Water Quality Monitoring for Rural Communities

Macro Project Report

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Under the Supervision of:

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July - Dec 2025

DECLARATION BY THE CANDIDATES

We hereby declare that the work entitled **"WATER QUALITY MONITORING FOR RURAL COMMUNITIES"** is our original work, conducted under the supervision of Dr. Varun Sharma, Assistant Professor, Department of Electronics & Telecommunication Engineering, during the session July–Dec 2025. The report submitted by us is a record of bonafide work carried out by the undersigned candidates.

We further declare that this report has not been submitted, either in part or full, for the award of any other degree or diploma in this institute or any other institute or university.

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Place: Gwalior

Certified that the above statements made by the candidates are correct to the best of my knowledge and belief.

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ABSTRACT

The *Water Quality Monitoring System* is a cost-effective solution designed to continuously monitor and evaluate the quality of water, particularly in **rural and semi-urban communities**. This project aims to provide a reliable and accessible method for assessing essential water parameters, ensuring safe and healthy water consumption for all. The system measures key parameters such as **pH, turbidity, Total Dissolved Solids (TDS), and temperature** using sensors interfaced with an **Arduino UNO microcontroller**. Real-time readings are displayed on an **LCD module**, enabling users to observe immediate changes in water quality.

In its current phase, the system includes **threshold-based indicators** that evaluate whether water is safe, moderately contaminated, or unsafe, based on **standard water quality guidelines**. The setup emphasizes **affordability, simplicity, and portability**, making it well-suited for field applications in resource-limited areas.

By promoting **awareness, transparency, and community engagement**, this project not only empowers individuals to understand their local water quality but also paves the way for an **IoT-enabled environmental monitoring framework**. Future enhancements could include wireless data transmission, cloud-based storage, and analytical dashboards for tracking long-term trends. Overall, the *Water Quality Monitoring System* serves as a foundational step toward building smart, data-driven, and sustainable water management solutions for rural communities.

ACKNOWLEDGEMENT

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Chapter 1

Introduction

The purpose of this project is to gain practical, real-world experience in the design and development of embedded monitoring systems through the creation of a Water Quality Monitoring System for Rural Communities. This project bridges the gap between theoretical knowledge acquired in electronics and microcontroller-based courses and its practical implementation in developing sustainable technological solutions for environmental and public health management.

The Water Quality Monitoring System is designed to measure and display key parameters that determine water quality, such as pH, turbidity, Total Dissolved Solids (TDS), and temperature. Using sensors interfaced with an Arduino UNO and a 16x2 LCD display, the system provides a simple, low-cost, and real-time method for assessing the safety of water sources. It serves as an affordable tool for rural communities, where access to advanced laboratory testing facilities is limited, helping users make informed decisions about water usability and health risks.

The main objective of this project is to understand and implement the process of developing a microcontroller-based data acquisition and monitoring system — including sensor interfacing, signal processing, data display, and threshold-based alerts. The project emphasizes the importance of accurate data collection, power efficiency, and user-friendly design to ensure practical usability in real-world rural conditions.

During the course of this project, we learned about sensor calibration, analog-to-digital conversion, and embedded system integration using Arduino. We also gained hands-on experience in circuit design, coding, debugging, and real-time testing of hardware components. The project further enhanced our professional skills such as teamwork, analytical thinking, and systematic problem-solving.

The significance of this project lies in its potential to promote water safety awareness and to serve as a foundation for future innovations in IoT-enabled environmental monitoring. By working on this system, we understood how technology can play a transformative role in addressing rural challenges, ensuring sustainable water management, and improving the overall quality of life in underserved communities.

1.1 Theory

Water quality monitoring ensures that the water used for drinking or irrigation is safe and free from harmful impurities. The Arduino UNO acts as the central processing unit, reading analog signals from pH, TDS, and turbidity sensors and converting them into digital values. The DS18B20 temperature sensor provides compensation for more accurate results. These values are displayed on the LCD and compared with WHO/BIS drinking water standards. If any parameter exceeds the threshold, the system activates an alert mechanism.

1.1.1 Key Parameters of Water Quality

a) pH (Potential of Hydrogen): Indicates the acidity or alkalinity of water on a scale from 0 to 14. The ideal range for drinking water is 6.5–8.5. pH below 6.5 indicates acidity, while above 8.5 indicates alkalinity. The pH sensor measures hydrogen ion concentration and outputs a voltage proportional to the pH value.

b) Total Dissolved Solids (TDS): Represents the concentration of dissolved minerals, salts, and organic matter in ppm. Acceptable limit for drinking water is below 500 ppm. High TDS indicates poor taste or contamination. The TDS sensor estimates water conductivity to determine the dissolved solids level.

c) Turbidity: Measures the clarity of water, affected by suspended particles. Expressed in NTU (Nephelometric Turbidity Units). High turbidity means more impurities and microbial risk. The turbidity sensor uses light scattering to detect suspended particles.

d) Temperature: Affects chemical reactions and microbial activity in water. High temperature reduces dissolved oxygen and may promote bacterial growth. The DS18B20 waterproof sensor measures water temperature digitally and helps compensate other sensor readings.

Chapter 2

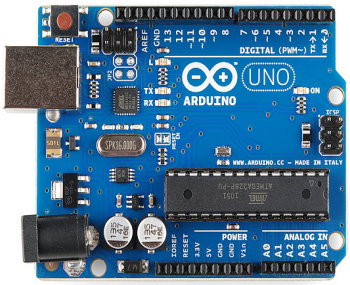
System Design

2.1 Objective

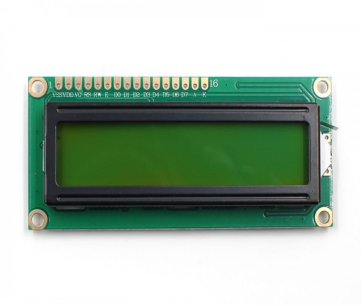
To design and develop a hardware-based system that monitors essential water quality parameters—pH, TDS, turbidity, and temperature—using Arduino UNO and sensors, and to provide real-time analysis of water safety for rural applications.

2.2 Components Required

1. Arduino UNO Microcontroller Board
2. TDS Sensor Module
3. Turbidity Sensor Module
4. DS18B20 Waterproof Temperature Sensor
5. 16x2 LCD Display (with I2C Module)
6. Breadboard and Jumper Wires
7. USB Cable or 9V Power Supply
8. Buzzer and LED Indicator
9. pH paper (A pH Sensor Module can also be used)



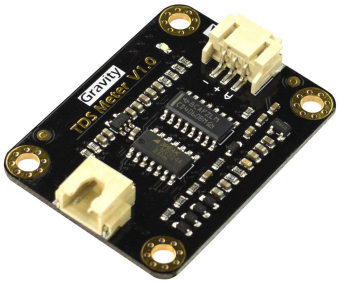
(a) Arduino UNO



(b) 16x2 LCD Display

(c) pH paper

(d) DS18B20 Waterproof Temperature Sensor



(e) TDS Sensor Module

(f) Turbidity Sensor Module

Figure 2.1: Images showing major circuit components

2.2.1 Block Diagram

```
+-----------------------------------+
|   Water Quality Monitoring System  |
+-----------------------------------+
| pH Value --> Manual Verification   |
| TDS Sensor --> Arduino (A1)        |
| Turbidity  --> Arduino (A0)        |
| Temp Sensor --> Digital Pin D2     |
+-----------------------------------+
```

2.2.2 Circuit Diagram

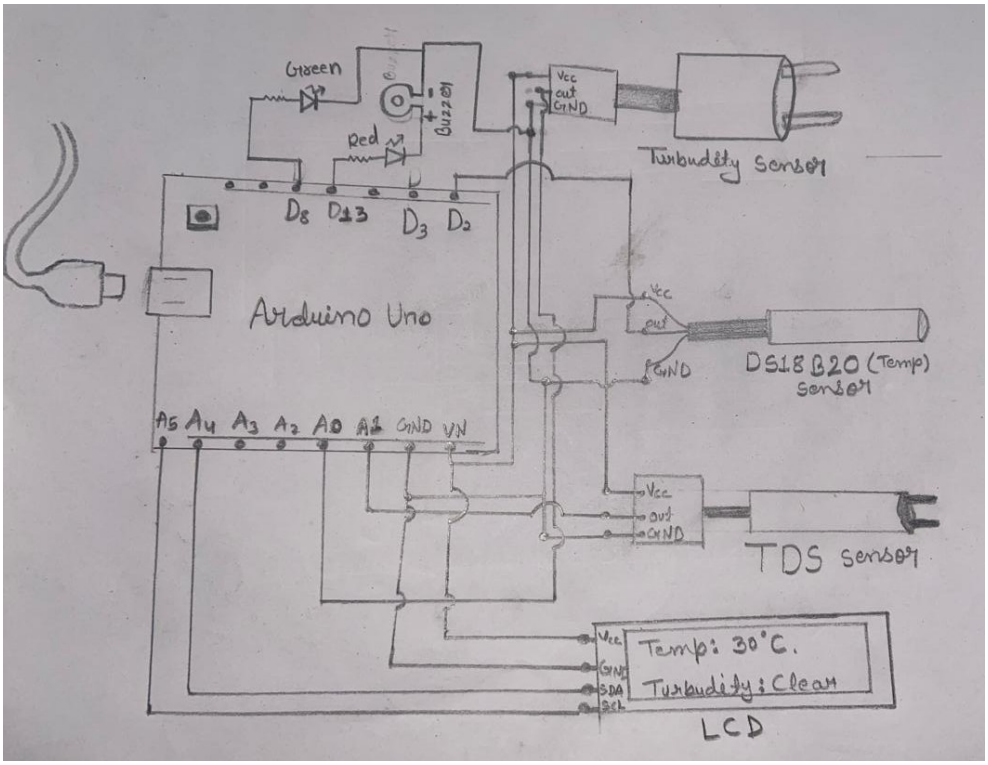


Figure 2.2: Circuit Diagram of Water Quality Monitoring System using Arduino UNO

2.3 Methodology / Procedure

1. Connect all sensors to Arduino UNO according to the circuit diagram.
2. Upload the Arduino code via Arduino IDE.
3. Power the circuit using USB or a 5V adapter.
4. Immerse the sensor probes into the water sample (keep sensor boards dry).
5. Observe readings for pH, TDS, turbidity, and temperature on the LCD.
6. Compare readings with standard safe water limits.
7. If unsafe, a buzzer or LED activates as a warning signal.

Chapter 3

Working Principle

The sensors collect water data and send analog signals to the Arduino UNO. The Arduino converts these readings into digital values and processes them using the programmed logic. The LCD displays real-time results, while the buzzer alerts the user if readings exceed safe thresholds. This enables immediate assessment of water safety without laboratory testing.

Water Quality Decision Logic

The microcontroller continuously reads sensor data from the DS18B20 temperature sensor, the TDS (Total Dissolved Solids) sensor, and the turbidity sensor. Based on the measured values, it determines whether the water is suitable for drinking.

The decision is made according to the following logic:

Listing 3.1: Water Quality Evaluation Logic

```
if (tdsValue < 500 && turbidity < 20 && temperature < 40.0) {
    // Water is suitable for drinking
    digitalWrite(PURE_WATER_PIN, HIGH);
    digitalWrite(IMPURE_WATER_PIN, LOW);
} else {
    // Water is not suitable for drinking
    digitalWrite(PURE_WATER_PIN, LOW);
    digitalWrite(IMPURE_WATER_PIN, HIGH);
}
```

Explanation:

- **TDS (Total Dissolved Solids)** should be below 500 ppm. Higher values indicate contamination or mineral excess.
- **Turbidity** should be below 20 (on the calibrated analog scale). Higher turbidity means the water is cloudy or dirty.
- **Temperature** should be below 40°C, since high temperature may promote bacterial growth.

If all three parameters fall within acceptable limits, the system activates the *Pure Water* indicator (green LED). Otherwise, it activates the *Impure Water* indicator (red LED or buzzer).

Chapter 4

Result

The Water Quality Monitoring System was successfully developed and tested. It accurately measured pH, turbidity, TDS, and temperature for various water samples. Safe water samples showed values within WHO/BIS limits, while contaminated samples triggered alerts. The readings were stable, reliable, and clearly displayed on the LCD screen.

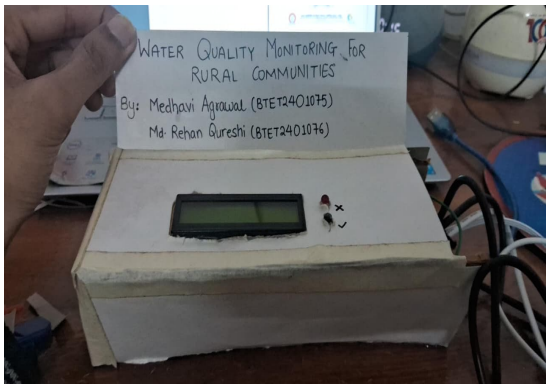


Figure 4.1: Water Quality Sensor Prototype

Figure 4.2: Arduino LCD Display Output

Chapter 5

Applications

1. Rural and community water testing stations
2. Smart village and IoT-based monitoring systems
3. Environmental and agricultural water management
4. Educational laboratories and student projects
5. Low-cost alternative to commercial water testers

5.1 Future Scope

1. **IoT Integration**: Add Wi-Fi or GSM modules for online monitoring and data logging.
2. **Solar Power**: Use a solar panel for sustainable rural deployment.
3. **Advanced Sensors**: Include DO, ORP, or conductivity sensors for more comprehensive analysis.
4. **Data Storage**: Use an SD card or cloud to log long-term readings.
5. **Wireless Network**: Deploy multiple nodes linked via ZigBee.
6. **AI-based Prediction**: Use data analytics for contamination forecasting.
7. **Mobile App**: Create an app for easy viewing and alerts.

5.2 Conclusion

The project successfully demonstrates a functional prototype for water quality monitoring using Arduino UNO and multiple sensors. It provides a practical, low-cost solution for rural communities to evaluate water safety in real time. This system can serve as a foundation for future IoT-based smart water networks, contributing to sustainable water management and community health.

5.3 References

1. `https://www.arduino.cc/`
2. WHO Guidelines for Drinking-water Quality
3. BIS 10500:2012 Indian Standards for Drinking Water