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IoT based Multi-Parameter Water Quality Monitoring System Development

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***Abstract*— Water quality monitoring is essential for ensuring the safety and suitability of water for domestic, agricultural, and industrial applications. Traditional methods of water quality assessment are time-consuming and require manual sampling and laboratory analysis. To overcome these limitations, an IoT-Based Multi-Parameter Water Quality Monitoring System has been proposed for real-time monitoring of important water quality parameters. The main objective of this project is to continuously monitor water quality by measuring parameters such as pH, Total Dissolved Solids (TDS), turbidity, temperature, and humidity. The system utilizes an ESP32 microcontroller along with a pH meter, TDS sensor, turbidity sensor, and DHT11 sensor to collect data from the environment. The acquired sensor readings are processed by the ESP32 and displayed on an LCD screen for local monitoring. The measured data is also transmitted to the Blynk IoT platform through Wi-Fi, enabling remote monitoring and analysis. The developed system provides real-time measurement and display of water quality parameters, allowing users to assess water conditions efficiently. The integration of IoT technology enables continuous monitoring and remote accessibility, reducing the need for frequent manual testing. The system can be applied in households, agricultural fields, laboratories, and small-scale water treatment facilities for effective water quality assessment. Future enhancements of the system include the integration of additional water quality sensors, cloud-based data storage, mobile alert notifications, and AI-based prediction techniques for advanced water quality analysis. These improvements can enhance the efficiency and reliability of the monitoring system and support smart water resource management.**

***Index Terms*— Internet of Things (IoT), ESP32, Water Quality Monitoring, TDS Sensor, Blynk IoT Platform.**

I. INTRODUCTION

Water is an essential resource for human life, and access to safe drinking water is necessary for maintaining good health. Although various water filtration methods are available, it is important to evaluate the quality of water after filtration to ensure that the water is suitable for consumption. Parameters such as pH, turbidity, Total Dissolved Solids (TDS), and temperature provide valuable information about the condition and quality of water.

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Conventional methods of water quality testing often require laboratory equipment and manual analysis, which may not be convenient for routine monitoring. With the advancement of sensor technology and the Internet of Things (IoT), it is possible to measure important water quality parameters quickly and efficiently using electronic sensors and microcontrollers. The IoT-Based Multi-Parameter Water Quality Monitoring System is developed to monitor the quality of water obtained after filtration through a NirNal water filter. The system uses multiple sensors to measure key water quality parameters and displays the collected data through an IoT platform. This enables users to observe and analyze the condition of the filtered water in a simple and systematic manner. The main objective of this project is to monitor and evaluate the quality of filtered water using sensor-based measurements. By integrating water quality sensors with IoT technology, the system provides a practical method for observing important water parameters and assessing the effectiveness of the filtration process [1].

II. Problem Statement

Water filtration systems improve water quality, but users often have limited information about the quality of water after filtration. Traditional water quality testing methods require manual sampling and laboratory analysis, which can be time-consuming and inconvenient. Therefore, there is a need for a simple system that can measure and monitor important water quality parameters such as pH, turbidity, TDS, and temperature of filtered water using IoT technology [2].

III. Objectives and Scopes with Significance of the Project

- To measure important water quality parameters such as pH, turbidity, TDS, and temperature of filtered water using sensors.
- To develop an IoT-based system for collecting and displaying water quality data.
- To evaluate the quality of water after filtration by analyzing the measured parameters.

The scope of this project is limited to monitoring the quality of filtered water using an IoT-based system. The system measures key water quality parameters such as pH, turbidity, TDS, and temperature through sensors and displays the collected data for analysis. The project focuses on evaluating the quality of water after filtration and does not include advanced water treatment, laboratory testing, or continuous monitoring of natural water sources. This project significance helps in assessing the quality of filtered water by measuring important parameters such as pH, turbidity, TDS, and temperature. The IoT-based monitoring system provides a simple and efficient method for obtaining water quality data, reducing the need for frequent manual testing. It enables users to better understand the condition of filtered water and supports informed decisions regarding its suitability for use and consumption. The proposed system is expected to provide an effective method for monitoring the quality of filtered water using multiple sensors and IoT technology. The system will enable the measurement and display of important water quality parameters such as pH, TDS, and turbidity, along with ambient temperature and humidity. The collected data will help users assess the condition of filtered water and demonstrate the application of IoT in water quality monitoring [3].

IV. Technologies Used

The major materials and technologies used in this project include - Materials Used - Nir Nal Water Filter, ESP32 Microcontroller, pH Meter, TDS Sensor, Turbidity Sensor, DHT 11 Sensor, Jumper Wires, Breadboard, Power Supply & Software used - Arduino IDE, Blynk IoT Platform, ESP32 Libraries, Wireless Communication (Wi-Fi) [4]

V. Literature Survey

A no. of authors proposed an Internet of Things enabled real-time water quality monitoring system for observing and analyzing water quality parameters continuously. The system mainly focuses on reducing the dependency on manual water testing by using sensors, communication modules, and cloud connectivity for remote data access. The major advantage of this work is that it enables continuous and real-time monitoring of water quality parameters, thereby supporting quick identification of changes in water condition. It also provides a low-cost and easy-to-implement solution for water resource management, especially in locations where frequent manual testing is difficult. The use of cloud-based monitoring improves accessibility and allows users to observe water quality data from remote locations. However, the system has certain limitations, as its performance strongly depends on stable internet connectivity and uninterrupted cloud services. The number of monitored water quality parameters is limited, and the accuracy of sensors may degrade over time due to calibration issues. Moreover, the system does not include advanced data analytics, machine learning based prediction, or intelligent decision-making features. Regular maintenance of sensors and communication modules is also required for reliable long-term operation [5].

VI. System Design and Methodology - Architecture

The proposed IoT-Based Multi-Parameter Water Quality Monitoring System is designed to monitor various water quality parameters in real time. The system utilizes an ESP32 microcontroller as the central processing unit and integrates a pH meter, TDS sensor, turbidity sensor, DHT11 sensor, LCD display, and Blynk IoT platform. Initially, water is passed through the NIRNAL filter to remove impurities and improve its quality. The filtered water is then analyzed using a pH meter, TDS sensor, and turbidity sensor. The pH meter measures the acidity or alkalinity of water, while the TDS sensor determines the concentration of dissolved solids. The turbidity sensor measures the cloudiness of water caused by suspended particles. The DHT11 sensor measures ambient temperature and humidity. The ESP32 collects readings from the TDS sensor, turbidity sensor, and DHT11 sensor and processes the data. The measured values are displayed locally on the LCD display and simultaneously transmitted to the Blynk cloud platform using Wi-Fi. The pH value obtained from the pH meter is used along with the sensor readings to assess overall water quality. The proposed system provides continuous monitoring, remote accessibility, and real-time observation of water quality parameters, making it suitable for domestic and industrial water monitoring applications [6].

VII. Block Diagram

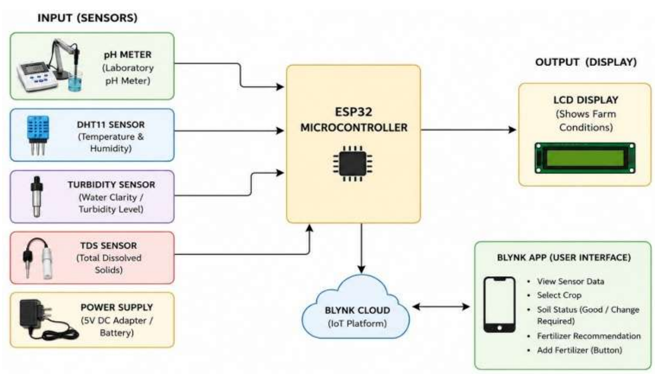

Fig. 1: Block Diagram

The block diagram as shown in the Fig. 1 illustrates the overall operation of the proposed IoT-based water quality monitoring system. The input section consists of the pH sensor, TDS sensor, turbidity sensor, and DHT11 sensor. These sensors continuously monitor various water quality parameters and environmental conditions. The ESP32 microcontroller acts as the central controller of the system. It receives data from all sensors, processes the information, and determines the quality status of the water based on predefined threshold values. The processed data is displayed on an LCD display for immediate observation. Additionally, the ESP32 transmits the collected data to the Blynk Cloud platform through Wi-Fi communication. The Blynk mobile application allows users to remotely monitor sensor readings from anywhere using a smartphone. The power supply unit provides the necessary operating voltage to the ESP32 and sensors. The combination of sensor monitoring, local display, and cloud connectivity makes the system suitable for smart water quality management applications [7].

VIII. Hardware and Software Details

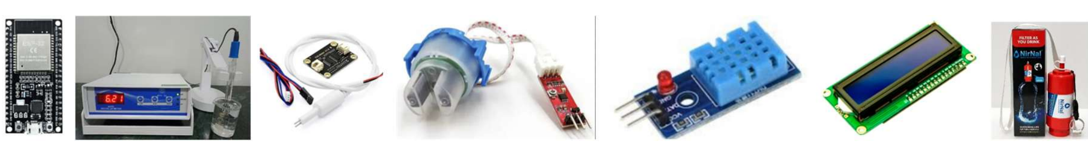

Fig. 2: ESP 32 Microcontroller / Ph Meter / TDS Sensor / Turbidity Sensor / DHT 11 Sensor / LCD Display / Nir Nal Filter Photo

Hardware & software details are shown in the Fig. 2 & 3 respectively. The ESP32 is a powerful microcontroller equipped with built-in Wi-Fi and Bluetooth capabilities. It serves as the main controller of the system and is responsible for collecting sensor data, processing readings, and transmitting information to the cloud platform. The pH meter is an electronic instrument used to measure the acidity or alkalinity of water. The pH scale ranges from 0 to 14, where a value of 7 indicates neutral water. The Total Dissolved Solids (TDS) sensor measures the concentration of dissolved substances present in water. Higher TDS values indicate greater amounts of dissolved minerals and salts. The turbidity sensor measures the cloudiness or haziness of water caused by suspended particles. The DHT11 is a low-cost digital sensor used to measure ambient temperature and relative humidity [8]. It is widely used in IoT and embedded system applications due to its simple interface and reliable performance. The sensor provides digital output data, making it easy to connect with microcontrollers such as the ESP32. The LCD display is used to display sensor readings locally. The NirNal Water Filter is a portable, non-electric water filtration device designed to improve the quality of drinking water. It uses a multi-stage filtration mechanism to reduce suspended particles, improve water clarity, and help remove harmful contaminants. Due to its compact size, lightweight design, and ease of use, the filter is suitable for household use, travel, outdoor activities, and emergency situations. In this project, the NirNal Water Filter is used to obtain filtered water samples for quality monitoring and analysis using IoT-based sensors. Blynk is an IoT platform used for remote monitoring and visualization of sensor data. Arduino IDE is used for developing, compiling, and uploading programs to the ESP32 microcontroller [9].

Fig. 3: Blynk Cloud Platform / Arduino IDE / results before & after filtration

IX. Circuit Diagram and Flow Chart

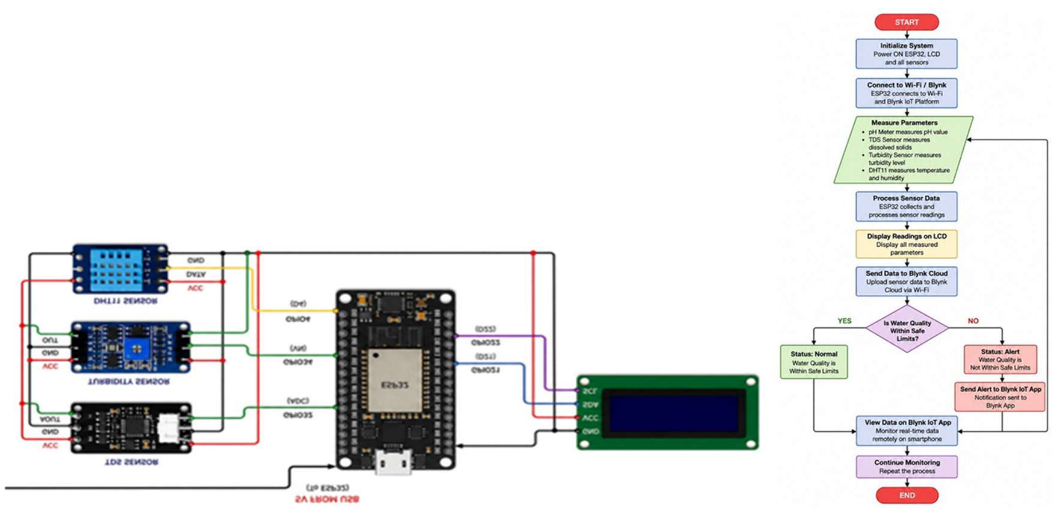

Fig. 4: Circuit Diagram & Flow Chart of the Proposed System

The circuit diagram shown in the Fig. 4 illustrates the complete hardware connection of the water quality monitoring system. The TDS sensor is connected to GPIO32 of the ESP32 through an analog input pin. The turbidity sensor output is connected to GPIO34, which is used to acquire analog turbidity measurements. The DHT11 sensor data pin is connected to GPIO4 for temperature and humidity sensing. The LCD display is connected using the I2C communication protocol. The SDA pin is connected to GPIO21 and the SCL pin is connected to GPIO22 of the ESP32. All sensors share a common power supply and ground connection. The

ESP32 is powered using a 5V USB supply. The microcontroller continuously reads sensor data and transmits it to the Blynk cloud platform through Wi-Fi. The pH meter is used separately to measure the pH value of filtered water and the obtained readings are recorded for water quality assessment [10].

The flowchart shown in the Fig. 4 describes the operational sequence of the system. Initially, the ESP32, sensors, and LCD display are powered on and initialized. The ESP32 then establishes a connection with the Wi-Fi network and Blynk cloud platform. The pH meter measures the pH value of the filtered water sample. Simultaneously, the TDS sensor, turbidity sensor, and DHT11 sensor collect water quality and environmental data. The ESP32 processes the sensor readings and displays the measured values on the LCD display. The processed data is then uploaded to the Blynk cloud platform for remote monitoring. The measured values are compared with predefined safe limits. If all parameters remain within acceptable ranges, the system indicates normal water quality. Otherwise, an alert condition is generated and a notification is sent to the user through the Blynk application. The process is repeated continuously to provide real-time monitoring.

X. ALGORITHM

Step 1: Start the system.
Step 2: Initialize ESP32, LCD, and sensors.
Step 3: Connect ESP32 to Wi-Fi.
Step 4: Connect to Blynk cloud platform.
Step 5: Measure pH value using pH meter.
Step 6: Read TDS sensor value.
Step 7: Read turbidity sensor value.
Step 8: Read temperature and humidity from DHT11 sensor.
Step 9: Process all sensor readings.
Step 10: Display readings on LCD.
Step 11: Upload data to Blynk cloud.
Step 12: Compare readings with standard water quality limits.
Step 13: Generate alert if limits are exceeded.
Step 14: Display water quality status.
Step 15: Repeat the monitoring process.
Step 16: Stop.

XI. WORKING METHODOLOGY

The proposed IoT-Based Multi-Parameter Water Quality Monitoring System is designed to monitor the quality of filtered water by measuring various physical and chemical parameters. The system consists of an ESP32 microcontroller, pH meter, TDS sensor, turbidity sensor, DHT11 sensor, LCD display, and the Blynk IoT platform. The filtered water obtained from the NirNal water filter is used as the sample for analysis. The pH meter is used to determine the acidity or alkalinity of the filtered water, while the TDS sensor measures the concentration of dissolved solids present in the water. The turbidity sensor measures the clarity of water by detecting suspended particles. The DHT11 sensor measures ambient temperature and humidity of the surrounding environment. All sensor readings are collected and processed by the ESP32 microcontroller. The ESP32 acts as the central processing unit of the system. It receives data from the sensors, processes the readings, and displays the measured values on the LCD display. Using its built-in Wi-Fi capability, the ESP32 transmits the collected data to the Blynk Cloud platform. The data can then be viewed remotely through the Blynk mobile application, allowing users to monitor the measured parameters conveniently. The system continuously acquires sensor data, updates the displayed values, and uploads the information to the IoT platform. Based on the obtained readings, the quality of the filtered water can be assessed and monitored. Thus, the proposed system provides a simple and effective method for observing important water quality parameters using IoT technology.

XII. SNAPSHOT AND RESULTS

The developed IoT-based Water Quality Monitoring System was tested using water samples before and after filtration. The measured parameters were Total Dissolved Solids (TDS), Turbidity, Temperature, and Humidity. The sensor readings were transmitted to the Blynk IoT platform for real-time monitoring. Fig. 3 shows the results before & after the filtration process is over.

TABLE I. RESULTS FROM BLYNK

Parameter	Before Filtration	After Filtration
TDS (ppm)	804.65	476.67
Turbidity	33.0	30.3
Temperature (°C)	25.9	26.2
Humidity (%)	62.6	61.3

The results shown in the Table 1 indicates a significant reduction in TDS from 804.65 ppm to 476.67 ppm after filtration. This demonstrates the effectiveness of the filtration process in reducing dissolved impurities and improving water quality. The final TDS value falls below the predefined safety limit of 500 ppm used in the system. The turbidity value decreased from 33.0 to 30.3 after filtration, indicating an improvement in water clarity. Although the reduction is comparatively smaller than the TDS reduction, it shows that suspended particles present in the water were partially removed by the filtration mechanism. The temperature remained nearly constant, changing only from 25.9°C to 26.2°C. This confirms that the filtration process does not significantly affect the temperature of the water sample. Similarly, humidity showed only a slight variation from 62.6% to 61.3%, indicating stable environmental conditions during experimentation. The filtered water was found to be safer and of better quality than the unfiltered sample, as indicated by the reduction in TDS and turbidity values. The IoT-based monitoring system effectively provided real-time assessment of water quality parameters.

XIII. CONCLUSIONS AND FUTURE ENHANCEMENTS

In this project, an IoT-Based Multi-Parameter Water Quality Monitoring System was successfully designed and implemented to monitor important water quality parameters in real time. The system utilizes an ESP32 microcontroller along with a pH meter, TDS sensor, turbidity sensor, and DHT11 sensor to evaluate the quality of filtered water. The measured parameters were displayed on an LCD display and transmitted to the Blynk Cloud platform using Wi-Fi connectivity, enabling remote monitoring through a smartphone application. The integration of multiple sensors allowed continuous observation of water quality conditions and provided accurate information regarding water purity and safety. The results demonstrated that the proposed system is capable of effectively monitoring water quality in a simple, low-cost, and reliable manner. The system reduces the need for manual testing and provides real-time access to water quality data. Therefore, the developed system can be used in households, water treatment plants, industries, and smart water management applications to ensure the availability of safe and clean water.

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