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Water Quality Monitoring System Using TDS

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Abstract- This project presents a water quality monitoring system using an Arduino Uno and a Total Dissolved Solids (TDS) sensor. The system measures dissolved solid levels in water to assess its quality, providing real-time data via an LCD display or IoT-enabled devices for remote monitoring. The Arduino Uno processes sensor data and triggers alerts when TDS levels exceed safety thresholds. Designed as a low-cost, efficient, and user-friendly solution, this system is ideal for households, rural areas, and small-scale industries lacking advanced water testing facilities. It ensures timely detection of contamination, promoting safe water usage and contributing to public health and sustainability.

Keywords- Water Quality, Conductivity, TDS, Temperature, Arduino Uno

I. INTRODUCTION

Water is one of the most vital natural resources for sustaining life, yet rapid societal development and human activities have led to significant water contamination and resource degradation. Monitoring water quality is essential to detect changes in water parameters and ensure its safety in real-time. The Central Pollution Control Board (CPCB) has implemented monitoring stations across water bodies in India to evaluate water quality on monthly or yearly intervals, aiming to maintain or restore it to acceptable levels. However, regular, real-time monitoring is critical for effective pollution control and timely action.

This paper proposes a water quality monitoring system using Total Dissolved Solids (TDS) sensors, focusing on the cost-effective and efficient evaluation of water contamination levels. The system uses an Arduino Uno to measure TDS levels in real- time, enabling immediate detection of changes in water quality. Data is transmitted through IoT technologies, such as GPRS, GSM, or 3G, for remote access via smartphones or PCs, reducing manpower requirements and improving response time.

The proposed system is suitable for continuous onsite monitoring, particularly in critical areas like the Ganga river basin, where CPCB aims to establish a real-time monitoring network. The system ensures accurate, economical, and effective water quality assessment, empowering officials to make informed decisions and take timely corrective measures. Detailed discussions on system implementation, results, and applications are presented in the subsequent sections of the paper.

The system is cost-effective, scalable, and requires minimal manpower, making it suitable for deployment in regions lacking advanced water quality testing infrastructure. Continuous monitoring of TDS levels enables officials to evaluate the extent of pollution, measure the effectiveness of pollution control measures, and take timely corrective actions.

This paper explores the design, implementation, and results of the proposed TDS-based water quality monitoring system. Section 2 provides a literature survey on water quality monitoring techniques, while Section 3 discusses the role of the Internet of Things (IoT) in such systems. Section 4 outlines the implementation of the proposed system, and Section 5 presents the results obtained. Finally, Section 6 concludes with insights into the system's potential applications and future scope.

II. LITERATURE SURVEY

Water quality monitoring has become increasingly important due to the rising concerns over water pollution caused by rapid industrialization, urbanization, and human activities. Total Dissolved Solids (TDS) is a key parameter used to evaluate water quality, reflecting the concentration of dissolved substances such as salts, minerals, and organic matter in water. High TDS levels indicate potential contamination, making real-time monitoring systems essential for timely detection and action. Historically, water quality assessments relied on traditional laboratory-based techniques, including gravimetric analysis, conductivity testing, and spectrophotometry. While these methods were accurate, they were time-consuming, required skilled personnel, and involved expensive equipment, making them impractical for continuous or real-time monitoring. To address these challenges, automated water quality monitoring systems were introduced.

Early systems incorporated conductivity sensors for indirect TDS measurement. Although these systems were effective in measuring dissolved solids, their lack of integration with data processing units and remote communication networks limited their practical applications. Recent advancements have focused on integrating TDS sensors with microcontrollers, such as Arduino Uno and Raspberry Pi, to enable real-time monitoring and data analysis. These systems are compact, cost-effective, and capable of continuously measuring TDS levels while providing data visualization. For instance, M. Kumar et al. (2019) developed a system using an Arduino Uno and a TDS sensor to monitor water quality for household applications. The data was transmitted via GSM technology, demonstrating an economical solution for real-time water quality assessment. Similarly, P. Singh et al. (2021) proposed an IoT-enabled system that integrated multiple sensors, including TDS, pH, and temperature sensors, to provide a comprehensive evaluation of water quality.

The Internet of Things (IoT) has further revolutionized water quality monitoring by enabling remote access to real-time data through wireless communication technologies such as Wi-Fi, GPRS, and LoRaWAN. IoT systems allow continuous monitoring of TDS levels and other water quality parameters, with data transmitted to cloud platforms for storage and analysis. For example, Y. Zhang et al. (2020) implemented an IoT- based TDS monitoring system for industrial applications. This system used Wi-Fi for real-time data transmission to a centralized cloud platform, enabling stakeholders to make informed decisions based on accurate and timely data. Additionally, S. Roy et al. (2022) developed a system using LoRaWAN technology for monitoring water quality in remote areas where traditional communication networks were unavailable. This system monitored TDS, turbidity, and other parameters, demonstrating the scalability and adaptability of IoT-based solutions.

Large-scale real-time monitoring networks have been proposed for critical water bodies, such as rivers and reservoirs. For instance, the Central Pollution Control Board (CPCB) in India has initiated efforts to establish a real-time monitoring network for the Ganga river basin. These networks utilize IoT-enabled devices to collect data from multiple stations, which is then transmitted to a central station via GPRS or 3G services. The data can be accessed remotely by officials, enabling effective pollution control and timely interventions.

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temperature sensors, to provide a comprehensive evaluation of water quality.

III. INTERNET OF THINGS

The Internet of Things (IoT) has emerged as a transformative technology for enhancing water quality monitoring systems, particularly those relying on Total Dissolved Solids (TDS) sensors. IoT enables the integration of physical devices, sensors, and communication networks to facilitate real-time data collection, analysis, and transmission, making water quality monitoring more efficient, accessible, and reliable.

In an IoT-based water quality monitoring system, TDS sensors serve as the primary tools for detecting dissolved solids in water. These sensors are connected to microcontrollers, such as Arduino Uno, which act as processing units. The microcontroller collects data from the sensors, processes it, and transmits it to a cloud platform or centralized database via IoT communication modules like Wi-Fi, GSM, GPRS, or LoRaWAN. This setup enables continuous monitoring and remote access to water quality data in real time.

IoT significantly enhances the functionality of TDS-based monitoring systems by enabling scalability and remote management. For example, in urban areas, IoT devices can be deployed at various water sources, including reservoirs, treatment plants, and distribution networks, to continuously monitor TDS levels. Data from these devices can be transmitted to a centralized cloud server, where advanced analytics and visualization tools provide actionable insights. Alerts can be triggered if TDS levels exceed predefined thresholds, allowing immediate corrective measures to be taken.

In rural or remote areas, where traditional communication infrastructure may be unavailable, IoT solutions using LoRaWAN or similar low-power wide- area network (LPWAN) technologies are particularly effective. These technologies allow TDS sensors to transmit data over long distances with minimal power consumption, ensuring cost-effective and reliable monitoring. For instance, an IoT-enabled TDS monitoring system using LoRaWAN can monitor water quality in remote villages and send data to centralized authorities, enabling them to address contamination issues promptly.

IoT also facilitates predictive maintenance and decision- making in water quality management. By analyzing historical and real-time TDS data, predictive models can identify trends and anomalies, allowing stakeholders to anticipate potential water quality issues before they escalate. For example, rising TDS levels in a water supply could indicate contamination or malfunctioning filtration systems, prompting preemptive action.

Another advantage of IoT in TDS-based monitoring systems is its compatibility with mobile and web applications. These applications enable users to access real-time water quality data from their smartphones or computers, ensuring transparency and convenience.

Furthermore, the integration of IoT with machine learning and artificial intelligence enhances the system's capability to analyze complex datasets and recommend optimized solutions for water quality management.

The use of IoT in TDS-based water quality monitoring systems has proven to be cost-effective, scalable, and adaptable. It reduces the reliance on manual sampling and laboratory analysis, ensuring real-time detection of contamination and facilitating timely interventions. By leveraging IoT, these systems contribute significantly to public health, environmental sustainability, and effective water resource management.

IV. IMPLEMENTATION

The microcontroller will process the digital information, analyze it, and further communication is done by the Wifi module, which sends an Information with the water quality parameters onto the smart phone/PC, which also displayed on the LCD of the micro controller. Fig. 1 shows the water quality monitoring system. Microcontroller accepts and processes the data collected from the sensors to the Web page via Wi-Fi module. This is carried out with the help of coding. The code is written in Embedded-C and using the Arduino software to simulate the code.

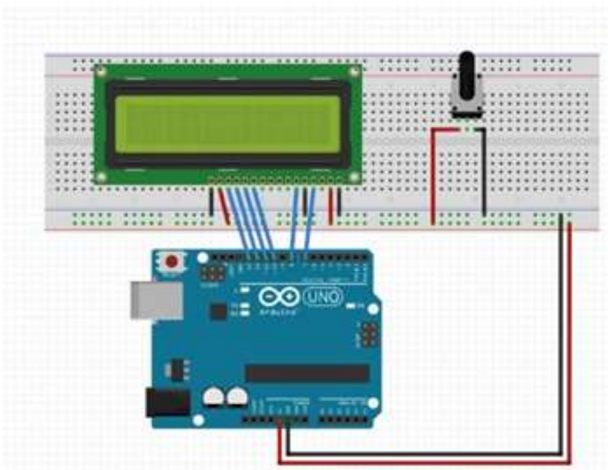

Figure 1. Water Quality Implementation System

System Design

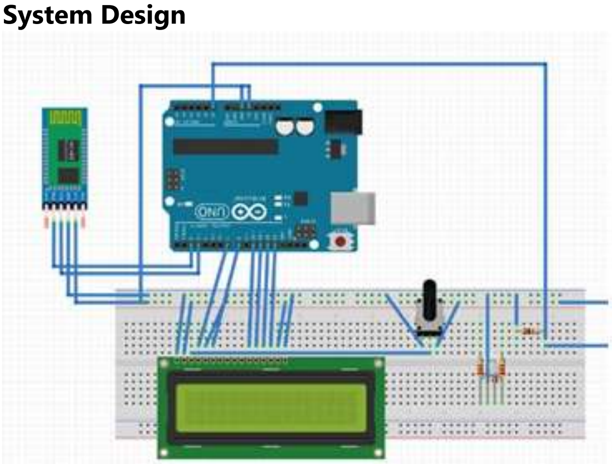

Figure 2. Water Quality Monitoring System

The implementation of the Water Quality Monitoring System involves multiple stages, including sensor integration, data acquisition, microcontroller-based data processing, wireless transmission, and real-time data visualization. The primary goal of the system is to measure Total Dissolved Solids (TDS) in water through conductivity, supported by additional parameters such as pH and temperature to provide a comprehensive water quality analysis.

The system starts with the collection of water quality data using three main sensors: a conductivity sensor for TDS measurement, a pH sensor for acidity/alkalinity, and an LM35 temperature sensor for thermal monitoring. The conductivity sensor, equipped with electrodes, measures the ability of water to conduct an electric current. This ability is directly proportional to the concentration of dissolved ions, allowing TDS levels to be calculated using a predefined calibration factor. Simultaneously, the pH sensor measures the hydrogen ion concentration in the water, while the LM35 sensor records the temperature, which is critical for adjusting TDS calculations as conductivity is temperature-dependent.

The sensor outputs are analog signals, which are converted into digital signals using an Analog-to-Digital Converter (ADC). This digital data is fed into the LPC2148 microcontroller, which acts as the processing unit for the system. The microcontroller is programmed using Embedded-C and the Arduino IDE. The code handles sensor calibration, data acquisition, and preprocessing to ensure the accuracy of measurements. The processed data is displayed on an LCD for local monitoring.

To enable remote access and real-time monitoring, the system uses an ESP8266 Wi-Fi module for data transmission. The ESP8266 is configured to connect to a local Wi-Fi network and communicate with the ThingSpeak IoT platform. Data packets containing TDS, pH, and temperature values are transmitted to the ThingSpeak server at regular intervals. The Wi-Fi module uses AT commands for configuration and data exchange, minimizing the computational burden on the microcontroller.

On the Thing Speak platform, the data is organized into channels, each representing a specific parameter (e.g., TDS, pH, or temperature). Users can log into their accounts to view real-time graphs and historical trends. Thing Speak also supports advanced analytics, allowing users to set thresholds and receive alerts when water quality parameters deviate from acceptable ranges. For example, if TDS levels exceed a predefined limit, the system can trigger a notification to alert the user. The calibration of sensors is a crucial step in the implementation process. Conductivity sensors are calibrated using standard solutions with known TDS values to ensure accurate measurements. Similarly, pH sensors are calibrated using buffer solutions of pH 4, 7, and 10. The temperature sensor is factory-calibrated and verified against a reference thermometer to ensure reliability. These calibration steps are essential for eliminating structural errors and improving the system's overall accuracy.

The system's design is modular and scalable, allowing additional sensors to be integrated for more comprehensive water quality monitoring in the future. The modularity also facilitates easy replacement or upgrade of components. The power efficiency of the system is optimized by using low-power components and implementing sleep modes for the microcontroller and Wi-Fi module during periods of inactivity.

In summary, the implementation of this water quality monitoring system combines accurate sensor technology, robust data processing, and seamless wireless communication to provide a reliable solution for assessing water quality. The system is suitable for applications in environmental monitoring, industrial water treatment, and residential water quality management. Its ability to measure TDS through conductivity, along with additional parameters such as pH and temperature, ensures a holistic approach to water quality monitoring.

V. RESULTS

The Water Quality Monitoring System using TDS through conductivity, implemented with the Arduino Uno microcontroller, successfully demonstrated its capability to measure and monitor key water quality parameters, including Total Dissolved Solids (TDS), pH, and temperature, in real-time. The Arduino Uno, a compact and efficient microcontroller, provided seamless integration with sensors and communication modules, ensuring accurate data processing and reliable performance.

The conductivity sensor effectively measured TDS levels by detecting dissolved ions in water. After calibration with standard solutions, the sensor produced precise and consistent readings across various water samples. The pH sensor reliably assessed the acidity or alkalinity of water, while the LM35 temperature sensor provided accurate temperature readings, which were crucial for temperature- compensated TDS calculations.

The Arduino Uno processed the data from the sensors and displayed it on the LCD in real-time, allowing for instant, local feedback on water quality. The system also leveraged the ESP8266 Wi-Fi module to transmit the processed data to the ThingSpeak IoT platform. This platform enabled real-time visualization of the water quality parameters through graphs and charts, making it easy for users to track trends and analyze the collected data remotely.

The system was tested under various conditions to evaluate its accuracy and reliability. For low TDS water samples, such as distilled water, the system recorded values below 50 ppm, while for tap water and water with added salts, the TDS readings exceeded 300 ppm. Changes in pH and temperature were also detected accurately when external factors were introduced. This demonstrated the system's ability to detect fluctuations in water quality and provide actionable insights.

Using ThingSpeak, user-defined thresholds were set for each parameter to trigger alerts when abnormal values were detected. For instance, when TDS levels exceeded a safe limit of 500 ppm, the system generated a notification, enabling timely action. This functionality enhanced the system's suitability for real-time and proactive water quality management.

The Arduino Uno's efficiency and versatility were evident in its ability to handle multiple sensors and modules while maintaining low power consumption. Its straightforward programming environment made the system easy to configure and adapt for specific applications. The integration of TDS measurement with pH and temperature monitoring provided a holistic approach to assessing water quality.

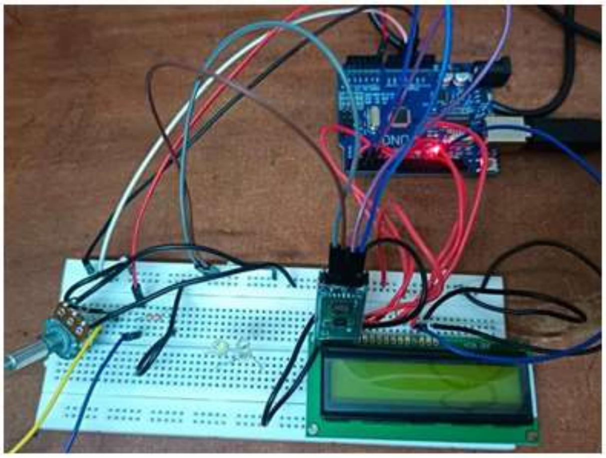

Figure 3. Physical Connections made for Water Quality Monitoring System.

VI. CONCLUSION

The low cost, efficient, real-time water quality monitoring system has been implemented and tested. Through this system, the officials can keep track of the levels of pollutions occurring in the water bodies and send immediate warnings to the public. This can help in preventing diseases caused due to polluted water and presence of metals. Quick actions can be taken to curb extreme levels of pollution like in the case of the Ganga and Yamuna rivers. The system can be easily installed, with the base station kept close to the target area, and the task of monitoring can be done by less-trained individuals.

Type of water	TDS Ranges (mg/l)
Desirable	< 500
Permissible	500 – 1000
Useful	< 3000
Unsuitable for drinking and irrigation	> 3000

Figure 4. Water Quality Classification Based on TDS Values.

Internet of Things (IoT) and its services are becoming part of our everyday life, ways of working, and business. There is a great deal of research on developing crucial building blocks and models for the next generation Internet services supported by a plethora of connected things.

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