A

CIA REPORT

ON

Water Quality Monitoring System

Subject: Internet of Things

Submitted By

01. Abhale Abhishek (UCS21M1001)

03. Aher Aniket (UCS21M1003)

04. Aher Kaushtubh (UCS21M1004)

15. Bhalerao Sahil (UCS21M1015)

Under the Guidance of

Prof. A.D Sangale

DEPARTMENT OF COMPUTER ENGINEERING
SANJIVANI COLLEGE OF ENGINEERING, KOPARGAON
(AN AUTONOMOUS INSTISTUTE)
DIST. AHMEDNAGAR (423603)
2023-24

CERTIFICATE

This is to certify that the project report entitled “**Water Quality Monitoring System”** submitted by Abhishek Abhale, Aniket Aher, Kaustubh Aher, Sahil Bhalerao in partial fulfillment of the requirementsfor the award of the degree of Bachelor of Technology in Computer Engineering of Sanjivani College of Engineering, Kopargaon is a record of bonafide work carried out under my guidance and supervision.

Prof A.D. Sangale Guide	Dr. D.B. Kshirsagar Head of the Department	Dr. A. G.Thakur Principal

DEPARTMENT OF COMPUTER ENGINEERING SANJIVANI COLLEGE OF ENGINEERING, KOPARGAON(AN AUTONOMOUS INSTISTUTE)
DIST. AHMEDNAGAR (423603)

ACKNOWLEDGEMENT

First and foremost, I express my deep sense of gratitude, sincere thanks to **Prof. A.D. Sangle** Department of Computer Engineering, Sanjivani College Of Engineering, Kopargaon. Your availability at any time throughout the semester, encouragement and support tremendously boosted this project work. Lots of thanks to Head of Computer Engineering Department, **Dr.D.B. Kshirsagar** for providing us the best support. I would like to express my sincere gratitudeto **Dr. A.G. Thakur,** Director, Sanjivani College Of Engineering, Kopargaon for providing great platform to complete the project within the scheduled time.

01. Abhale Abhishek (UCS21M1001)

03.Aher Aniket (UCS21M1003)

04.Aher Kaushtubh (UCS21M1004)

15. Bhalerao Sahil (UCS21M1015)

INDEX

1. Abstract:

This study presents the development of an integrated water quality measurement system utilizing an ESP32 microcontroller, TDS (Total Dissolved Solids) sensor, turbidity sensor, temperature sensor, and LCD display for real-time measurement and monitoring. The system aims to provide accurate and efficient analysis of key parameters affecting water quality, crucial for various applications including environmental monitoring, water treatment, and research.

The ESP32 microcontroller serves as the central processing unit, facilitating data acquisition from the connected sensors and controlling the display interface. The TDS sensor measures the concentration of dissolved solids in water, providing insights into its overall purity and contamination levels. The turbidity sensor detects suspended particles in the water, indicating its clarity and potential presence of pollutants. Additionally, the temperature sensor measures the water temperature, an important factor influencing various chemical and biological processes.

The system is designed to be user-friendly, with a LCD display providing real-time readings of TDS levels, turbidity, and water temperature. This enables quick and easy interpretation of water quality data, aiding decision-making processes for users. Moreover, the system can be configured for continuous monitoring, allowing for trend analysis and early detection of anomalies in water quality.

2. Introduction:

Ensuring water quality is essential for human health, environmental sustainability, and industrial processes. In response to this critical need, advancements in technology have facilitated the development of sophisticated monitoring systems. This introduction outlines the creation of a robust water quality measurement system using ESP32 microcontroller, TDS (Total Dissolved Solids) sensor, turbidity sensor, temperature sensor, and an LCD display for real-time data visualization.

1. ESP32 Microcontroller: The ESP32 is a powerful microcontroller known for its versatility and connectivity capabilities. With built-in Wi-Fi and Bluetooth, it serves as the central processing unit for our water quality measurement system. Its low power consumption and ample processing power make it an ideal choice for IoT applications.

2. TDS Sensor: Total Dissolved Solids (TDS) refer to the combined content of all inorganic and organic substances present in a liquid in molecular, ionized, or micro-granular suspended form. A TDS sensor measures the conductivity of the water, which correlates with the concentration of dissolved solids. By integrating a TDS sensor into our system, we can quantify the overall purity of the water sample.

3. Turbidity Sensor: Turbidity is a measure of water clarity, indicating the presence of suspended particles and colloidal matter. Turbidity sensors employ light scattering or absorption principles to assess the cloudiness of the water. By incorporating a turbidity sensor, our system can assess the physical impurities present in the water, providing insights into its suitability for various applications.

4. Temperature Sensor: Temperature plays a crucial role in determining water quality as it affects various chemical and biological processes. A temperature sensor enables us to monitor the thermal characteristics of the water sample accurately. By tracking temperature fluctuations, our system can identify potential environmental influences on water quality and ensure optimal operating conditions.

5. LCD Display: Real-time data visualization is essential for effective monitoring and decision- making. An LCD display integrated into our system provides a user-friendly interface for presenting water quality parameters such as TDS levels, turbidity values, and temperature readings. This enables users to interpret data promptly and take necessary actions to maintain water quality standards.

3. Problem Statement:

Develop an integrated water quality measurement system utilizing an ESP32 microcontroller, TDS sensor, turbidity sensor, temperature sensor, and LCD display for real-time measurement and monitoring. The system aims to provide accurate and efficient analysis of key parameters affecting water quality, crucial for various applications including environmental monitoring, water treatment, and research.

The ESP32 microcontroller serves as the central processing unit, facilitating data acquisition from the connected sensors and controlling the display interface. The TDS sensor measures the concentration of dissolved solids in water, providing insights into its overall purity and contamination levels. The turbidity sensor detects suspended particles in the water, indicating its clarity and potential presence of pollutants. Additionally, the temperature sensor measures the water temperature, an important factor influencing various chemical and biological processes.

The system is designed to be user-friendly, with an LCD display providing real-time readings of TDS levels, turbidity, and water temperature. This enables quick and easy interpretation of water quality data, aiding decision-making processes for users. Moreover, the system can be configured for continuous monitoring, allowing for trend analysis and early detection of anomalies in water quality.

4. Scope & Objective :

Scope:

1. Hardware Development: Design and assemble the integrated system comprising an ESP32 microcontroller, TDS sensor, turbidity sensor, temperature sensor, and LCD display. Ensure compatibility and effective communication between the components.

2. Software Development: Develop firmware for the ESP32 microcontroller to facilitate data acquisition from the sensors, control the display interface, and enable real-time monitoring. Implement algorithms for data processing, calibration, and error handling.

3. Sensor Calibration: Calibrate the TDS sensor, turbidity sensor, and temperature sensor to ensure accurate measurements. Develop procedures for periodic recalibration to maintain measurement accuracy over time.

4. User Interface Design: Design a user-friendly interface for the LCD display to present real-time readings of TDS levels, turbidity, and water temperature. Incorporate intuitive controls and indicators for easy navigation and interpretation of data.

5. Integration and Testing: Integrate the hardware components and software modules to form a cohesive system. Conduct comprehensive testing to validate the functionality, accuracy, and reliability of the system under various operating conditions.

6. Documentation and User Manual: Prepare detailed documentation covering system architecture, hardware schematics, software algorithms, calibration procedures, and troubleshooting guidelines. Develop a user manual to guide users in system setup, operation, and maintenance.

7. Deployment and Field Testing: Deploy the integrated system for field testing in real-world environments such as water treatment facilities, natural water bodies, and research laboratories. Gather feedback from users to identify areas for improvement and optimization.

8. Scalability and Customization: Design the system with scalability in mind to accommodate future expansion and integration of additional sensors or functionalities. Provide options for customization to meet specific user requirements and application scenarios.

Objectives:

1. Develop Integrated System Components: Design and develop the hardware components including the ESP32 microcontroller, TDS sensor, turbidity sensor, temperature sensor, and LCD display, ensuring compatibility and functionality.

2. Implement Data Acquisition and Processing: Develop firmware for the ESP32 microcontroller to acquire data from the sensors, process the raw sensor readings, and calculate TDS levels, turbidity, and water temperature.

3. Ensure Measurement Accuracy and Reliability: Calibrate the sensors to ensure accurate and reliable measurements of TDS levels, turbidity, and water temperature under varying environmental conditions.

4. Create User-Friendly Interface: Design an intuitive user interface for the LCD display to present real-time readings of water quality parameters in a clear and understandable format, enabling easy interpretation by users.

5. Enable Real-Time Monitoring and Display: Implement functionality to continuously monitor water quality parameters and display real-time readings of TDS levels, turbidity, and water temperature on the LCD display.

6. Facilitate User Interaction and Control: Incorporate user controls and indicators on the LCD display to allow users to navigate through menu options, adjust settings, and view historical data as needed.

7. Support Continuous Monitoring and Trend Analysis: Enable the system to support continuous monitoring of water quality parameters, allowing users to track changes over time and perform trend analysis to identify patterns or anomalies.

8. Ensure System Stability and Robustness: Conduct thorough testing to ensure the stability, robustness, and reliability of the integrated system under normal operating conditions and potential environmental stressors.

5. Methodology:

1. Requirement Analysis: Gather requirements from stakeholders including environmental scientists, water treatment experts, and regulatory authorities to understand the specifications and expectations for the water quality measurement system.

2. Component Selection: Select appropriate components including the ESP32 microcontroller, TDS sensor, turbidity sensor, temperature sensor, and LCD display based on performance, compatibility, and cost considerations.

3. Hardware Development:Design and assemble the hardware components into a cohesive system, ensuring proper wiring, connection, and integration. Test the hardware setup to verify functionality and compatibility.

4. Software Development: Develop firmware for the ESP32 microcontroller using suitable programming languages (e.g., C/C++, Arduino IDE). Implement algorithms for data acquisition, processing, and display control. Integrate sensor libraries and communication protocols for seamless interaction between components.

5. Sensor Calibration:Calibrate the TDS sensor, turbidity sensor, and temperature sensor using standard calibration solutions and procedures. Validate the calibration results through comparison with known reference values.

6. User Interface Design: Design a user-friendly interface for the LCD display to present real-time readings of water quality parameters. Develop interactive menus, screens, and controls for user interaction and customization.

7. Integration and Testing:Integrate the hardware and software components to form a complete system. Conduct rigorous testing to validate functionality, accuracy, and reliability under various operating conditions including temperature variations and water quality scenarios.

8. Documentation:Prepare detailed documentation covering system architecture, hardware schematics, software algorithms, calibration procedures, and user manuals. Document troubleshooting guidelines and best practices for system operation and maintenance.

9. Training: Provide training sessions for users to familiarize them with the operation, maintenance, and troubleshooting procedures of the water quality measurement system. Address any questions or concerns raised by users during the training sessions.

10. Deployment and Evaluation: Deploy the integrated system for field testing in real-world environments such as water treatment plants, rivers, lakes, and research laboratories. Gather feedback from users and stakeholders to evaluate the performance, usability, and effectiveness of the system. Iterate on the design and implementation based on the feedback received.

6.System Architecture:

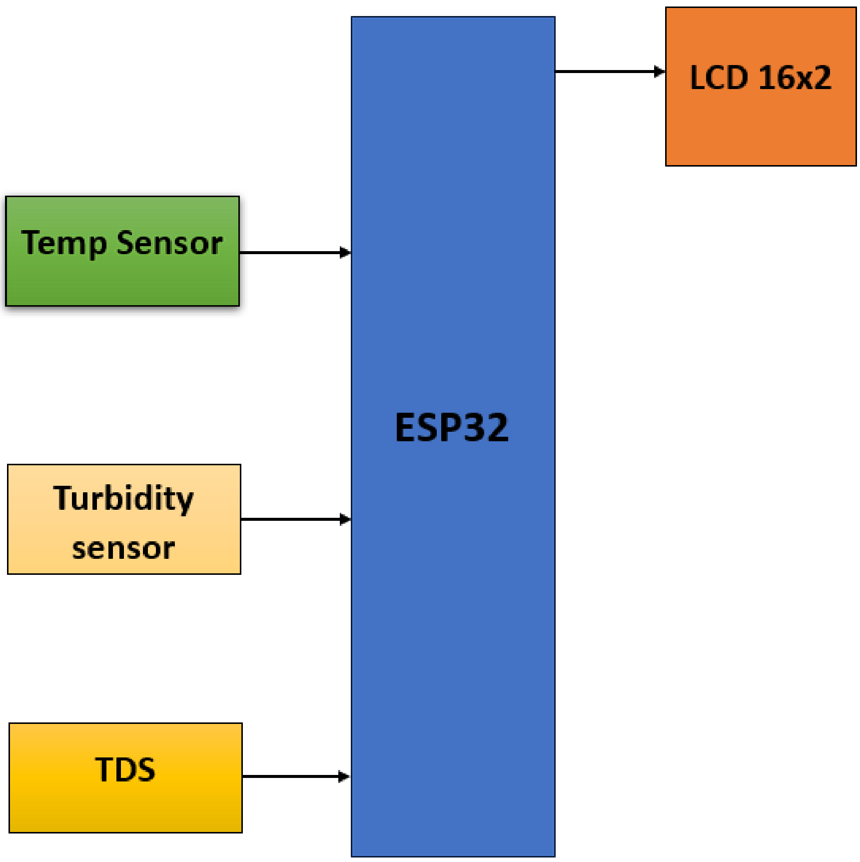

Fig.-Block Diagram Of Water Quality Monitoring

Sure, here's a basic system architecture for a water quality measurement system using an ESP32 microcontroller, TDS (Total Dissolved Solids) sensor, turbidity sensor, temperature sensor, and an LCD display:

1. ESP32 Microcontroller: The ESP32 serves as the main controller for the system. It handles data acquisition from the sensors, processes the data, and controls the display.

2. TDS Sensor: The TDS sensor measures the total dissolved solids in the water, which includes salts, minerals, and other impurities. It typically outputs an analog signal that varies with the concentration of dissolved solids.

3. Turbidity Sensor: The turbidity sensor measures the cloudiness or haziness of the water caused by suspended solids. It typically uses light scattering or absorption to determine turbidity and outputs an analog or digital signal.

4. Temperature Sensor: The temperature sensor measures the temperature of the water. It can be an analog or digital sensor, such as a thermistor or a digital temperature sensor like DS18B20.

5. LCD Display: The LCD display provides a user-friendly interface to show the measured water quality parameters such as TDS, turbidity, and temperature. It allows users to easily read the measurements.

7.Source Code/ Program:

```
 #include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <WiFi.h>
#include <WebServer.h>

const char* ssid = "Abhi";
const char* password = "123456789";

LiquidCrystal_I2C lcd(0x27, 16, 2); // Set the LCD address to 0x27 for a 16 chars and 2 line display
WebServer server(80);

// Pin definitions for sensors
const int tdsPin = A0;  // TDS sensor analog pin
const int turbidityPin = A1; // Turbidity sensor analog pin
const int tempPin = A2;  // Temperature sensor analog pin

void setup() {
  Serial.begin(9600);
  lcd.init(); // Initialize the LCD
  lcd.backlight();  // Turn on backlight

  // Set up analog pins
  pinMode(tdsPin, INPUT);
  pinMode(turbidityPin, INPUT);
  pinMode(tempPin, INPUT);

  // Connect to Wi-Fi
  Serial.print("Connecting to ");
  Serial.println(ssid);
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(1000);
    Serial.println("Connecting to WiFi...");
  }
  Serial.println("Connected to WiFi");

  // Start the web server
  server.on("/", handleRoot);
  server.begin();
  Serial.println("HTTP server started");
```

```
}

void loop() {
  server.handleClient();  // Handle incoming HTTP requests
}

void handleRoot() {
  // Read sensor values
  int tdsValue = analogRead(tdsPin);
  int turbidityValue = analogRead(turbidityPin);
  int tempValue = analogRead(tempPin);

  // Convert sensor values to actual measurements
  float tds = map(tdsValue, 0, 1023, 0, 2000);  // Adjust the range according to your sensor
  float turbidity = map(turbidityValue, 0, 1023, 0, 100);  // Adjust the range according to your sensor
  float temperature = (tempValue / 1023.0) * 3300 / 10;  // Convert the raw value to temperature in Celsius

  // Display readings on LCD
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("TDS: ");
  lcd.print(tds);
  lcd.print(" ppm");

  lcd.setCursor(0, 1);
  lcd.print("Turbidity: ");
  lcd.print(turbidity);
  lcd.print(" NTU");

  // Send HTTP response
  server.send(200, "text/plain", "TDS: " + String(tds) + " ppm\nTurbidity: " + String(turbidity) + "
NTU\n");
```

8. Challenges:

1. Sensor Accuracy and Calibration: Ensuring the accuracy and reliability of sensor measurements is crucial for obtaining meaningful water quality data. Calibrating sensors such as TDS, turbidity, and temperature sensors can be challenging and may require specialized equipment and procedures.

2. Interference and Environmental Variability:Environmental factors such as temperature fluctuations, ambient light, and electromagnetic interference can affect sensor readings and system performance. Implementing measures to minimize interference and account for environmental variability is essential for accurate data acquisition.

3. Data Integration and Processing: Integrating data from multiple sensors and processing it in real-time can be computationally intensive. Efficient data processing algorithms need to be developed to handle large volumes of data and extract meaningful insights for monitoring and analysis.

4. Power Management: Balancing the power consumption of the system components to ensure prolonged operation on battery power or in remote locations can be challenging. Implementing power-saving techniques and optimizing the system's energy efficiency are essential for sustainable long-term monitoring.

5. User Interface Design: Designing a user-friendly interface for displaying real-time water quality data and enabling user interaction requires careful consideration of usability principles and human-computer interaction guidelines. Ensuring that the interface is intuitive, informative, and accessible to users with varying levels of expertise is critical for effective use of the system.

6. Field Deployment and Reliability: Deploying the system in real-world environments such as rivers, lakes, or water treatment plants introduces challenges related to durability, ruggedness, and reliability. Ensuring that the system can withstand harsh environmental conditions and operate consistently over extended periods without maintenance or failure is essential for long-term monitoring applications.

9. Future Scope:

1. Enhanced Sensor Capabilities: Integrate advanced sensors or sensor arrays capable of detecting additional water quality parameters such as pH, dissolved oxygen, conductivity, and specific ions. This expansion would provide a more comprehensive understanding of water quality and enable the system to address a wider range of applications and environmental monitoring needs.

2. Wireless Connectivity and IoT Integration: Incorporate wireless communication capabilities such as Wi-Fi, Bluetooth, or LoRaWAN to enable remote monitoring, data transmission, and control functionalities. Integrating the system with IoT platforms would facilitate real-time data sharing, cloud-based storage, and advanced analytics for decision support and predictive modeling.

3. Data Analytics and Machine Learning: Implement data analytics algorithms and machine learning techniques to analyze large datasets collected by the system. Develop predictive models for water quality forecasting, anomaly detection, and early warning systems to proactively address water quality issues and optimize resource management strategies.

4. Mobile Applications and Web Interfaces: Develop mobile applications and web-based interfaces to enable users to access and interact with the water quality data remotely. Provide features for data visualization, trend analysis, historical data retrieval, and customizable alerts to empower users with actionable insights and decision-making support.

5. Integration with Smart Water Management Systems: Integrate the water quality measurement system with smart water management systems and infrastructure such as water treatment plants, distribution networks, and smart meters. This integration would enable real-time monitoring, control, and optimization of water treatment processes, resource allocation, and infrastructure maintenance.

6. Community Engagement and Citizen Science: Engage local communities and citizen scientists in water quality monitoring initiatives by deploying decentralized sensor networks or community-driven monitoring programs. Provide training, educational resources, and participatory platforms to empower citizens to contribute to environmental stewardship efforts and advocate for water quality conservation.

7. Cross-Disciplinary Research and Collaboration:Foster collaboration between academia, industry, government agencies, and non-profit organizations to address interdisciplinary challenges related to water quality monitoring and management. Support research initiatives focused on understanding the complex interactions between water quality, environmental factors, and human activities to inform evidence-based policy decisions and sustainable development strategies.

8. Global Deployment and Impact Assessment: Expand the deployment of the integrated water quality measurement system to diverse geographical regions and socio-economic contexts worldwide. Conduct impact assessments to evaluate the effectiveness, scalability, and socio-environmental implications of the system in addressing local water quality challenges, promoting public health, and supporting sustainable development goals.

10. Result Analysis:

1. Accuracy and Precision: Evaluate the accuracy and precision of the water quality measurements obtained from the integrated system by comparing them to reference values obtained through laboratory analysis or certified instruments. Assess the system's performance across a range of water quality conditions and environmental scenarios to identify any discrepancies or sources of error.

2. Sensor Performance:Analyze the performance of individual sensors (e.g., TDS sensor, turbidity sensor, temperature sensor) in terms of sensitivity, response time, and drift over time. Conduct calibration tests and sensor validation studies to ensure that the sensors maintain their accuracy and reliability throughout the monitoring period.

3. Real-Time Monitoring: Assess the effectiveness of the system in providing real-time monitoring of key water quality parameters such as TDS levels, turbidity, and temperature. Evaluate the system's ability to detect changes in water quality conditions promptly and accurately, enabling timely intervention or corrective actions as needed.

4. User Satisfaction: Gather feedback from users, stakeholders, and field operators regarding their experience with the integrated system. Assess user satisfaction with the system's ease of use, reliability, and functionality. Identify any usability issues, technical challenges, or areas for improvement based on user feedback and suggestions.

5. Data Interpretation: Analyze the effectiveness of the system's user interface in presenting water quality data in a clear, understandable format. Assess users' ability to interpret and analyze the data provided by the system for decision-making purposes. Evaluate the system's capability to generate actionable insights and support informed decision-making regarding water quality management and resource allocation.

6. Long-Term Monitoring: Evaluate the system's performance over extended monitoring periods to assess its reliability, stability, and robustness. Analyze trends in water quality parameters over time to identify seasonal variations, long-term trends, or emerging patterns indicative of environmental changes or anthropogenic impacts.

7. Compliance and Reporting: Verify that the integrated system complies with relevant regulatory standards and guidelines for water quality monitoring systems. Assess the system's capability to generate accurate and reliable data for regulatory reporting purposes. Ensure that the system meets the data quality requirements specified by regulatory authorities and can provide audit trails and documentation as needed.

8.Impact Assessment: Evaluate the impact of the integrated water quality measurement system on environmental management practices, public health outcomes, and resource allocation decisions. Assess the system's contribution to improving water quality monitoring capabilities, enhancing environmental awareness, and fostering community engagement in water stewardship efforts.

11. Conclusion & Reference:

Conclusion:

In conclusion, employing a comprehensive system comprising an ESP32 microcontroller, TDS sensor, turbidity sensor, temperature sensor, and an LCD display significantly enhances water quality measurement capabilities. By integrating these components, real-time monitoring and analysis of crucial parameters such as total dissolved solids (TDS), turbidity, and temperature become feasible, offering valuable insights into water purity and safety. This setup facilitates prompt detection of any deviations from desired water quality standards, enabling timely intervention and maintenance efforts. Furthermore, the inclusion of an LCD display ensures user-friendly visualization of measured data, enhancing accessibility and usability. Overall, this integrated approach represents a powerful tool for effective water quality management, contributing to the preservation of clean and safe water resources.

Reference:

1. Class Notes

2. T. Sandeep Rao, P. Pranay, S. Narayana, Y. Reddy, S. Sunil, and P. Kaur, "ESP32 Based Implementation of Water Quality and Quantity Regulating System," in Proceedings of the 3rd International Conference on Integrated Intelligent Computing Communication & Security (ICIIC 2021), January 2021, pp. xx-xx, DOI: 10.2991/ahis.k.210913.016.

3. R. Rathna, U. V. Anbazhagu, L. Mary Gladence, V. Maria Anu, and J. Sybi Cynthia, "An Intelligent Monitoring System for Water Quality Management using Internet of Things," IEEE Xplore, Date Added: 06 September 2021.

4. Zhua, X.; Lia, D.; Heb, D.; Wanga, J.; Maa, D.; Li, F. A remote wireless system for water quality online monitoring in intensive fish culture. Comput. Electron. Agric. 2010, 71S, S3–S9.

5. Odey, A.J.; Li, D. AquaMesh—design and implementation of smart wireless mesh sensor networks for aquaculture. Am. J. Netw. Commun. 2013, 2, 81–87.