

Water Quality Monitoring and Purification System Using Arduino

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Abstract: This project presents a smart and cost-effective system for water monitoring and water purification based on Arduino. The objective is to provide safe drinking water by monitoring vital water quality parameters continuously like pH, turbidity, temperature, and Total Dissolved Solids (TDS). The Arduino microcontroller reads data from sensors and provides the output in real-time. If the water turns out to be unsafe, the system turns on a simple purification unit employing filters and UV light. This arrangement is low-cost, low-maintenance, and ideal for rural and mountainous regions where access to clean water is sparse. The system can also be enhanced with IoT to transmit information online for far-off monitoring. As a whole, it is a simple yet efficient remedy for water quality control.

Keywords: Arduino, IR sensor, Turbidity sensor, dc pump, 16*2 LCD Display, Calibration Button, Capacitor

I. INTRODUCTION

Clean and safe drinking water is important to human health, but substandard quality of water persists in most communities, especially developing and rural communities. Waterborne diseases, resulting from dirty water, lead to serious health effects. Traditional water testing techniques are expensive, require laboratory facilities, and provide slow feedback. As a solution to this issue, a growing demand has been established for smart, affordable, and easy-to-use systems that simultaneously filter and monitor water.

The proposed system is also designed to be user friendly, energy saving, and best suited for operation in remote or resource-limited areas. It can also be combined with Internet of Things (IoT) technology for remote monitoring and logging of data. The system generally provides an efficient and scalable means of delivering clean water access.

II. LITERATURE SURVEY

Various researchers and developers have worked on water quality monitoring systems using various technologies to address the problem of water pollution in the world. Microcontroller-based systems have gained popularity in recent years due to their cost and real-time monitoring capabilities. Researchers have also tried to integrate Internet of Things (IoT) platforms, as in Singh et al. (2020), where remotely water quality data were monitored by cloud services using Nedelcu and Blynk application. Past research has incorporated purification methods, for example, simple filtration or UV light, for example, proposed by Ramesh et al. (2021), who built a double system with a monitoring and treating capacity for water. Past research also verifies the effectiveness of sensor-based systems to monitor water but also indicates issues such as sensor calibration, source of power for off-grid locations, and maintenance. Based on these studies, the system here aims to create a more integrated, low-cost, and user-friendly system that covers both monitoring and purification, especially suitable for underdeveloped and rural communities.

II. METHODOLOGY

A. Existing system

in the current water quality monitoring systems, water samples are normally acquired manually and analysed in the laboratory using chemical and physical means. These conventional methods, though accurate, are labor intensive,



costly, and need experts, thus they are not practical for repeated or distant monitoring. They cannot generate real-time information, which can result in late reactions in the event of contamination of water. This latency may result in severe health hazards, particularly in waterborne endemic districts. There are certain automated systems based on high-technology developed; however, these are usually complicated, expensive, and not practical for field application in rural or low-income districts. Additionally, most of these systems only have monitoring functions, and they do not have the ability to treat or remove contaminated water, so they are less efficient in providing safe water at the point of use.

B. Proposed System

The suggested system offers a smart, affordable, and real-time water quality monitoring and purification solution based on the Arduino microcontroller. The system has several sensors, such as pH, turbidity, temperature, and Total Dissolved Solids (TDS) sensors, to monitor the quality of water continuously. The sensors are connected to the Arduino, which analyzes the data and shows the results on an LCD display. The device automatically identifies unsafe water conditions; upon detection of any parameter going beyond the safe limit, it activates a purification mechanism. The purification unit consists of the provision for simple filtration to take out suspended matter and a UV light mechanism to destroy harmful microorganisms. The whole setup is low-power consumption, compact, and easy installation, and hence is ideal for rural communities, schools, disaster areas, and areas with resource constraints. Moreover, the system can be supplemented with IoT functionalities like Wi-Fi or GSM modules so that users or authorities can remotely monitor water quality and keep historical records. This combined method not only gives early warning of contamination but also provides instant purification, reducing health hazards and enhancing the supply of clean drinking water.

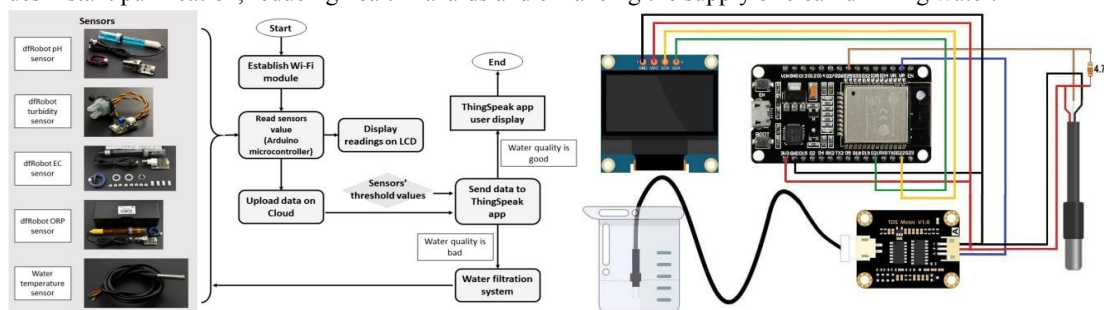


Figure 1 : Block Diagram

B. Hardware and software

When all parameters are within the acceptable range, the water is safe, and the sensor readings are shown on an LCD screen for reference purposes. If any parameter goes above the safe threshold, the Arduino turns on the purification unit. This unit contains a simple filtration unit to remove physical contaminants and a UV light module to get rid of lethal microorganisms and bacteria. Besides, the system can incorporate a power supply unit and other optional communication units like Wi-Fi or GSM for IoT-based remote monitoring. This block diagram presents an efficient, automatic, and real-time system providing safe water by integrating monitoring and purification capabilities

IV. IMPLEMENTATION

A. System Architecture

The system architecture of the IoT-based water quality monitoring system consists of several layers working together. Sensors like pH, turbidity, and TDS measure water parameters and send the data to an Arduino microcontroller. The Arduino processes the readings, compares them with predefined threshold values, and displays them on an LCD. If the water quality is poor, the system uploads the data to the ThingSpeak cloud platform and activates a water filtration unit using a relay. The Wi-Fi module ensures communication with the cloud, while the ThingSpeak app allows users to remotely monitor the water quality status.



Requirement

1. Arduino Uno

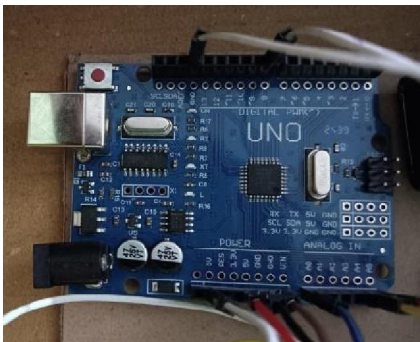


Figure 3 : Arduino Uno

The Arduino UNO is not just a microcontroller board but a highly flexible development platform used for creating interactive electronics projects. It's an open-source hardware and software system, widely popular among hobbyists, educators, and professionals. The ATmega328P microcontroller, which powers the Arduino UNO, offers a robust environment for rapid prototyping of electronic systems, where sensors and actuators can interact in real-time through an easy-to-use interface.

2. IR Sensor 2pices



Figure 4 : IR Sensor

An Infrared (IR) sensor operates on the principle of emitting infrared light and detecting its reflection from nearby objects. It consists of two main components: an IR LED that emits infrared light and a photodiode or phototransistor that detects the reflected light. The amount of light reflected back to the sensor varies based on the distance and properties of the object, such as its color and texture. The sensor converts this reflected light into an electrical signal, which can then be interpreted to determine the presence or proximity of an object.

IR sensors are commonly used in various applications like proximity sensing, motion detection, and water level monitoring. In water quality systems, they can detect the water level in tanks by measuring the reflection of infrared light from the water's surface. When the water level changes, the amount of infrared light reflected back to the sensor varies, allowing the system to make decisions such as activating or deactivating a pump based on the water's level.

3. Turbidity sensor



Figure 5: Turbidity sensor



The turbidity sensor measures the cloudiness or haziness of water, which indicates the presence of suspended particles. Typically uses an infrared light-emitting diode (LED) and a photodetector to measure the scattering of light caused by particles in the water. Turbidity is an important parameter in water quality monitoring, as high turbidity may indicate the presence of harmful contaminants or microorganisms

4. DC pump



Figure 6 : dc pump

A DC pump is used to pump or circulate water through the filtration or purification system. When the water quality parameters (like turbidity or pH) exceed a certain threshold, the pump will be activated to push clean or purified water through the system. The DC pump operates with a direct current motor that drives the impeller inside the pump. The Arduino will control the pump's operation using a relay or a MOSFET. The pump might turn on if the water needs to be filtered or when the system is in purification mode.

5. Capacitor

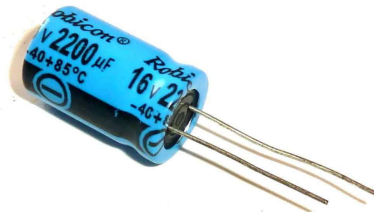


Figure 7 : Capacitor

A capacitor is used in various parts of the circuit, primarily for filtering, noise reduction, and stabilizing voltage supply. A capacitor stores electrical energy and releases it when needed, which helps maintain a steady power supply to components. It can also smooth out power spikes or fluctuations from the power source.

6. Calibration Button



Figure 8 : calibration button

A calibration button allows users to manually calibrate the sensors (e.g., turbidity sensor, pH sensor) to their reference values. When the button is pressed, the Arduino will enter calibration mode, where sensor readings are adjusted to known standards. This ensures accurate measurements of the water quality.



7. LCD Display



Figure 9: LCD Display

The 16x2 LCD Display is used to show real-time readings from the sensors (e.g., pH level, turbidity, TDS) and any system status (e.g., pump on/off, system warnings). This display consists of a 16-character wide, 2-line text display. The characters are formed by individual segments of liquid crystals that change according to the data fed to the screen from the Arduino. In your project, it will show values like turbidity levels, water quality status, or alerts if certain thresholds are crossed.

C. Flowchart

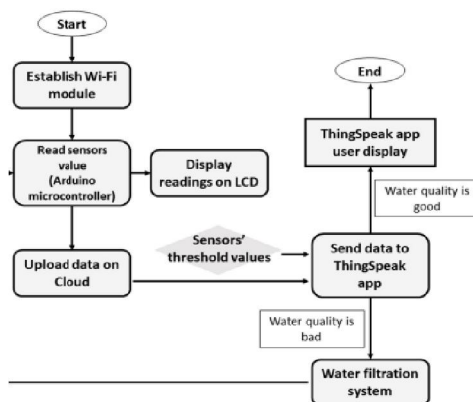


Figure 10 : Flowchart Functional Requirements are as follow :-

Data Collection: Sensors (pH, turbidity, TDS, temperature, and dissolved oxygen) continuously measure water quality parameters from the water source.

- Data Transmission to Arduino: The sensor data is sent to Arduino Uno, which processes the information.
- Data Processing: Arduino compares the sensor values with pre-set WHO or BIS standards to determine if water quality is within safe limits.
- Safe Water Monitoring: If the water quality is within safe limits, the system continues to monitor without action.
- Compare current level with threshold limit

Requirements are as follow :-

- o Start
- o Read sensor values using Arduino microcontroller – to gather water quality data.
- o Display readings on LCD – to show real-time water quality readings locally.
- o Upload data to Cloud – for remote access and storage.
- o Compare values with threshold –
 - If water quality is good → just display the data.
 - If water quality is bad
 - Send data to the ThingSpeak app
 - Activate the Water Filtration System.
 - End



V. RESULTS & DISCUSSION

The results of the Arduino Uno-based Water Quality Monitoring & Purification System demonstrate its effectiveness in real-time monitoring and purification. The system successfully detects key water parameters such as pH, turbidity, TDS, temperature, and dissolved oxygen, processing the data through Arduino Uno and comparing it with predefined safe limits. When contamination is detected, alerts are triggered via an LCD display and IoT platforms, and the purification system—comprising UV filtration, activated carbon filters, and chemical dosing—is activated to restore water quality. The system ensures continuous monitoring, automatic purification, and user notifications, making it a reliable, cost-effective, and scalable solution for safe drinking water.



Figure 11 : Start-up Display of the System

VI. CONCLUSIONS

The Arduino Uno-based Water Quality Monitoring & Purification System is an efficient, cost-effective, and real-time solution for ensuring safe drinking water. This system successfully integrates sensor-based water quality monitoring, automated purification mechanisms, and IoT-enabled remote tracking to detect and address water contamination issues. By utilizing sensors such as pH, turbidity, TDS, temperature, and dissolved oxygen, the system provides continuous real-time data on water quality. The Arduino Uno microcontroller processes the collected data, compares it with standard safety thresholds, and determines whether the water is safe for consumption. If the water quality is within safe limits, the system continues monitoring. However, when contamination is detected, it triggers alerts and activates automated purification mechanisms to treat the water.

The automated purification process includes technologies such as UV filtration, activated carbon filtration, and chemical dosing, which work together to remove harmful bacteria, chemicals, and suspended particles. Once purification is complete, the water is re-tested using sensors, ensuring it meets safe drinking water standards. The system continuously cycles between monitoring, purification, and re-testing until the water quality is restored. Additionally, the IoT integration enhances the system's usability by enabling remote access through platforms like Blynk or Thing Speak, allowing users to monitor water quality and receive real-time alerts on their mobile devices.

VII. FUTURE SCOPE

The Arduino Uno-based Water Quality Monitoring & Purification System has immense potential for future advancements. With increasing concerns over water pollution, climate change, and clean water scarcity, further



development of this system can enhance its efficiency, accuracy, and applicability. Below are some key areas for future improvements:

1. Integration of Advanced Sensors

Currently, the system relies on basic sensors to measure pH, turbidity, TDS, temperature, and dissolved oxygen. In the future, additional sensors can be integrated to detect heavy metals (lead, arsenic, mercury), pesticides, bacteria (E. coli), and industrial pollutants. This will enable a more comprehensive assessment of water quality and ensure better safety standards.

2. AI and Machine Learning for Predictive Analysis

By incorporating Artificial Intelligence (AI) and Machine Learning (ML), the system can analyze historical water quality data to predict contamination trends. AI-based models can identify patterns in water pollution, helping authorities take preventive measures before contamination reaches dangerous levels. Additionally, self-learning algorithms can adjust purification methods automatically based on real-time contamination levels.

3. IoT and Cloud-Based Monitoring for Smart Cities

Future iterations of this system can be connected to cloud-based platforms that allow global data access. Government agencies, municipal corporations, and environmental organizations can monitor water quality remotely using IoT-enabled dashboards. This will support smart city initiatives, where real-time water quality monitoring is integrated into urban infrastructure.

4. Solar-Powered and Energy-Efficient Operation

To make the system sustainable and eco-friendly, future versions can be powered by solar energy. This will be particularly useful for rural and remote areas where electricity supply is limited. Implementing low-power sensors and energy-efficient microcontrollers will further optimize power consumption.

5. Blockchain for Secure Water Quality Data Management

Blockchain technology can be used to store and verify water quality data securely. By ensuring tamper-proof data logging, blockchain can help maintain transparency in water safety reports, which is crucial for government agencies, industries, and consumers.

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