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Water Quality Monitoring System

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Abstract

Water contamination is a serious issue that endangers both human health and the environment. Monitoring water quality in real time is crucial to ensuring that people have access to clean and safe drinking water. This project uses internet of things (IoT) technologies to provide a low-cost, straightforward water quality monitoring device. The system measures the temperature, pH, turbidity (cloudiness), and water flow using a variety of sensors. These tests aid in determining whether water is suitable for human consumption. As the core controller, the ESP8266 module is the primary component of the system. Data is gathered from the sensors and processed instantly. This data is transmitted to an internet platform over Wi-Fi so that it may be watched from any location. Because of this real-time access, any changes in the quality of the water are promptly observed, enabling prompt response if problems occur. Through early detection of water pollution, this method contributes significantly to health protection. By maintaining the safety and cleanliness of water supplies, it also contributes to environmental conservation. The system can be utilized in homes, businesses, and farms due to its low cost and simplicity of setup. This water quality monitoring system makes it easier and more effective to assess the safety of the water by utilizing IoT technology. It helps guarantee that everyone has access to safe water and offers precise, up-to-date statistics. This idea provides a clever and workable way to stop water contamination and encourage a more sustainable, healthy future.

Keywords: Water quality monitoring, internet of things (IoT), sensors, microcontroller, wireless communication, data platform, environmental monitor

INTRODUCTION

The depletion of natural water supplies, rising pollution, and climate change have made it more difficult to guarantee access to clean and safe drinking water, even though it is one of the most basic needs for human survival. Technological developments in the twenty-first century have improved people's lives in many ways, but they have also led to major environmental problems including water contamination and global warming [1]. Monitoring water quality has never been more important due to the discharge of pollutants into water bodies caused by industrialization, fast urbanization, and population growth. Water scarcity, major health problems, and environmental harm can result from unclean water if it is not properly monitored and managed. Water contamination is a major issue that poses serious risks to both human health and the environment. Monitoring water quality in real time is essential for ensuring access to safe drinking water. This project aims to address that need by creating a simple and

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affordable water quality monitoring device using internet of things (IoT) technology. The system measures key water quality parameters such as temperature, pH, turbidity (cloudiness), and water flow through various sensors. These measures help determine whether the water is safe for consumption. At the heart of the system is the ESP8266 module, which serves as the controller. The device collects data from the sensors and processes it immediately. The information is then sent to an online platform via Wi-Fi, allowing users to monitor the water quality from anywhere. With real-time access, any changes in water quality can be quickly detected, allowing for a fast response if issues arise.

By detecting water pollution early, this system plays a crucial role in protecting public health. It also helps preserve the environment by ensuring the water supply remains clean. The low cost and easy setup of the system makes it suitable for use in homes, businesses, and farms.

This IoT-based water monitoring solution offers a practical and affordable way to keep track of water safety. It provides accurate, up-to-date information, helping to ensure that everyone has access to clean, safe water. By preventing contamination and promoting sustainability, this project contributes to a healthier future for both people and the planet [2].

Water quality monitoring in real time is one of the biggest problems of our time. Water samples are frequently manually collected from various sites using traditional methods, and they are then tested in labs. Despite producing reliable findings, this method is expensive, time-consuming, and labor-intensive. Furthermore, the fact that it only provides periodic data makes it challenging to identify abrupt changes in the quality of the water. Water quality metrics must be regularly monitored and in real time using sophisticated and automated systems to overcome these obstacles.

pH, turbidity, temperature, and water flow are some of the important factors that are measured to assess the quality of water. Indicating the amount of hydrogen ions present, pH establishes whether the water is alkaline, neutral, or acidic. While drinking water should ideally have a pH of 6.5 to 8.5, pure water has a pH of 7. Turbidity is a measure of how cloudy water is due to suspended particles; increased turbidity frequently denotes pollution and raises the risk of cholera and other waterborne illnesses. The chemistry of the water and the existence of microorganisms can be impacted by temperature sensors, which measure how hot or cold the water is. Flow sensors monitor the flow of water via distribution networks and pipes, assisting in the effective management of water consumption [3].

The use of IoT technology is intended to provide an economical and effective water quality monitoring system. The ESP8266 module serves as the system's primary controller and includes several sensors to measure the physical and chemical characteristics of the water. The gathered information is analyzed and sent over Wi-Fi, allowing it to be accessed from anywhere on an internet platform. Immediate identification of water quality problems is made possible by these real-time monitoring capabilities, which facilitate quicker reaction times and improved water resource management. This technology supports initiatives to maintain a sustainable and safe water supply, eventually promoting environmental and public health protection through constant, precise, and remote monitoring.

SYSTEM ARCHITECTURE

The proposed water quality monitoring system consists of four main components: sensors, microcontroller, wireless communication module, and data platform.

Block Diagram

Block diagram of the proposed system (Figure 1).

Flowchart

Work flowchart is shown in Figure 2.

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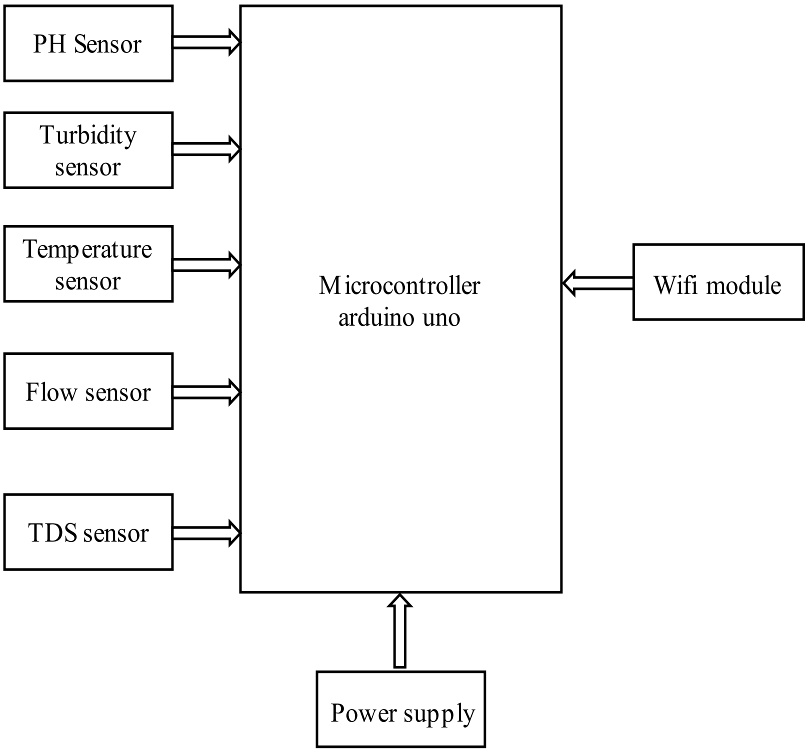

Figure 1. The block diagram of the proposed system.

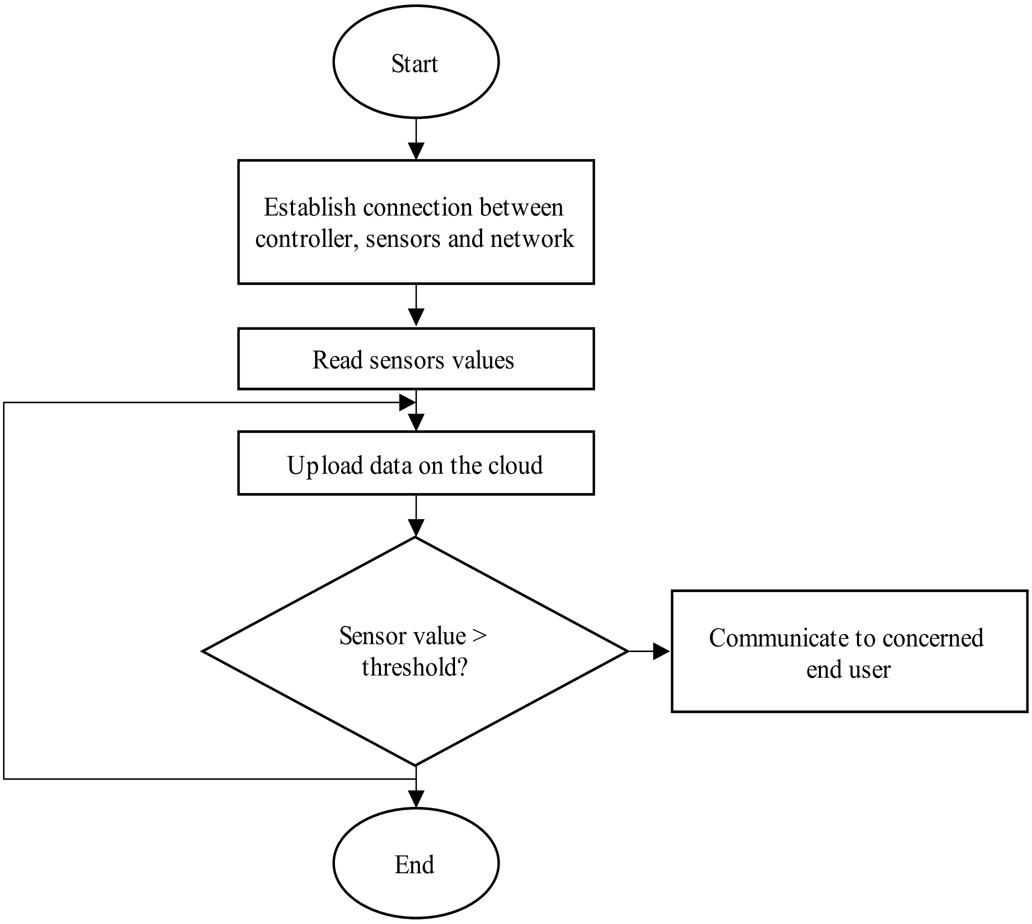

Figure 2. Flowchart of the proposed system.

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Sensors

1. *Temperature Sensor:* Measures the temperature of water, providing insights into thermal pollution and habitat suitability.
2. *Sensors for Data Collection:* The system uses various sensors to measure crucial water quality parameters like temperature, pH, turbidity (cloudiness), and water flow. These sensors are placed in the water to collect real-time data, which provides valuable information about water quality.
3. *Turbidity Sensor:* Determines the clarity of water by measuring the number of suspended particles, indicating sedimentation, erosion, or organic matter levels.
4. *Microcontroller (ESP8266):* The ESP8266 module acts as the central controller of the system. It gathers the data from the sensors, processes it, and ensures that the information is ready for transmission. The ESP8266 is chosen for its low cost and Wi-Fi connectivity, allowing easy integration into the system.
5. *pH Sensor:* Measures the acidity or alkalinity of water, influencing chemical reactions and biological processes.
6. *Data Processing:* Once the data is collected, the ESP8266 processes it locally. The system may also perform basic checks or calculations to ensure the data is accurate and reliable before sending it to the cloud platform.
7. *Cloud Platform:* The processed data is transmitted wirelessly to a cloud-based platform via Wi-Fi. This platform stores and displays data, allowing users to access it from anywhere via a web interface or mobile app. The cloud platform ensures that the data is always available for remote monitoring.
8. *Real-Time Monitoring:* The cloud platform provides real-time monitoring, so users can check the water quality anytime. Alerts can be set up to notify users if any of the parameters fall outside safe limits, allowing for immediate action.
9. *Power Supply:* The system is designed to be energy-efficient, ensuring that it can run continuously. Power management is important for the device, especially in remote areas where access to electricity might be limited.
10. *Total Dissolved Solids Sensor:* Estimates the concentration of total dissolved solids (TDS) in water, including salts, minerals, and organic compounds.
11. *User Interface:* The data visualization on the platform is user-friendly, providing clear, easy-to-read graphs and notifications that help users understand the water quality status at a glance.

Microcontroller

An Arduino or ESP8266 microcontroller is utilized to interface with the sensors, acquire data, and perform initial processing tasks. The microcontroller in this water quality monitoring system is a vital component that ensures the device operates smoothly. For this project, the ESP8266 module is chosen as the central controller. This microcontroller is compact, cost-effective, and comes with built-in Wi-Fi, which makes it ideal for IoT applications like this one [4].

ESP8266's primary role is to gather data from the sensors that measure water quality parameters such as temperature, pH, turbidity (cloudiness), and flow rate. Once the sensors capture this data, the microcontroller processes it to ensure its accuracy and prepares it for transmission.

A key feature of the ESP8266 is its Wi-Fi connectivity, which allows the system to send the collected data to the cloud over the internet. This ensures that users can monitor the water quality remotely and in real-time, making it more convenient to keep track of the water's status from anywhere.

In addition to collecting and transmitting data, the ESP8266 handles other essential functions, such as error checking, managing power consumption, and maintaining a stable connection to the cloud platform. It ensures the device operates efficiently and can adapt to any interruptions in power or Wi-Fi connection. For instance, if the Wi-Fi connection is temporarily lost, the microcontroller can try reconnecting or notify the user of the issue.

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Another advantage of the ESP8266 is its energy efficiency. This is especially important when the device is used in remote areas with limited access to power sources. It consumes minimal energy, allowing continuous operation without draining resources.

Overall, the ESP8266 microcontroller serves as the heart of the system, controlling data collection, communication, and power management, ensuring reliable and efficient water quality monitoring.

Wireless Communication Module

An ESP8266 or similar Wi-Fi module enables wireless connectivity, allowing data transmission to a remote server or cloud platform. The wireless communication module is a key component of the water quality monitoring system, enabling it to send collected data over the internet. For this project, the ESP8266 module is used as the primary communication interface, offering reliable and efficient wireless connectivity.

The ESP8266 is an affordable, small-sized Wi-Fi module that can easily connect devices to wireless networks. It is well-suited for IoT applications like this water quality monitoring system due to its ability to integrate with low-cost, wireless solutions. The module allows the system to transfer real-time data from sensors (measuring parameters like water temperature, pH, turbidity, and flow rate) to a cloud-based platform, providing users with remote access to water quality information.

Wireless communication is essential for this system as it removes the need for physical connections, making it flexible and easy to deploy in various locations. The ESP8266 connects to the internet via Wi-Fi, ensuring that the device can operate without complex wiring or expensive infrastructure. This makes it ideal for installations in remote or hard-to-reach areas, where running cables would be difficult or costly.

With Wi-Fi connectivity, the module facilitates the immediate transfer of data, ensuring that water quality can be monitored in real time. This is particularly important for detecting sudden changes in water conditions, such as increased turbidity or pH variations, which might indicate contamination. The system can trigger notifications or alerts for users, enabling quick action if needed.

Moreover, the ESP8266 is energy-efficient, which is beneficial for battery-powered systems or installations in areas with limited access to power. Overall, the wireless communication module plays a vital role in enhancing the system's effectiveness, ease of use, and versatility.

Data Platform

Data collected from the sensors are sent to a cloud-based platform, such as Quiberon, for storage, analysis, and visualization. Users can access the platform via web or mobile applications to view real-time water quality data and generate reports.

COMPONENTS USED

pH Sensor

The pH of a solution is the measure of the acidity or alkalinity of that solution. The pH scale is a logarithmic scale whose range is from 0-14 with a neutral point being 7. Values above 7 indicate a basic or alkaline solution and values below 7 would indicate an acidic solution. It operates on 5V power supply, and it is easy to interface with Arduino. The normal range of pH for water is 6 to 8.5 from Figure 3.

Turbidity Sensor

Turbidity sensor (Figure 4) is a measure of the cloudiness of water. Turbidity has indicated the degree at. which the water loses its transparency. It is considered a good measure of the quality of water. Turbidity blocks out the light needed by submerged aquatic vegetation. It also can raise surface water temperatures above normal because suspended particles near the surface facilitate the absorption of heat from sunlight [5].

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Parameter	Value/Range
Operating voltage	3.3 V/5 V DC
Output interface	Analog/digital
Connector	1 Grove/ 1 power interface
Size	20 × 40 mm
Cost	INR 2000/-

Figure 3. pH sensor.

Weight	54 g
Battery	Excluded
Operating voltage	3.0–5.5 V
Chip	DS18B20
Length	2 m
Operating temperature	–55°C to +125°C
Cost	INR 500/-

Figure 4. Turbidity sensor.

Items	Values
Operating voltage	3.3 V/5 V
Range	0–14 pH
Resolution	0.15 pH (STD)
Response time	<1 min
Probe interface	BNC
Measure resistance	0-60°C
Internal resistance	<250 Mohm (25°C)
Alkali error	0.2 pH (1 mol/L) Na^+ pH 14 (25°C)
Cost	INR 2500/-

Figure 5. Temperature sensor.

Temperature Sensor

Water temperature indicates whether the water is hot or cold. The range of DS18B20 temperature sensor (Figure 5) is –55°C to +125°C [6]. This temperature sensor is a digital type which gives accurate reading.

Total Dissolved Solids Sensor

This sensor detects the TDS (Figure 6) levels in the water which can be used to indicate the water quality [7].

Implementation

The system is implemented using off-the-shelf components and open-source software libraries [8]. Sensors are connected to the microcontroller via analog or digital interfaces, depending on their specifications. Data acquisition and processing are performed within the microcontroller, which then transmits the data to the cloud platform using Wi-Fi connectivity.

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Observation Table

Water quality parameter on different samples of drinking water are presented in Tables 1 and 2.

Figure 6. Total dissolved solids (TDS) sensor.

Parameter	Value
Input voltage	3.3 V/5 V
Output voltage	0–2.3 V
Working current	3–6 mA
TDS measurement range	0–1000 ppm
Connection interface	Grove 4-pin/XHB 2.54mm 2p
Interface	Analog
Cable length	60 cm
Connection interface	XHB 2.54mm 2p
Cost	INR 1200/-

Table 1. Water quality parameter range for drinking water.

Parameter	Range
pH	6.5 to 8.5
Turbidity	<5 NTU
Conductivity, carbon dioxide, humidity	200 to 800 µS/cm
Carbon dioxide	<2.0 mg/L
Humidity	40% to 100%

Table 2. Water quality parameters for different samples.

Sample	Parameter	Measured Value
Water sample 1	pH	7.5
	Turbidity	4 NTU
	Conductivity	450 µS/cm
	Carbon dioxide	1.20 mg/L
	Humidity	42%
	Temperature	20°C
Water sample 2	pH	9.3
	Turbidity	5.6 NTU
	Conductivity	600 µS/cm
	Carbon dioxide	1.820 mg/L
	Humidity	60.44%
	Temperature	29.4°C
Water sample 3	pH	9.72
	Turbidity	5.33 NTU
	Conductivity	709 µS/cm
	Carbon dioxide	1.89 mg/L
	Humidity	64.67%
	Temperature	26.4°C

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Evaluation

The performance of the water quality monitoring system is evaluated in terms of accuracy, reliability, and scalability. Calibration procedures are conducted for each sensor to ensure accurate measurement of water parameters. Field tests were carried out in various water bodies, including rivers, lakes, and reservoirs, to validate the system's effectiveness under real-world conditions. The system's scalability was assessed by deploying multiple sensor nodes across different locations to monitor water quality on a larger scale.

Applications

The IoT-based water quality monitoring system has diverse applications in environmental monitoring, water resource management, and disaster prevention. It can be deployed in urban and rural areas, industrial sites, agricultural fields, and aquaculture facilities to monitor water quality in real-time and detect anomalies or pollution events promptly [9, 10]. Additionally, the data collected by the system can be used for scientific research, policy-making, and public awareness campaigns regarding water conservation and pollution control.

CONCLUSION AND FUTURE WORK

The development of an IoT-based water quality monitoring system represents a significant step towards addressing the challenges of water pollution and resource management. The system provides a cost-effective, scalable solution for continuous monitoring of key water parameters, enabling timely interventions and informed decision-making. Future work includes the integration of additional sensors for monitoring parameters such as dissolved oxygen, conductivity, and heavy metals, as well as the development of predictive analytics models for early warning systems.

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