



# Quality Aware Smart Water Monitoring System with Automated Alerts

Kalahastri V Lalitha<sup>1</sup>, Javvadi Kamakshi<sup>2</sup>, Thamminaina Saiprasad<sup>2</sup>, Matta Ashokumar<sup>2</sup>, Majji Sai Murali Karthik<sup>2</sup>

Department of ECE, Godavari Global University, Rajamahendravaram, INDIA.

Department of ECE, Godavari Institute of Engineering & Technology (A), Rajamahendravaram, INDIA.

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## KEYWORDS

Water Quality Monitoring, Internet of Things (IoT), Arduino Uno, Node MCU ESP8266, pH Sensor, Turbidity Sensor, GSM Module, Blynk Cloud, Smart Water System.

## ABSTRACT

The Water Quality Monitoring System uses various sensors to measure different parameters: pH, temperature, turbidity, salinity, and humidity, focusing on real-time IoT applications. The system's collected data is processed using an Arduino Uno and Node MCU (ESP8266). The LCD module displays the data processed and the data is sent to the Blynk cloud where it can be accessed and analyzed. If parameters go above or below the defined limits, the GSM module is triggered and sends alerts. To stop the flow of contaminated water, an automatic water control system with a relay and DC pump is configured. This prototype presents a system that can be used for drinking water sources, fishery, and industrial applications.

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## INTRODUCTION

Water is an invaluable natural resource. It is essential for healthy living, agriculture, industry, and ecosystems. Safe and clean water is essential for drinking, sanitation, food production, and industrial activities. The world is currently facing water pollution as a result of rapid urbanization, the growing population, industrialization, and poor waste management. Water resources continue to degrade.

Over the past few years, water bodies like rivers, lakes, canals, and groundwater sources have been polluted more than ever before, mainly due to industrial effluents, chemical fertilizers, untreated sewage, and plastic waste. This pollution degrades the water quality and endangers humans and aquatic life. In developing countries like India, the disease-causing bacteria present in polluted water sources demonstrate the importance of the development of more sophisticated water quality monitoring and management systems.

Water quality is out of question a function of a series of physical and chemical parameters which include pH, temperature, turbidity, salinity and the presence of what are in fact harmful substances. Present water quality monitoring methods which depend on manual sample collection and lab testing do in fact take a great deal of time and are also very costly which in turn makes them unsuitable for real time monitoring. Also by the time we do detect contamination it is often after the water has been used which in turn leads to health and environmental issues. These issues put into play the need for automated and real time monitoring solutions. The Internet of Things (IoT) presents itself as an excellent solution for continuous and remote water quality monitoring. IoT based systems which integrate sensors, microcontrollers, wireless communication and cloud platforms to collect, process and display data in real time. Also they enable us to detect contamination at an early stage, reduce human effort and improve monitoring accuracy.

This project reports a project which has developed an IoT based Water Quality Monitoring System which uses Arduino Uno, NodeMCU ESP8266, GSM and the Blynk cloud platform. We have put together a system which constantly tests for key water quality parameters via many sensors and which also gives out local display as well as remote cloud based results. We have included features for SMS alerts and an automatic water control which improves safety and reliability. We put forth this system which is low cost, scalable and very efficient in the field of smart water quality monitoring and in that of sustainable water resource management

## LITERATURE SURVEY

Water quality degradation and global water scarcity have become major concerns due to rapid urbanization, industrial growth, population increase, and climate change. van Vliet et al. reported that water scarcity is not only related to limited water availability but also to poor surface water quality, which reduces the usability of available water resources for domestic and industrial purposes [4]. Even when water quantity is sufficient, pollution significantly affects its quality, increasing the demand for clean water technologies and continuous monitoring systems. These observations highlight the

need for automated and real-time water quality monitoring solutions to support sustainable water resource management.

Conventional water quality monitoring methods mainly depend on manual sampling and laboratory analysis, which are time-consuming and unsuitable for continuous monitoring. Harshith Gowda and Mohammed Abdul Kader Jailani proposed an IoT-based monitoring system that integrates multiple sensors with cloud platforms to enable real-time monitoring and remote access [3]. Pawar et al. further emphasized the importance of remote monitoring for large water bodies such as reservoirs, where manual sampling is inefficient and delayed detection can lead to severe environmental impacts [2]. These studies demonstrate that IoT based monitoring systems offer better efficiency, scalability, and responsiveness than traditional methods.

Wireless Sensor Networks (WSNs) and IoT technologies play a crucial role in real-time water quality monitoring. Pule et al. presented a survey on WSN-based monitoring systems, discussing commonly used sensors, network structures, and key challenges such as energy efficiency and data reliability [7]. Rathna demonstrated that low-cost IoT systems using sensors and microcontrollers can effectively transmit water quality data to cloud platforms, enabling remote monitoring and timely decision-making [5]. These studies confirm the practicality of low-cost sensor-based IoT solutions for continuous monitoring.

Several researchers have focused on automation and real-time visualization of water quality parameters. Sai Bhatt Keshipeddi developed an IoT-based smart water quality monitoring system using Arduino and NodeMCU for continuous parameter monitoring without manual intervention [6]. Mohiyaden and Sidek analyzed water quality improvements during the COVID-19 movement control period and highlighted the importance of continuous monitoring to maintain water quality once industrial activities resume [9]. These works underline the significance of automated systems combined with real-time data visualization platforms.

Recent studies have also highlighted the role of advanced data analytics in water quality management. Shi et al. used high-frequency sensor data with wavelet and ANN models to provide early warnings of water quality anomalies [8]. Wu et al. demonstrated that integrating IoT data with cloud computing and smart

data analytics improves pollution detection and decision-making [1]. The base paper by Bakar et al. further validated the importance of sensor calibration and real-time monitoring by comparing IoT data with laboratory results, showing improved accuracy and reliability [9]. Overall, these studies indicate that combining real-time sensing, cloud platforms, calibration, and data analytics significantly enhances water quality monitoring and management

## PROPOSED METHODOLOGY

Recent reports also present on the role of advanced data analytics in water quality management. Shi et al. reported on the use of high frequency sensor data with wavelet and ANN models which they put forth as a early warning system for water quality anomalies [8]. Also Wu et al. presented that which to put IOT data together with cloud computing and smart data analysis improves pollution detection and decision making [1]. Base research by Bakar et al. which looked at sensor calibration and real time monitoring and which they did by way of a study which put out IOT data against lab results reported improved accuracy and reliability [9]. As a whole these studies report that what improves water quality monitoring and management is the combination of real time sensing, cloud platforms, calibration and data analysis.

The suggested system employs an Internet of Things (IoT)-based methodology for ongoing real-time assessments of water quality metrics and automated control of water quality measurements. The key focus of the methodology is on effective measurement and reliable transmission and prompt notification and alert, along with analytical reasoning to avoid the usage of unsafe water. The system's general structure incorporates modular sensing, embedded processing and wireless communication, cloud visualization, alerts, and automated control.

At first we see that which is of primary importance in terms of water quality is monitored by way of dedicated sensors. These parameters which we pay close attention to do so because they play key role in the determination of water safety for drinking, industrial use and aquatic life. Each sensor reports back constantly on environmental and water related data and puts out analog or digital signals which in turn report what is measured. These signals are then put into an Arduino

Uno microcontroller which in turn is the main processing unit of the system.

Arduino Uno takes in sensor data which it then transforms from raw signals into what is relevant and safe for human interpretation. The processed data is put through pre set threshold which we have based on what is typical in water quality reports. This comparative process is what allows the system to report out of the ordinary or dangerous water conditions as they happen. We use threshold based decision which in turn results in quick detection and response without human input. For local use the real time sensor info is put out to a 16x2 LCD module. This feature is for site which has no internet access, which in turn reports back to the user in real time. Also the LCD does a great job at simply presenting key info which makes the system a good fit for remote and rural areas.

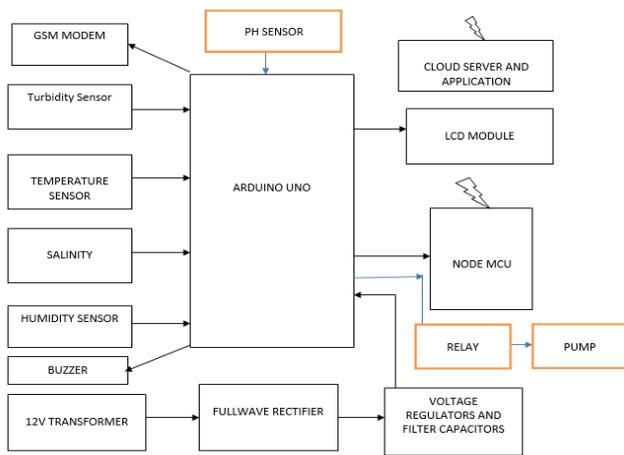
A NodeMCU ESP8266 Wi-Fi Module has been integrated into the system for remote monitoring and accessing system data. The NodeMCU sends the processed sensor data to the Blynk IoT cloud. Users can visualize and analyze water quality data in real-time or historically on the user-friendly dashboard of the Blynk application. Since monitoring water quality can be done from any place, the cloud-based system is easily accessible via the web or smartphone. Additionally, to further improve safety and reliability, the system was developed with a GSM Module for alert notifications. The registered user is sent an SMS notification if any of the monitored parameters are above the allowed threshold. This system also sends notifications in situations where there is no internet access. Also a buzzer is used which gives immediate local warning which in turn enables nearby personnel to take quick correct action.

We have put in an automatic water control feature which uses a relay module and a DC water pump. When we see that critical parameters like turbidity or salinity have gone beyond safe levels the relay goes off which in turn stops the pump from working thus it stops the supply of contaminated water. This auto control feature reduces human dependence and also it prevents the distribution or consumption of unsafe water. We have a regulated power supply unit which consists of a step down transformer, rectifier, filter caps, and voltage regulator which in turn provide a stable and reliable power source for all system components. Proper power

regulation we found to be key in consistent sensor performance, reliable data transfer, and in the unbroken operation of the system.

Overall, the proposed methodology offers an efficient and scalable solution for real-time water quality monitoring and control. By combining IoT technology, cloud computing, GSM-based alerts, and automated decision-making, the system ensures improved water safety, rapid response to contamination, and remote accessibility. The proposed system is well-suited for applications such as drinking water quality monitoring, industrial water management, agricultural irrigation systems, and fisheries management.

### BLOCK DIAGRAM



**Fig.1: Block diagram of the proposed IoT-based water quality monitoring system**

#### 1.pH Sensor:

The pH sensor is used to measure the acidity or alkalinity of water by sensing the concentration of hydrogen ions. It produces an electrical signal corresponding to the pH value of the water sample. This signal is continuously sent to the Arduino controller, which helps in identifying whether the water lies within the safe pH range. Monitoring pH is essential for maintaining water quality, especially in drinking water systems, aquaculture, and environmental monitoring applications.

#### 2.Temperature Sensor:

The temperature sensor measures the thermal condition of water, which directly affects chemical reactions and biological activities. In this project, a digital temperature sensor such as the DS18B20 is used to provide accurate temperature readings. The sensor is

interfaced with the Arduino microcontroller for continuous monitoring. Temperature monitoring helps in detecting abnormal thermal variations and ensures safe operating conditions in water treatment and environmental systems.

#### 3.Turbidity Sensor:

The turbidity sensor is used to determine the clarity of water by detecting the presence of suspended particles. It works based on light scattering principles, where higher turbidity indicates contaminated or polluted water. The sensor data is processed by the Arduino, and alerts are generated if turbidity exceeds safe limits. This sensor plays a crucial role in monitoring drinking water sources and natural water bodies.

#### 4.Salinity Sensor:

The turbidity sensor is used to determine the clarity of water by detecting the presence of suspended particles. It works based on light scattering principles, where higher turbidity indicates contaminated or polluted water. The sensor data is processed by the Arduino, and alerts are generated if turbidity exceeds safe limits. This sensor plays a crucial role in monitoring drinking water sources and natural water bodies.

#### 5.Humidity Sensors:

The humidity sensor is used to measure the amount of moisture present in the surrounding environment. In this system, a digital humidity sensor such as the DHT11 is employed to provide real-time humidity readings. Monitoring environmental humidity is useful for understanding external conditions that may influence sensor performance and overall system stability. The humidity data is collected by the Arduino controller and displayed locally and remotely through the IoT platform. This additional environmental parameter improves system reliability and supports better analysis of water quality monitoring conditions.

#### 6.16×2 LCD Module:

The 16×2 LCD module is used for local display of water quality parameters in real time. It shows sensor readings such as pH, temperature, turbidity, salinity, and humidity without the need for internet connectivity. This enables on-site monitoring and quick observation of system status. The LCD improves user interaction and system reliability.

## 7.Arduino Uno:

Arduino Uno acts as the main processing unit of the system. It collects data from all connected sensors, processes the information, and controls output devices such as the LCD, buzzer, relay, and communication modules. The Arduino is chosen for its simplicity, reliability, and ease of interfacing with multiple sensors. It ensures real-time data processing and smooth coordination between hardware components.

## 8.NodeMCU ESP8266:

The Node MCU ESP8266 is used to provide Wi-Fi connectivity to the system. It receives processed data from the Arduino and uploads it to the cloud platform for remote monitoring. With built-in TCP/IP support, the NodeMCU enables real-time data transmission to the Blynk application. This allows users to access water quality data from anywhere using a mobile phone.

## 9.Blynk Platform:

The Blynk platform is an IoT-based cloud service used for real-time monitoring of water quality parameters. In this project, sensor data collected by the Arduino and transmitted through the Node MCU ESP8266 is uploaded to the Blynk cloud. The platform displays live values using dashboards and enables easy remote access. This improves monitoring efficiency and supports timely decision-making.

## Circuit Implementation:

Figure 1 shows the complete circuit diagram of the proposed IoT-based water quality monitoring system. The circuit integrates pH, temperature, turbidity, salinity, and humidity sensors with the Arduino Uno microcontroller. The Arduino collects and processes sensor data and displays real-time values on a 16x2 LCD module. NodeMCU ESP8266 is interfaced for wireless data transmission to the Blynk cloud platform. A GSM module is used to send alert messages during abnormal conditions, while a relay-controlled pump enables automatic water flow control. The regulated power supply ensures the stable operation of all components. The circuit design confirms proper integration and reliable system operation.

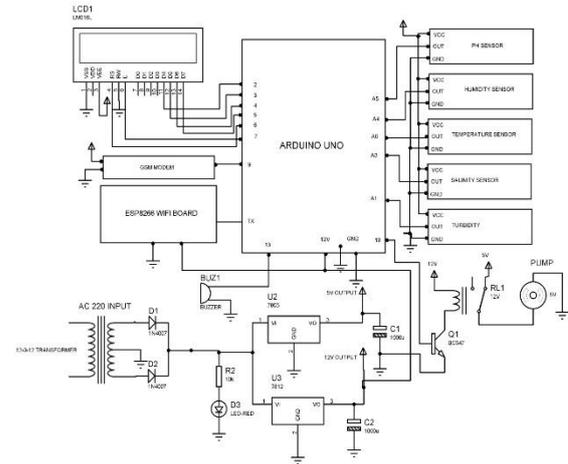


Fig. 2. Circuit diagram of the proposed water quality monitoring system

## Hardware Prototype:

Figure 2 illustrates the developed hardware prototype of the water quality monitoring system. The prototype demonstrates real-time data acquisition from multiple sensors and successful processing by the Arduino controller. Sensor readings are displayed locally on the LCD and simultaneously transmitted to the Blynk platform through NodeMCU for remote monitoring. When any parameter exceeds the predefined threshold, the relay automatically turns off the pump, and alert notifications are generated through the GSM module and buzzer. The prototype results verify the effectiveness of the system in real-time water quality monitoring and control.

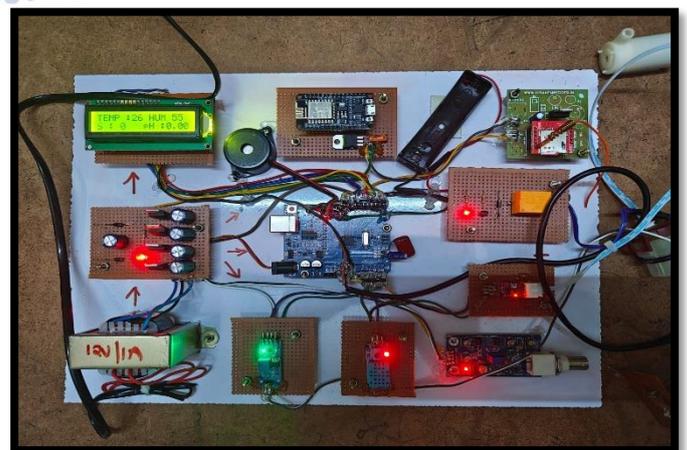


Fig. 3. Hardware prototype of the IoT-based water quality monitoring system

## RESULTS AND DISCUSSION

### 4.1. Blynk Console:

The Blynk Console provides a cloud-based web dashboard for real-time monitoring of water quality parameters in the proposed system. As shown in Fig. 4, sensor data such as pH, temperature, turbidity, salinity, and humidity transmitted by the NodeMCU ESP8266 are displayed using value widgets. The dashboard allows users to view live readings and observe parameter variations over different time intervals. This cloud integration enables remote monitoring, improves data accessibility, and supports timely identification of abnormal water quality conditions.

In addition to real-time visualization, the Blynk Console also supports automated alert generation based on predefined threshold values configured within the system. When any parameter such as pH, turbidity, or salinity deviates from the permissible range, the system triggers instant notifications through the cloud platform. This feature enhances the reliability of the Smart Water Monitoring System by enabling proactive intervention before water quality reaches critical levels. The integration of NodeMCU ESP8266 with the Blynk cloud ensures seamless data transmission using Wi-Fi connectivity, reducing the need for manual sampling and laboratory testing.



Fig. 4. Real-time sensor data visualisation on the Blynk Console

### 4.2. GSM Alert System:

The GSM module is used in the proposed system to provide instant alert notifications during abnormal water quality conditions. When parameters such as temperature, turbidity, or salinity exceed predefined threshold values, the Arduino controller triggers the GSM module to send SMS alert messages to the

registered mobile number. These alerts clearly indicate the type of parameter that has increased, enabling quick identification of the issue.

This alert mechanism ensures a timely response even in locations where internet connectivity is unavailable or unreliable. The GSM-based notification system enhances system reliability and safety by enabling real-time warnings and supporting immediate corrective action. The successful reception of alert messages, as shown in the results, confirms the effective integration of GSM technology in the water quality monitoring system.

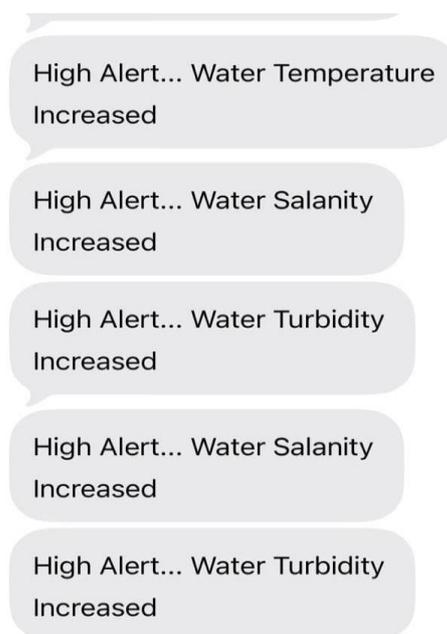


Fig. 5. SMS Alerts Generated by GSM Module During Threshold Violation

### 4.3. Buzzer Alert System:

The buzzer alert system is integrated as a local warning mechanism to provide immediate notification of abnormal water quality conditions. It operates independently of internet connectivity, thereby increasing the reliability of the Smart Water Monitoring System. The buzzer is directly interfaced with the Arduino controller through a digital output pin. During operation, the controller continuously compares real-time readings of temperature, turbidity, and salinity with predefined threshold values set according to safe water quality standards.

When any parameter exceeds its permissible limit, the Arduino instantly activates the buzzer to generate an audible alarm. This immediate sound indication enables users at the monitoring site to quickly identify unsafe

water conditions and take corrective action. The buzzer remains active until the parameter values return to the acceptable range or the system is manually reset, ensuring that abnormal conditions are not ignored.

The buzzer system works alongside the GSM-based SMS notification module, forming a dual-alert mechanism. While the GSM module provides remote alerts, the buzzer ensures local awareness at the monitoring location. This combined alert strategy enhances system responsiveness and safety, making the proposed solution suitable for drinking water monitoring, industrial applications, and aquaculture management.

#### 4.4. Automatic Pump Control Based on Water Quality Thresholds:

The system implements an automatic pump ON/OFF control mechanism driven by real-time water quality monitoring. Sensors measuring salinity, turbidity, pH, temperature, and other critical parameters continuously assess water conditions. When any parameter exceeds predefined safe limits, the controller automatically switches OFF the pump to prevent the circulation or usage of contaminated water. Once all sensed values return to acceptable ranges, the pump is switched ON automatically without manual intervention. This approach minimises human error and ensures consistent adherence to safety standards. The automated control logic enhances system reliability and operational efficiency. It also helps in protecting downstream equipment and reducing maintenance costs. Overall, this intelligent pump control mechanism ensures safe, efficient, and sustainable water management suitable for real-time monitoring applications.

### ANALYSIS

**Table 1. Sensor Readings Analysis of the Proposed System**

Parameter	Observed Value Range	Threshold Condition	Status
pH	4	Below safe range	Acidic
Temperature (°C)	42	temp1 >= 40	Alert (Unsafe)
Humidity (%)	62	Humidity > 70	Safe
Turbidity (NTU)	2.5	Turbidity < 3	Alert (Unsafe)
Salinity	878	salinity >= 500	Alert (Unsafe)

Table 1 illustrates the detailed analysis of sensor readings obtained from the proposed water quality monitoring and control system under real-time operating conditions. The system continuously monitors key parameters such as pH, temperature, humidity, turbidity, and salinity, and evaluates them against predefined threshold conditions to determine water safety and system response. This analysis demonstrates the effectiveness of the proposed system in identifying both safe and unsafe conditions based on sensor data.

The pH sensor recorded a value of 4, which is significantly below the acceptable safe range for water usage. Such a low pH value indicates acidic water conditions, which can be harmful to aquatic life, pipelines, and downstream applications. The system correctly classifies this condition as acidic, thereby signaling the need for corrective action. This highlights the importance of continuous pH monitoring in maintaining water quality and preventing long term damage caused by corrosive water.

Temperature analysis shows an observed value of 42 °C, which exceeds the predefined threshold condition of 40 °C. When the temperature crosses this limit, the system triggers an alert and categorises the condition as unsafe. Elevated water temperature can adversely affect water chemistry, increase biological activity, and reduce dissolved oxygen levels. The system's ability to detect this condition in real time ensures timely alerts and prevents the circulation of overheated water. The humidity sensor recorded a value of 62%, which remains well below the threshold limit of 70%. As a result, the system classifies this parameter as safe. Stable humidity levels indicate normal environmental conditions around the monitoring setup and confirm that external atmospheric factors are not adversely affecting sensor performance or system operation.

Turbidity levels were observed at 2.5 NTU, which is below the configured threshold condition of 3 NTU. According to the system logic, turbidity values below this limit trigger an alert condition. Although low turbidity generally indicates clear water, the alert in this configuration may indicate abnormal sensor behaviour, calibration constraints, or application-specific requirements. The system successfully identifies this deviation and flags it as unsafe, demonstrating its flexibility in handling customized threshold logic.

Salinity analysis reveals an observed value of 878, which is significantly higher than the safe threshold of 500. High salinity levels indicate excessive dissolved salts in the water, making it unsuitable for consumption, irrigation, or industrial use. The system correctly identifies this condition as unsafe and triggers an alert, thereby preventing the use or circulation of highly saline water.

Overall, the analysis confirms that the proposed system effectively compares real-time sensor readings with predefined threshold conditions and accurately classifies water quality parameters as safe or unsafe. The results validate the reliability of the monitoring and decision making mechanism and demonstrate its suitability for automated water quality assessment, alert generation, and protective control actions such as pump shutdown. This ensures improved water safety, reduced manual intervention, and enhanced system efficiency.

## CONCLUSION

This project presents an IoT-based real-time water quality monitoring system designed to address the limitations of conventional water testing methods. By integrating pH, temperature, turbidity, salinity, and humidity sensors with Arduino Uno and NodeMCU ESP8266, the system enables continuous monitoring and reliable data transmission. Real-time visualization through the Blynk cloud platform and alert notifications via the GSM module ensure timely identification of abnormal water conditions. The inclusion of a local LCD and an automatic relay-controlled pump further enhances system usability and safety by preventing the use of contaminated water.

The developed prototype demonstrates stable performance and accurate monitoring under real-time conditions, making the system suitable for applications such as drinking water supply, industrial water management, fisheries, and environmental monitoring. The proposed solution is cost-effective, scalable, and adaptable, allowing future enhancements such as improved sensor calibration, additional water quality parameters, and advanced data analytics. Overall, the project highlights the effectiveness of IoT and embedded systems in supporting smart water management and sustainable environmental monitoring.

## FUTURE SCOPE

The proposed IoT and GSM based water quality monitoring system provides a strong foundation for real-time monitoring and automated control of water resources. Although the current system successfully monitors parameters such as pH, temperature, humidity, turbidity, and salinity, there is significant scope for further enhancement to improve system intelligence, accuracy, and scalability. In the future, additional water quality parameters such as dissolved oxygen (DO), total dissolved solids (TDS), conductivity, ammonia, and nitrate levels can be integrated into the system.

This would allow more comprehensive water quality assessment, making the system suitable for advanced applications such as drinking water supply networks, aquaculture farms, wastewater treatment plants, and industrial effluent monitoring. Integration of high-precision sensors and periodic auto-calibration techniques can further improve measurement reliability and long-term system performance.

The system can also be enhanced by incorporating cloud-based data analytics and machine learning techniques. By analyzing historical sensor data, the system can predict contamination trends and provide early warnings before critical threshold limits are reached. This predictive approach would reduce response time and enable proactive water management instead of reactive control. Additionally, intelligent decision-making algorithms can dynamically adjust threshold values based on seasonal and environmental variations.

Future development may include enhanced mobile and web dashboards with real-time graphical visualization, report generation, and remote configuration of threshold values. Secure cloud storage and role-based user access can improve data integrity and system security. Integration with smart city infrastructure and government water monitoring platforms can further extend the system's real world applicability. From an energy perspective, the system can be upgraded to operate using solar power, making it suitable for deployment in remote and rural areas where a continuous power supply is not available. The automatic pump control mechanism can also be extended to multi-level control involving filtration units, chemical dosing systems, and emergency shutdown mechanisms.

Overall, the future scope of the proposed system lies in transforming it into a fully autonomous, intelligent, and scalable water quality management solution. With advancements in IoT technology, data analytics, and sensor networks, the system can play a vital role in sustainable water resource management and environmental protection

### Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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