Department of Mechatronics Engineering
Rajshahi University of Engineering and Technology

Project Report

On

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Project Name: Real Time Water Quality Monitoring System

Submitted by

Name	ID No.
Saydul Mursalin Peash	1808019
Multazimul Islam	1808020
Anik Ghosh	1808021
Nazmul Islam	1808026
Bishowjit Paul	1808029
Mohammad Fahim Hossain	1808041
Md Hasibul Islam Hasib	1808054

Submitted to

Md. Manirul Islam
Assistant Professor
Department of Mechatronics Engineering
Rajshahi University of Engineering & Technology

Sarafat Hussain Abhi
Lecturer,
Department of Mechatronics Engineering
Rajshahi University of Engineering & Technology

Real time Drinkable Water Quality Monitoring System

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Introduction:

Water is an indispensable resource for sustaining life, and ensuring its quality is of paramount importance for human health. Access to clean and safe drinking water is a fundamental human right and a cornerstone of public health. However, water quality can deteriorate due to various factors, including contamination from industrial activities, agricultural runoff, and natural disasters. To ensure the safety and potability of drinking water, continuous monitoring of its key parameters is essential [1].

In the pursuit of safe and clean drinking water, the development of real-time water quality monitoring systems has become crucial. This project focuses on the design and implementation of a comprehensive Real-Time Water Quality Monitoring System (RTWQMS) utilizing sensor technology and a mobile application. The RTWQMS will continuously monitor critical water quality parameters such as temperature, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), and conductivity. Based on predetermined threshold values aligned with drinking water standards, the system will assess the potability of the water and provide real-time feedback through a user-friendly mobile app. This project aims to provide a cost-effective and reliable solution for monitoring water quality in various settings, including households, schools, and communities [2].

Four critical water quality parameters, namely temperature, total dissolved solids (TDS), dissolved oxygen (DO), and conductivity, will be investigated in this study. The determination of these parameters will be used to assess the overall water quality. Conductivity measurement can be performed using a conversion factor ranging from 0.55 to 0.75, as per the equation TDS (mg/L) = k × EC (μS/cm) [5]. These four parameters are well-established indicators for monitoring and controlling water quality [6]. Additionally, the optimal temperature range for the studied system is found to be between 10 and 22 degrees Celsius [7].

Objectives:

- Design and develop a real-time water quality monitoring system
- Implement NodeMCU with TDS and temperature sensors for real-time data acquisition
- Design a web server/app to visualize and analyse water quality data of different water sources from remote.

System Architecture:

The system consists of-

1. **NodeMCU (ESP8266) Microcontroller for Data Acquisition:** The NodeMCU serves as the central processing unit of the system, responsible for data acquisition from the connected sensors and facilitating data transmission to the web server/app.
   - Utilizes the ESP8266 module for Wi-Fi connectivity, enabling seamless communication with the web server/app.
   - Reads data from the TDS sensor and temperature sensor through specified pins.
   - Implements firmware to process sensor data, ensuring accuracy and reliability.

2. **TDS Sensor for Measuring Total Dissolved Solids:** The Total Dissolved Solids (TDS) sensor is employed to quantify the concentration of dissolved solids in water, providing a crucial parameter for assessing water quality.
    - Utilizes electrical conductivity to measure the concentration of ions in the water, including minerals, salts, and other dissolved substances.
    - Outputs a voltage signal proportional to TDS, which is interpreted by the NodeMCU for further processing.

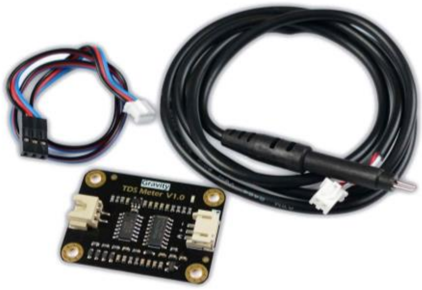


Figure 1 :TDS sensor

3. **Temperature Sensor for Measuring Water Temperature:** The temperature sensor plays a vital role in determining water quality, as temperature variations can impact the solubility of gases and the overall chemical composition of water.
    - Utilizes a temperature-sensitive element to measure the water temperature accurately.
    - Outputs temperature data in a readable format for integration into the overall water quality assessment.

Figure 2:Temperature sensor

4. **Web Server/App for Data Visualization:** The web server/app acts as the user interface, providing a platform for visualizing, analysing, and interpreting real-time water quality data.
    - Displays sensor readings in a user-friendly format, such as numerical values
    - Allows users to monitor water quality remotely, facilitating prompt decision-making regarding the suitability of water for consumption.
5. **Port Selection Options for Specifying the Water Source:** Port selection options enhance the system's versatility by allowing users to specify and monitor different water sources, such as water from various purifiers or filters.
    - Incorporates a user interface element that enables the selection of a specific port or water source.

- Modifies the data displayed on the web server/app based on the chosen port, facilitating targeted monitoring and analysis.

Cost Estimation:

Item No.	Item Name	Pieces	Cost
1.	Waterproof DS18B20 Digital Temperature Sensor	1	855
2.	Gravity Analog TDS Sensor/ Meter	1	2900
3.	ESP8266 NodeMCU V3 Development Board with CH340 WIR-00093	1	420
4.	Bread Board	2	60
5.	CD4051- 8-Channel analog multiplexer		30
6.	Resistor	2	4
7.	Led	2	4
8.	PVC board	1	50
9.	Jumper wire	15	30
Total			**4353**

Methodology:

The project methodology involves:

1. **Sensor Setup:** The sensor setup involves strategically mounting a Gravity Analog TDS sensor, a DO sensor, and a temperature sensor in close proximity to the water filter. These sensors are connected to a microcontroller board, which facilitates the acquisition of real-time readings at regular intervals. The system calculates the conductivity from the TDS value using a specified conversion factor and displays the sensor readings, including temperature, TDS, DO, and conductivity, on a user-friendly mobile app.

2. **Data Acquisition and Processing:** Water quality assessment is a critical aspect of the project, where threshold values for each parameter are defined based on established drinking water standards. The measured values are then compared against these thresholds, and the system provides a clear indication of water quality, determining whether the water is deemed drinkable or not. The parameters considered for assessment are temperature, TDS, DO, and conductivity, with temperature ideally falling within the range of 10-22 degrees Celsius.

3. **<u>Water Quality Assessment:</u>** Measured values will be compared against predefined threshold values for each parameter to determine the potability of the water.

4. **<u>NodeMCU Communication and Mobile App:</u>** To enhance the accessibility and usability of the system, communication between the NodeMCU board and a mobile app is established using Wi-Fi technology. The mobile app serves as an interface to receive sensor data and water quality assessment results in real-time. It provides users with a detailed overview of each filter's status (drinkable or not) and an overall summary of the water quality monitoring system.

5. **<u>Deployment and Testing:</u>** The validation of the system includes the deployment of sensors and the mobile app in practical settings. Rigorous testing is conducted to ensure the accuracy of measurements and the reliability of water quality assessments. Continuous monitoring of the system's performance is undertaken, with adjustments made as necessary to optimize its functionality [3] [4].

This project not only addresses the technical aspects of sensor integration and data processing but also emphasizes the practical application of real-time water quality monitoring for safeguarding public health. Through the implementation of this system, we aim to contribute to the ongoing efforts to ensure access to safe and clean drinking water for communities worldwide.

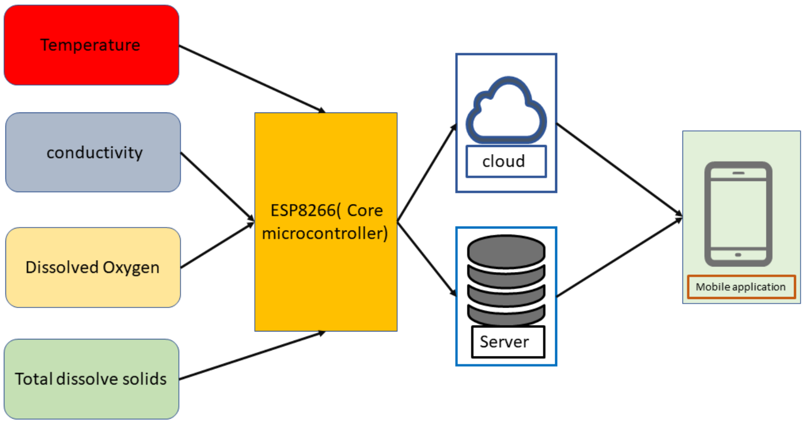


Figure 3: Methodology diagram

Figure 3 illustrates the core components of our water quality monitoring project, centered around the Esp8266 (nodemcu) microcontroller. Employing two TDS sensors and a temperature sensor, the system assesses critical parameters—TDS, temperature, Dissolved Oxygen, and conductivity—from a meticulously filtered water source. Once the sensors collect data, the Esp8266 processes and transmits it to a designated server. This server acts as an intermediary, linking the microcontroller to a mobile application. Users can access real-time data, empowering them with valuable insights for prompt decision-making in water quality management. The project showcases the seamless integration of sensors, microcontroller, server, and mobile application for efficient and comprehensive water quality monitoring.

Hardware Implementation:

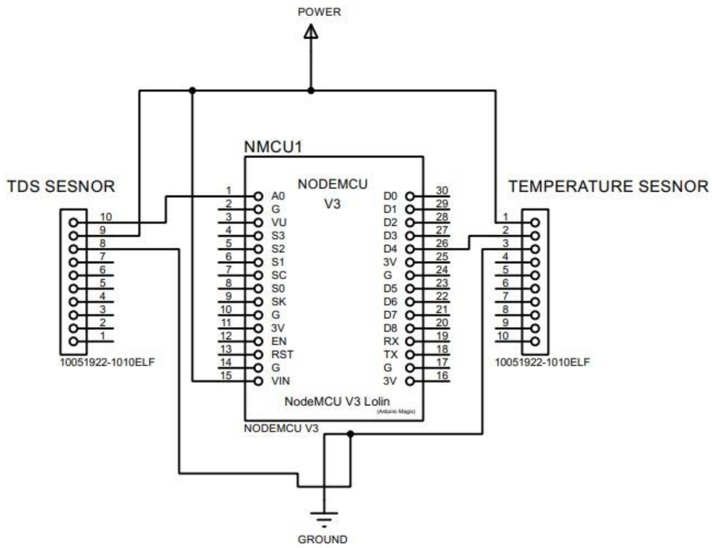


Figure 4: Hardware circuitry

The circuit diagram shows a NodeMCU microcontroller board connected to a TDS sensor and a temperature sensor. The TDS sensor measures the total dissolved solids in water, while the temperature sensor measures the water temperature. The NodeMCU board is powered by a 5V power supply and communicates with the sensors using analog-to-digital converters (ADCs). The TDS sensor is connected to the NodeMCU board at pin A0. The temperature sensor is connected to the NodeMCU board at pin D1. The NodeMCU board also has a port selection module, which allows you to select which water purifier or filter's water you want to monitor. The NodeMCU board is programmed to read the sensor values and calculate additional parameters like DO and conductivity. The NodeMCU board then sends this data to a web server or app, which displays the real-time sensor readings and water quality assessment.

Here is a more detailed explanation of the pin connection of the circuit diagram:

- VCC: This is the positive power supply terminal. The NodeMCU board is powered by a 5V power supply, so the VCC terminal should be connected to the 5V output of the power supply.
- GND: This is the ground terminal. The NodeMCU board and the sensors should all be connected to the same ground terminal. This ensures that all the components are at the same electrical potential.
- A0: This is an analog input pin on the NodeMCU board. The TDS sensor is connected to this pin.
- D1: This is a digital input/output pin on the NodeMCU board. The temperature sensor is connected to this pin.
- D6: This is a digital input/output pin on the NodeMCU board. The port selection module is connected to this pin.

- RX: This is the receive pin on the NodeMCU board. It is used to receive data from the web server or app.
- TX: This is the transmit pin on the NodeMCU board. It is used to transmit data to the web server or app.

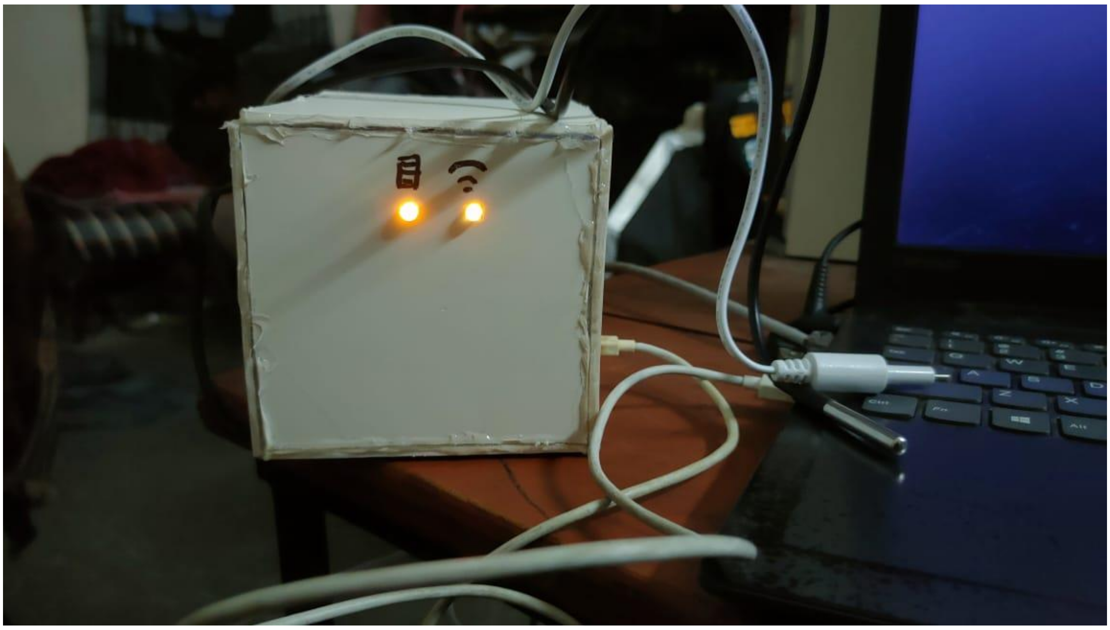
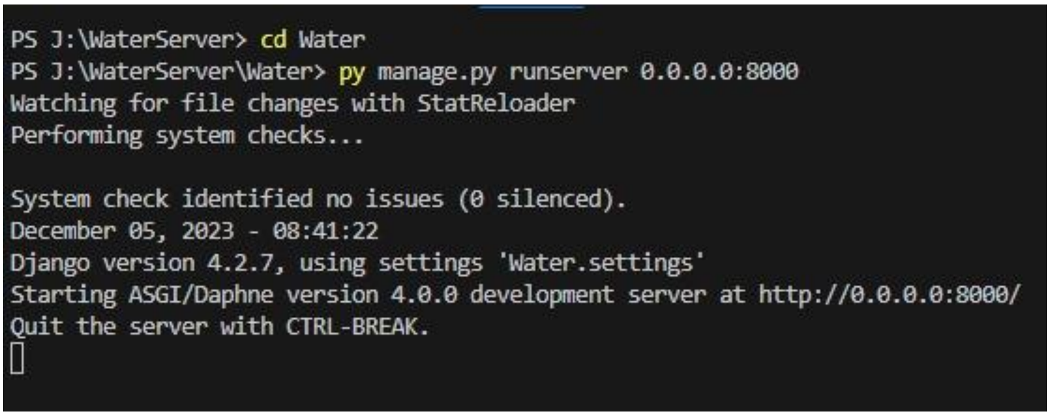


Figure 5:Hardware Implementation

Here we implemented the project according to our designed circuit diagram.

Software Implementation:

The software implementation comprises two distinct segments: the server and the web application. Figure 6 visually represents the server, while Figure 6 provides a depiction of the application interface. These components work collaboratively to facilitate the seamless functioning of the system, showcasing a well-integrated software architecture. The server and web application serve as integral elements in the overall software framework, as illustrated in Figures 6 and 7, ensuring effective communication and interaction within the system.



```
PS J:\WaterServer> cd Water
PS J:\WaterServer\Water> py manage.py runserver 0.0.0.0:8000
Watching for file changes with StatReloader
Performing system checks...

System check identified no issues (0 silenced).
December 05, 2023 - 08:41:22
Django version 4.2.7, using settings 'Water.settings'
Starting ASGI/Daphne version 4.0.0 development server at http://0.0.0.0:8000/
Quit the server with CTRL-BREAK.
```

Figure 6:Server

Figure 7:Application Interface

System Workflow:

- **Initialization:** Power on the system, ensuring the NodeMCU, TDS sensor, and temperature sensor have a stable power supply. The NodeMCU initializes its Wi-Fi module and establishes a secure connection to the designated network. The web app is accessed through a web browser or a dedicated application.
- **Sensor Data Acquisition:** The NodeMCU initiates the data acquisition process by reading analog signals from the connected TDS sensor and temperature sensor. Raw sensor data, representing Total Dissolved Solids and water temperature, is obtained.
- **Data Processing and Calculation**: The NodeMCU firmware processes raw sensor data, applying calibration algorithms to ensure accuracy. TDS sensor data is converted into Total Dissolved Solids readings, and temperature sensor data is interpreted for accurate temperature values. Additional parameters such as Dissolved Oxygen (DO) and conductivity are calculated based on the acquired sensor data.
- **Data Transmission:** The NodeMCU establishes a secure Wi-Fi connection using the ESP8266 module. Data packets containing water quality parameters (TDS, temperature, etc.) are transmitted to the designated web server or app using HTTP/HTTPS protocols. Transmission occurs at regular intervals, ensuring real-time updates.

- **Web App Interaction:** Users access the web app through a web browser or a dedicated application. The web app provides a user-friendly interface displaying real-time water quality data, historical records, and system status.
- **Data Visualization and Analysis:** Sensor readings are visualized through graphs, charts, or numerical displays on the web app, allowing users to interpret the information easily. Port selection options enable users to specify the water source or purifier/filter they want to monitor. Users can analyse historical data, compare trends, and make informed decisions regarding water quality.
- **System Shutdown:** When not in use or during maintenance, the system can be powered down safely. The web app can be closed or accessed as needed for future monitoring sessions.

Discussion:

Water quality monitoring, employing Total Dissolved Solids (TDS), temperature, and conductivity sensors, has become pivotal in environmental management. TDS sensors quantify dissolved substances, temperature sensors track environmental conditions, and conductivity measurements indicate salinity and contamination levels. Integrating a server and web application enhances real-time data access and analysis. The server acts as a centralized hub for data storage, while the web application provides a user-friendly interface for stakeholders to interpret and respond to water quality data promptly. This comprehensive approach ensures efficient water resource management and environmental conservation.

Conclusion:

This project successfully developed a cost-effective and reliable Real-Time Water Quality Monitoring System (RTWQMS). The RTWQMS continuously monitors critical water quality parameters, including temperature, TDS, DO, and conductivity. Real-time data is transmitted to a mobile app, enabling users to monitor water quality and assess its potability. The system's accuracy and reliability were validated through rigorous testing, paving the way for its deployment in practical settings. This project contributes to ensuring access to safe and clean drinking water for communities by providing a valuable tool for water quality monitoring. By continuously monitoring and evaluating water quality, communities can make informed decisions regarding water usage and treatment, ultimately promoting public health and well-being.

References:

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