Water Quality Estimator

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Abstract

This report presents the development and implementation of a water quality monitoring sensor designed to assess the purity of water from natural sources, particularly in remote locations and during outdoor expeditions. The device integrates multiple sensors, including pH, temperature, conductivity, MQ135 and PM2.5 sensor , to evaluate key water quality parameters. The sensors are calibrated and connected to an Arduino Mega, which reads the data and displays it on an ST7735 display. The device is powered by an external 5V battery. The user-friendly interface provides real-time sensor data, ensuring accessibility and ease of interpretation. Based on threshold ranges, the device can determine whether the water is suitable for drinking. This project demonstrates significant progress toward developing a reliable, on-site water quality assessment tool, promoting health and well-being, particularly in outdoor and remote environments.

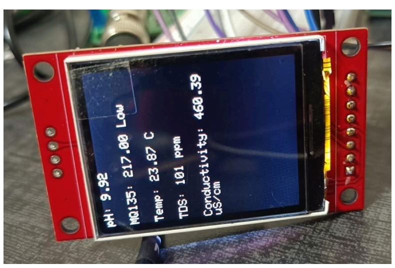


Fig1:Shows final display

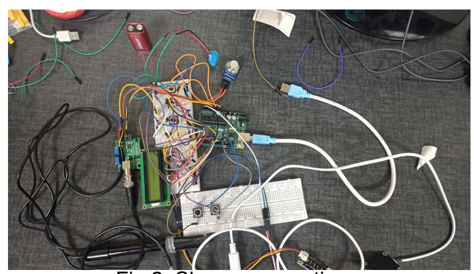


Fig 2: Shows connections

1 Introduction

Access to clean and safe drinking water remains a significant challenge in many parts of the world, especially in remote areas and during outdoor activities. The presence of contaminants in natural water sources such as rivers and streams can lead to serious health issues. As such, there is a pressing need for reliable and portable solutions that can quickly assess water quality to ensure it is safe for consumption.

To address this issue, we embarked on a project to develop a water quality monitoring sensor capable of evaluating the purity of water from natural sources. This device aims to serve individuals such as travelers, hikers, and residents of remote locations, offering them a means to verify the safety of their drinking water during their journeys.

The core objective of our project is to design and build a sensor system that can measure key water quality parameters: pH, turbidity, conductivity, and temperature. By integrating these sensors into a single device, we hope to provide a comprehensive tool for water quality assessment. Our system uses an Arduino Mega to read the data from the sensors and displays the results on an ST7735 screen. Powered by an external 5V battery, the device presents real-time data, allowing users to determine water safety based on specific threshold.

This report outlines the development process of our water quality monitoring sensor, detailing the calibration of each sensor and their integration into the Arduino-based system. It also discusses the user-friendly interface designed to display sensor data clearly and accurately. By combining multiple sensors into one cohesive device, this project aims to make water quality assessment more accessible, particularly for those in challenging environments where water safety is a critical concern.

2 Components:

i)Sensors

- pH sensor
- TDS sensor
- Conductivity sensor
- Temperature sensor
- MQ135 sensor

ii) Micro controller n display

- Ardiuno Mega
- ST7735 display

iii) Others

- Breadboard
- 9V battery
- Jumper Wires

3 Sensors and their Calibration

3.1 pH Sensor

A pH sensor works by measuring the potential difference generated by a glass electrode in response to the hydrogen ion concentration in a solution. This potential difference is compared to a stable reference electrode, and the resulting voltage is converted to a pH value by a pH meter.

Calibration:

- Zero Point Calibration:The sensor was immersed in a neutral buffer solution (pH 7.0), the reading stabilized, and the meter was adjusted to match the known pH value.

- Slope Calibration:The sensor was rinsed, immersed in a second buffer solution (pH 4.0), the reading stabilized, and the meter was adjusted to match the known pH value.

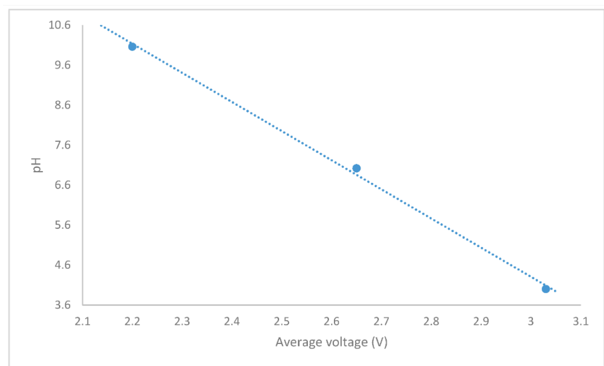
- Slope Calculation:To determine the relationship between pH and voltage, the slope (m) was calculated using the following formula:

  where
  –> $pH_1 = 7, V_1 = 3.232V$

  –> $pH_2 = 4, V_2 = 3.615V$ m= (4−7)

  $m = (pH_2 - pH_1)/(V_2 - V_1)$

  $= -3/0.383 = -7.8328 pH/V$



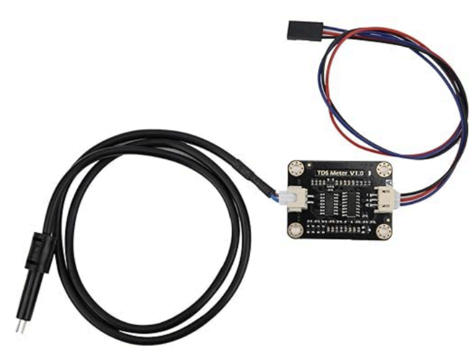
3.2 Conductivity Sensor

A conductivity sensor works by measuring the ability of a solution to conduct an electric current, which is directly related to the concentration of ions in the solution. The sensor typically consists of two or more electrodes placed in the solution. An alternating current (AC) voltage is applied across the electrodes, and the resulting current flow is measured. The conductivity of the solution is then calculated based on the current flow and the known geometry of the electrodes. This measurement is converted to a conductivity value by a conductivity meter.

Calibration :

The conductivity of a 332 ppm NaCl solution is estimated to be around 664 μS/cm. Hence the solution used for the calculation of TDS calibration was used for the Conductivity sensor

Conductivity calibration factor = 664 uS/cm

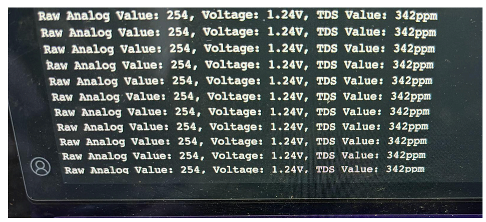


3.3 TDS Sensor

A TDS sensor operates by measuring the electrical conductivity of a liquid solution, reflecting the concentration of dissolved solids. It uses electrodes to detect current flow, which is directly related to the amount of ions present. A TDS meter converts the conductivity data into a TDS value using a specific conversion factor.

Calibration :

• The TDS sensor was calibrated using a 332 ppm NaCl solution. The analog values produced by the sensor were recorded and compared with the known concentration.
• Calibration Factor: The calibration factor was calculated as 342/462 to map the sensor's analog output to the actual TDS value, ensuring accurate and reliable measurements.
TDS calibration factor = 342ppm



3.4 Temperature Sensor

The DS18B20 temperature sensor operates digitally, measuring temperature through a built-in sensor and transmitting data via a single-wire digital interface. It offers high accuracy and resolution, making it suitable for various temperature monitoring applications without the need for manual calibration.

Calibration : Unlike analog sensors, DS18B20 temperature sensors do not require manual calibration. They are factory-calibrated and provide accurate readings within their specified temperature range without user intervention.

3.5 MQ135 Sensor

The MQ135 is typically used as an air quality sensor, sensitive to various gases like NH_3, NO_x, alcohol, benzene, smoke, and CO_2. The MQ135 gas sensor operates by detecting changes in electrical conductivity within its tin dioxide sensing element when exposed to gases. It converts these changes into measurable signals indicative of gas concentration

Calibration :

-> Reading 1: In clean air - 400ppm
-> Reading 2 : On the surface of a marsh -1000ppm

->Threshold= (Reading 1+ Reading 2)/2= 700ppm

3 Integration

Code - Water Quality Estimation Device Code

The integration of various sensors into the water quality estimation device involved a systematic approach to ensure accurate readings and efficient data processing. Below is a summary of the integration process, detailing the components and methods used:

Components and Pin Connections

The device integrates several sensors, each connected to specific pins on the Arduino Mega. The key components include:

- pH Sensor: Connected to analog pin A0.
- MQ135 Sensor: Connected to analog pin A1 for air quality measurement.
- TDS Sensor: Connected to analog pin A2 for measuring total dissolved solids.
- Conductivity Sensor: Connected to analog pin A3.
- DS18B20 Temperature Sensor: Connected via a OneWire bus on digital pin 2.

Additionally, an Adafruit ST7735 display module is used to present the sensor data, connected to the Arduino using pins 8, 9, and 10.

Data Processing and Display

The Arduino Mega handled the data acquisition and processing as follows:

1. **Initialization**: The setup function initialized the display and sensors, filling the screen with a black background and setting the text properties.

2. **Sensor Data Acquisition**: In the loop function, sensor readings were taken periodically. Each sensor's data was read, processed, and stored in respective variables.
3. **Data Display**: The processed data from all sensors was displayed on the ST7735 screen in a user-friendly format. The display showed pH, air quality (MQ135), temperature (DS18B20), TDS, and conductivity values, allowing the user to easily interpret the water quality.

4 Result and Conclusion

The project demonstrates the feasibility of a water quality monitoring device that integrates multiple sensors into a single, cohesive system. By leveraging an Arduino Mega and a variety of calibrated sensors, the device provides real-time, accurate assessments of key water quality parameters. The user-friendly display interface ensures that users can easily interpret the data to determine water safety. Although the device is currently larger than initially envisioned, it represents a significant step toward reliable and accessible water quality monitoring, especially for individuals in remote locations or outdoor settings. Future work may focus on miniaturizing the device for enhanced portability while maintaining its accuracy and functionality through deploying an ML model.