Water Quality Monitoring System Using Raspberry Pi

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***Abstract*—Water quality monitoring is crucial for ensuring safe and clean drinking water. Traditional methods of water quality monitoring are often expensive and time-consuming, making them impractical for many applications. In this project, we present a water quality monitoring system using a Raspberry Pi 0 W that is both affordable and easy to use. Our system incorporates three sensors, including a TDS sensor, a KPE03 pH sensor, and a turbidity sensor, to collect real-time water quality data. The data is then compared with the standard values provided by WHO to determine whether the water is fit for drinking or not. Our system provides a cost-effective and user-friendly solution to water quality monitoring, with potential applications in both developed and developing countries. We believe our research makes a valuable contribution to the field of water quality monitoring and presents an innovative solution for addressing this important public health issue.**

INTRODUCTION

Water quality is a critical issue that affects the health and wellbeing of millions of people around the world. The availability of safe and clean water is essential for various domestic, industrial, and agricultural purposes. According to India's eleventh five-year plan document (2007–12), there are roughly 2.17 lakh poor quality water affected habitations in the nation, with high iron affecting more than half of them, followed by fluoride, salinity, nitrate, and arsenic in that order. Additionally, there are around 10 million instances of diarrhoea, 7.2 lakh typhoid infections, and 1.5 lakh cases of malaria.

Every year, there are instances of viral hepatitis, and poor sanitation and lack of access to clean water are key contributors. The eleventh five-year plan document for India (2007–2012) aims to address water quality issues in all habitations that are affected by it by putting an emphasis on community participation and awareness campaigns as well as giving water quality issues top priority[8]. A study conducted by IIT Kharagpur showed that almost 20% of India's total land area has toxic levels of arsenic in its groundwater[9]. However, water pollution is a significant challenge that threatens the quality of water resources not only in India, but globally. To address this challenge, various water quality monitoring systems have been developed to provide accurate and timely data on water quality parameters. However, many of these systems are expensive, complex, and require technical expertise to operate.

In this paper, we present a water quality monitoring system using Raspberry Pi 0 W, a low-cost, compact, and user-friendly platform that can be used for water quality monitoring. Our system incorporates three analog sensors, namely the TDS sensor, pH sensor, and turbidity sensor, along with an ADC(ADS1115), to measure key water quality parameters such as TDS, pH, and turbidity.

The proposed water quality monitoring system using Raspberry Pi 0 W has several advantages over existing systems. Firstly, it is cost-effective and accessible, making it an ideal solution for small-scale water quality monitoring projects. Secondly, the system is easy to use and requires minimal technical expertise, making it accessible to a wider range of users. Finally, the system provides accurate and timely data on key water quality parameters, helping to inform decision-making around water resource management. This project can be used in household water monitoring, agricultural water monitoring, environmental monitoring and also for research purposes, but our purpose is to test whether the water sample is fit for drinking or not.

Overall, this paper presents a novel approach to water quality monitoring using Raspberry Pi 0 W, which has the potential to improve access to clean and safe water resources globally.

I. LILTEARUE REVIEW

Water is a precious resource that is essential for human health and the environment. However, water pollution has become a global challenge, and it's vital to monitor water quality to ensure safe and sustainable water resources. Smart water quality monitoring systems have emerged as an innovative solution to improve water quality management.

[1]Rizqi Putri Nourna Budiarti, Anang Tjahjono, Mochamad Hariadi, Mauridhi Hery Purnomo, in this research IoT platform has been built which incorporates water condition monitoring sensor, embedded system which can process sensor data and send it to data center, data transmission with MQTT protocol.

[2]Sooryansh Singh, Avinash Kumar, Apurv Prasad, and Nitish Bharadwaj developed a low cost, efficient, real-time water quality monitoring system has been implemented and tested. Through this system, the officials can keep track of the pollution in the water bodies and take needful action immediately. [3]Bharati Sengupta, Soham Sawant, Mayuresh Dhanawade, and Mrs. Anushree Prabhu developed a low cost system for real time water quality monitoring and controlling the flow of water. Their system consists of pH sesnsor, turbidity sensor and temperature sensor but there are certain other parameters that must be

considered such as TDS and electrical conductivity for ensuring good water quality. [4]Nikhil Kumar Koditala, Dr. Purnendu Shekar Pandey worked on paper which presented a practical and economical solution to monitor the quality of water especially in rural areas without any human intervention. This paper also shows the use of various contemporary technologies such as IoT, cloud computing and Machine learning.
[6]Monira Mukta, Samia Islam, Surajit Das Burman and Ahmed Wasif developed an IOT based Smart Water Quality System using various sensors and ML to test any water sample and classify it as fit for drinking or not. One such study was conducted by [7] Pradeepkumar M, Monisha J, Pravenisha R, Praiselin V, Suganya Devi K which shows their work on their paper that discusses not only sensor based system but also introduces cloud computing architecture into IoT which makes the sensor data accessible remotely.

II. SYSTEM OVERVIEW

The proposed Water Quality Monitoring system is able to gauge pH, turbidity, and TDS of water sample using sensors through the Raspberry Pi Zero W and compare them to the standard values of pH, turbidity, and TDS. The block diagram of Water Quality Monitoring system in Fig. 1 comprises of three different sensors connected with Raspberry Pi Zero W through ADC(ADS1115) as shown in Fig. 2, to measure three significant parameters (pH, TDS, and turbidity) of water samples. The pH sensor KPE 03 is used to measure the presence of acidity or alkalinity of any solution in logarithmic scale. Turbidity sensor is used to detect the presence of suspended particles present in water sample by using light. TDS meter is used to measure total dissolved solid(TDS) in a liquid. It gives concentration of inorganic and organic substances that are dissolved in water sample. The extracted data from these sensors are accessed by the Raspberry Pi and then transferred to the webpage. Real time sensor values are shown on webpage and the result is also shown.

Sr. No	Component	Use
1	Raspberry pi 0 W	For interfacing sensors
2	KPE 03 pH sensor	To gauge pH value of water sample
3	Turbidity Sensor	To gauge turbidity of water sample
4	TDS Sensor	To measure TDS of water sample
5	ADS1115	To connect sensors to Raspberry Pi
6	9V battery	To power the pH sensor module

Table I. List of Components

III. METHODOLOGY

This section provides a detailed account of the research process including data collection, data analysis and interpretation. In this section, we describe the methods used to measure and analyze the water quality parameters, including pH, turbidity, and TDS, in order to determine the quality of the water.
There are several steps that led to the complete working and execution of our project. The first and foremost step is to identify the goals and scope of our drinking water quality monitoring system. The following points show the methodology of our work.
1. Hardware Setup: This step includes determining the types of sensors to be used and the different water quality parameters to be monitored. The parameters which are to be monitored are pH level of the water sample (for which KPE03 pH electrode is used), turbidity level of the water sample (for which turbidity sensor with its module is used), and TDS of the water sample (for which TDS sensor with its module is used). The hardware setup of the water quality monitoring system includes the three sensors used for measuring different parameters of water quality and the Raspberry Pi 0 W used as a microcontroller for collecting and processing data from the sensors. Since all the three sensors used produce analog output, an ADC(ADS1115) is also used to connect the sensors to the Raspberry Pi. Now, we have to setup the Raspberry Pi 0 W and connect it to ADS1115 using the appropriate wiring connections and then install the necessary software libraries for interfacing it with the sensors (e.g. adafruit- circuit python-ads 1x15, adafruit circuit python-ph.). After installing the libraries and setting up the raspberry pi we will connect all the sensors to appropriate pins on ADS1115.

2. Data Collection: This step involves reading the analog signals from the sensors using the GPIO pins of Raspberry Pi and converting the analog values to digital values for further processing and also determining the frequency of data collection.

3. Data Analysis: This step involves the process of data analysis to determine the quality of water. This involves comparing the collected sensor data with the standard values given by WHO for various parameters of water quality, such as pH and turbidity. For

TDS, the Bureau of Indian Standards (BIS) has set the acceptable value of TDS in drinking water at 500ppm[8]. Based on the comparison results, the water is classified as drinkable or non-drinkable.

Parameters	WHO standard values
pH	6.5 - 8.5
Turbidity	<5NTU(Nephelometric Turbidity Units)

Table II. Standard Values

4. Web Development: The development of the web interface for displaying the sensor data and water quality analysis results involves creating a web page using HTML, CSS, JavaScript, and Python and connecting it to the Raspberry Pi using a web server. The web server is created using Flask. The Python code reads the sensor values from the sensors connected to the Raspberry Pi and sends them over the WebSocket connection to the web page. HTML, CSS and JavaScript is used to develop the webpage.

5. Testing: This step involves testing the system under different conditions, such as varying water samples, and comparing the results

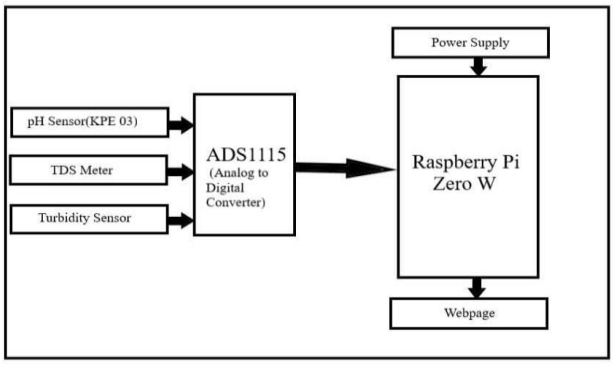

Fig. 1 Block Diagram

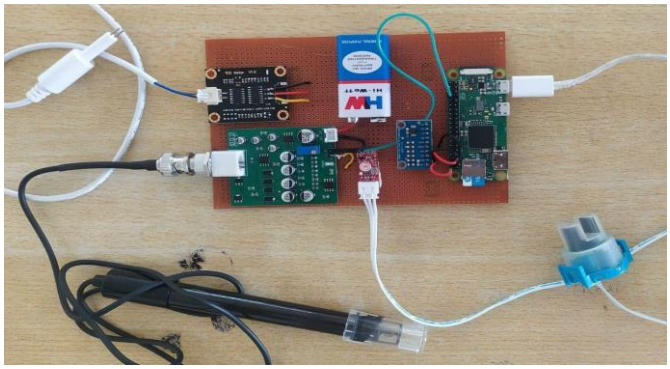

Fig. 2 Sensors with Raspberry Pi

IV. RESULT AND DISCUSSION

Various water samples were collected and pH, turbidity, and TDS of water samples were tested using the water quality monitoring system that incorporates the sensors to gauge the above mentioned parameters. The measured parameters are then compared to the standard values of TDS, turbidity, and pH. The measured values of some of the water sample are shown in Table III below.

Water sample	pH	TDS	Turbidity	System's Result
Mud Water	7.48	2409.04	33.94	Unfit for drinking
Tap Water	7.15	1429.6	5.12	Unfit for drinking
Soap water	8.31	2420.79	12.73	Unfit for drinking
Drinking water	6.97	101.98	2.57	Fit for drinking

supplied at home				
Packaged Drinking water I	7.09	75.07	1.19	Fit for drinking
Packaged Drinking water II	6.89	32.9	0.89	Fit for drinking

Table III. Values of Detected Parameters and System's Result

The detected turbidity and pH values of drinking water samples comply with the standard values defined by the WHO. Although the TDS value also complies with the standard value given by BIS, but it is observed that packaged drinking water samples have drastically low TDS which is not recommended for drinking on a regular basis. Water samples having TDS lower than 80ppm lack vital requisite mineral content which are important for human body. It is not recommended to drink water which has TDS below 80ppm. The TDS in range of 80ppm-150ppm is acceptable. 150ppm-250ppm range of TDS in drinking water is considered to be the best for cardiovascular health[11]. The measured pH values of most of the water samples is around 7 which implies the water is neither too acidic nor alkaline in nature. The acceptable range of pH is shown in Table II.

Turbidity below 1 NTU is considered to be best for drinking water and 5 NTU is the maximum acceptable value. Turbidity indicates presence of various microbes and pollutants in the water sample. Drinking high turbidity water may lead to several gastrointestinal ailments.

The developed system is able to measure the all three parameters with high accuracy and give correct results. The webpage shows the real time sensor data, measures the values from sensors with the standard values in the backend and shows the result as shown in Fig. 3 below.

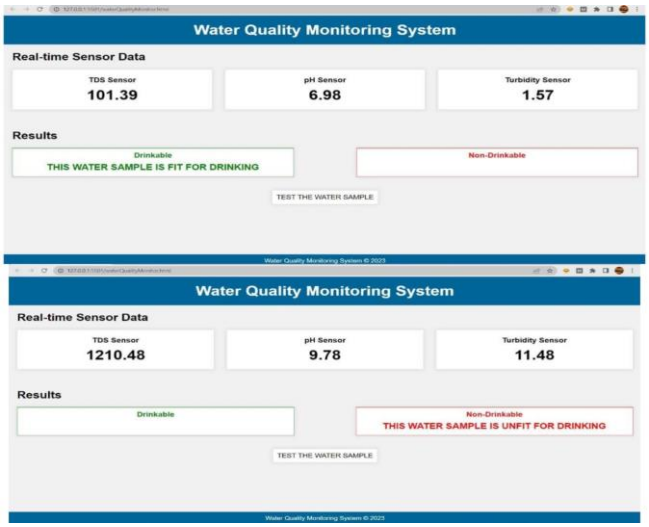

Fig. 3 Developed Webpage

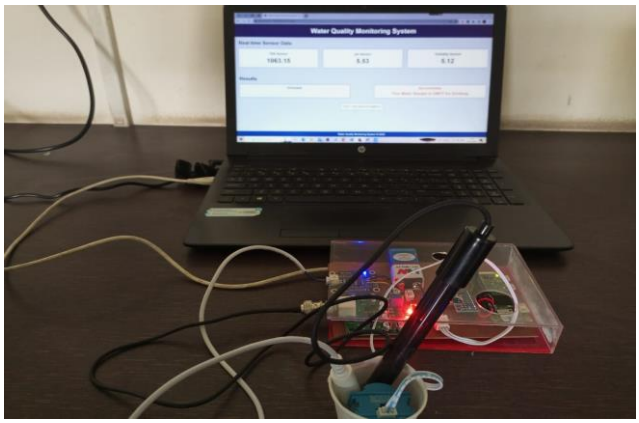

Fig. 4 The complete working project

V. CONCLUSION

The Drinking Water Quality Monitoring System provides an easy to use and cost-effective system using Raspberry Pi 0 W. This system successfully measures the value of pH, turbidity, and TDS of any water sample and shows the result on the webpage along

with the real time sensor values. This project can be useful for various applications. Flask, Python, HTML, CSS, and JavaScript are used to create and the webserver and webpage.
This project is useful for domestic purposes, medical purposes, and environmental purposes. This project makes a valuable contribution a lot to the field of water quality monitoring and sanitation. The developed system provides an innovative technique of water quality monitoring whereas traditional methods of water quality monitoring are often high-priced and time-taking. This project can be enhanced further by making use of cloud to store sensor data and display the sensor data remotely on any device.

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