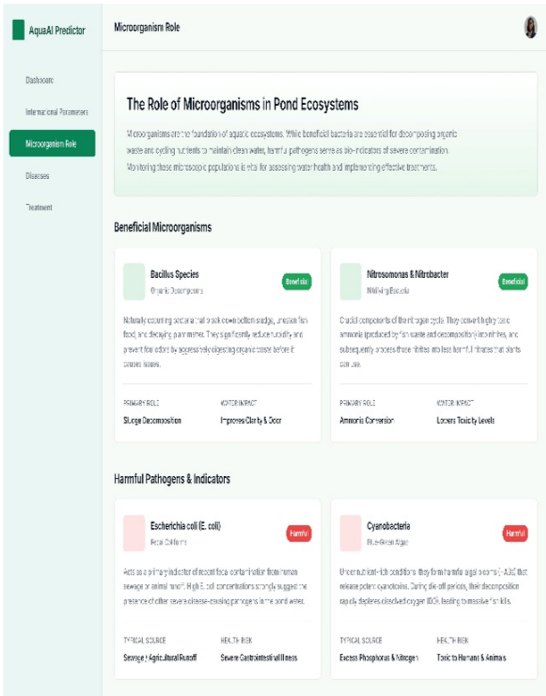
(a) Water treatment and management guidelines



(b) International water quality guidelines



(c) Waterborne diseases tracker



(d) Role of microorganisms in pond ecosystems

Figure 11. The prototype also shows features like: (a) water treatment and management guidelines; (b) international water quality guidelines; (c) different waterborne diseases; and (d) the role of microorganisms in ecosystems.

sample data after conducting tests. Users can input parameters such as pH level, turbidity, dissolved oxygen and presence of microorganisms, as shown in Figure 9.

- **Historical database** — this section stores all previously entered data. It helps in comparing past and present water quality from different locations, as shown in Figure 8.

- **Recent collected data** — this shows the most recently added samples along with their test values and results, as shown in Figure 10.

Under these sections, the dashboard also displays the latest collected data details, where parameters such as pH level, turbidity (clarity), dissolved oxygen, and microorganisms found are shown clearly. This makes it easy for users to directly see the condition of recent samples.

Apart from the dashboard, there are additional sections available for gaining more knowledge about water quality, as shown in Figure 11. These include:

- **International parameters** — this section provides standard acceptable ranges for different water quality parameters based on global guidelines.
- **Microorganism role** — it explains how certain microorganisms can be beneficial while others can be harmful.
- **Disease and treatment** — this gives basic information about diseases caused by contaminated water and possible treatments or precautions.

All these sections are connected properly, so when a user clicks on any option, the related information is displayed clearly. The current prototype operates on manually uploaded laboratory data collected from different locations in Berhampur, which makes the system more realistic and useful.

Overall, the web interface makes the system more interactive and helps both researchers and local users to understand water quality in a simple and practical way.

9 Results and Discussion

Based on the test results, the 20 water samples were divided into three categories: Safe, Moderate, and Not Safe. Among the 20 samples, 9 samples (45%) were found to be Safe, 4 samples (20%) were classified as Moderate, and 7 samples (35%) were classified as Not Safe. This shows that a good number of the tested water sources still need proper attention and regular monitoring.

There were some differences in the water quality results from one sample to another. The samples having pH values closer to the recommended range and lower levels of chlorinity were generally found to be safer. In some samples, higher pH, higher chlorinity, or a positive H_2S test was observed, and these samples were placed in the Not Safe category. The samples in the Moderate category showed changes in one or more parameters, but the results were not as concerning as those of the Not Safe samples.

Table 4. Average parameter values for each water quality category.

Parameter (avg.)	Safe	Moderate	Not Safe
Samples (n)	9	4	7
Chlorinity (mg/L)	183	220	367
Salinity (mg/L)	363	546	890
pH	8.44	7.88	10.47
Temperature (°C)	19.2	24.5	34.3
H_2S (mg/L)	0.08	0.33	0.90

To examine the trend behind these categories, the average value of each parameter was computed for the three classes, as shown in Table 4. A clear pattern emerges: moving from Safe to Not Safe, the average chlorinity, salinity, hydrogen sulphide, and temperature all increase steadily. The Not Safe group had the highest mean chlorinity (367 mg/L), salinity (890 mg/L), and H_2S (0.90 mg/L), which confirms that chloride load together with bacterial activity (indicated by H_2S) were the dominant contamination indicators in the study area.

Considering the parameters individually, a positive H_2S reaction was observed in 14 of the 20 samples, indicating that bacterial contamination is widespread among the sampled ponds. Chlorinity remained within the desirable limit of 250 mg/L in 11 samples, while the remaining samples—particularly S-14 (700 mg/L) and S-15 (678 mg/L)—showed very high chloride loads that pushed them firmly into the Not Safe category. Salinity showed the widest spread (120–2000 mg/L), with sample S-1 reaching the permissible upper limit of 2000 mg/L. It should be noted that the recorded pH values ranged widely (4.5–14), and several samples reported pH values well outside the WHO/BIS range of 6.5–8.5; where such values were originally labelled as Safe or Moderate in the field records, they should be re-verified, since the rule-based procedure in Algorithm 1 would place strongly acidic or alkaline samples in a lower category. This inconsistency motivates the adoption of a single composite index (WQI) and automated classification in future versions of the system, so that category assignment is fully reproducible.

The web-based system was useful for keeping all the test results in one place. It allows the collected samples to be stored and viewed easily, and the results from different locations can also be compared. The stored records can be used later to check the water quality of a particular location and observe changes over time.

The results show that combining laboratory testing with a web-based system can make water quality monitoring easier to manage.

9.1 Limitations

While the proposed system demonstrates a practical monitoring approach, several limitations should be acknowledged. First, the study is based on a limited dataset of 20 samples collected from a single city (Berhampur) during a single season, so the findings cannot yet be generalized to other regions or to seasonal variation. Second, the current parameter set does not include important indicators such as heavy metals, nitrates, biochemical oxygen demand (BOD), or standard microbiological counts (e.g., total and faecal coliform), which would give a more complete picture of drinking-water safety. Third, classification currently relies on a rule-based threshold comparison. The original field labels in the "Result" column of Table 3 were assigned by operators prior to formalisation of Algorithm 1 and are inconsistent with a strict algorithmic application for several samples. This discrepancy highlights the need for automated, real-time classification to eliminate operator subjectivity, and motivates the adoption of a continuous Water Quality Index (WQI) in future versions of the system. Finally, data entry is manual, which can introduce human error and limits real-time monitoring. Addressing these limitations through larger multi-season sampling, an expanded parameter set, and automated data acquisition forms the basis of the future work described next.

10 Conclusion

In this study, an effort has been made to understand and monitor the quality of water in different local areas using a simple and practical approach. By collecting water samples from various locations in Berhampur and performing different laboratory-based tests, it was possible to analyze the condition of water in a clear manner. The results show that while some areas have safe water, many locations still face moderate to high levels of contamination. This clearly indicates the impact of factors such as waste disposal, poor sanitation and increasing pollution on local water sources.

The main contribution of this project is the development of a web-based system that helps in storing, organizing and analyzing the collected samples. This project shows that even with simple tools and proper planning, it is possible to create an effective environmental monitoring system. It not only helps in identifying unsafe water sources but also raises public awareness of the importance of water quality monitoring. With further improvements, this system can play a useful role in maintaining a healthier environment.

In future, the proposed system can be extended along several directions. IoT-based sensors (for pH, turbidity, dissolved oxygen, and temperature) can be integrated to enable continuous, real-time monitoring and to remove the need for manual data entry. Machine learning models, such as those explored by Hridoy et al. [2] and Khare and Kushwaha [6], can be incorporated to predict water quality trends, compute a continuous Water Quality Index (WQI), and provide early contamination alerts. The parameter set can be broadened to include heavy metals, nitrates, BOD, and standard microbiological indicators, and sampling can be expanded across more locations and multiple seasons to improve reliability. Adding GPS-based mapping and a mobile application would further help local communities visualize nearby water quality and contribute their own readings, strengthening the participatory nature of the platform.

Data Availability Statement

The source code and data used to support the findings of this study are available at https://github.com/ipsitasamantara-dot/water_quality_web.git.

Funding

This work was supported without any funding.

Conflicts of Interest

The authors declare no conflicts of interest.

AI Use Statement

The authors declare that ChatGPT was used for language editing and improving the clarity of the manuscript during revision. The authors have carefully reviewed, revised, and verified the AI-assisted output and take full responsibility for the content of the manuscript.

Ethical Approval and Consent to Participate

Not applicable.

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