Southeast Europe Journal of Soft Computing ISSN 2233 – 1859
Available online: http://scjournal.ius.edu.ba

Vol 13, No. 1, March 2024, pp. 14-18

Smart Water Quality Monitoring and Treatment Using IoT Technology

[1*]Mayra S. Fulgar, [2]Syed Rafeek Ahmed

[1]Faculty of Engineering,
University of Technology and Applied Sciences
Muscat, Sultanate of Oman
**Corresponding Author*: mayra.sanchez@utas.edu.om

Article Info

Article history:

Article received on 28 12 2024

Received in revised form 20 01 2024

Keywords:

PH sensor, turbidity, total dissolved solids, chlorine content, Arduino Mega, IoT

ABSTRACT: The primary purpose of this study is to design and build a water quality monitoring and treatment system with the concept of the Internet of Things (IoT) using Arduino Mega as a core controller, an esp8266 wifi module to connect to the internet, and smartphones to control and monitor the system. The system utilized a water level sensor to monitor the water level in the tank to avoid possible overflow, and to monitor the essential parameters of water quality such as PH, turbidity, total dissolved solids, and chlorine content, and to perform chlorination as a treatment process to maintain chlorine residuals in water. The Blynk App framework was used to integrate the system into the Internet of Things. In addition, a liquid crystal display (LCD) is employed to view the parameters of water quality, if the internet is not available. These sensors wirelessly send the data they continuously collect on water quality indicators to a centralized server for processing. The server responds to requests for smartphones that the Blynk Apps has installed. The automated control mechanisms are put into place at the water treatment control stage based on the data analysis. Additionally, the smart water monitoring and treatment system has user interfaces that can be accessed via web and mobile applications. These interfaces give stakeholders remote access to real-time information about the quality of the water as well as personalized alarms. Such accessibility improves the ability to make decisions and enables quick responses to crucial water quality occurrences. From the results and findings of the research, the IoT-based Water Quality Monitoring and Treatment System is efficient and effective in detecting water quality and provides treatment using automatic chlorination

1. INTRODUCTION

One of the major issues facing the world today is water contamination. It is among the biggest sustainability challenges. Sustainable environmental elements, like water, are critical to the survival of all life on Earth as well as to the future of all living things [1]. Water quality refers to the properties of water that are chemical, physical, and biological, usually with regard to their suitability for a particular purpose [2]. Water is a fundamental resource that is essential for life, and it is crucial to ensure that it is safe and clean for human consumption. Access to clean and safe water is a critical issue facing governments around the world. The availability of potable water is a crucial aspect of ensuring the health and well-being of a population. However, maintaining the quality of water in distribution systems is a challenging task, and water treatment plants face significant challenges in meeting water quality standards. This is due to pipe degradation, erosion, and material interactions, the existing distribution of water systems lowers the quality of drinking water[3].

consumption. Access to clean and safe water is a critical issue facing governments around the world. The availability of potable water is a crucial aspect of ensuring the health and well-being of a population. However, maintaining the quality of water in distribution systems is a challenging task, and water treatment plants face significant challenges in meeting water quality standards. This is due to pipe degradation, erosion, and material interactions, the existing distribution of water systems lowers the quality of drinking water[3].

2. PROBLEM STATEMENT

The conventional approach to water quality monitoring involves collecting a sample of the water and sending it to a laboratory for manual analysis using analytical techniques. Conventional approaches to assessing water quality require skilled personnel and costly, specialized equipment[4]. In addition, it is prone to human error that might cause data loss. Also, the analysis made by humans may not show patterns that could be used to foresee future analysis like in machine learning.

One approach to addressing these challenges is using the smart technique and Internet of Things (IoT) technology, which can provide real-time monitoring of water quality and enable rapid response to any issues that arise. Water filtration methods aid in eliminating diseases that spread utilizing water, which is the primary concern [5]. On the other hand, numerous critical physical and chemical parameters of water are monitored by sensors in a low-cost system designed for real-time Internet of Things water quality monitoring [6].

3. BACKGROUND

A smart water quality monitoring and treatment system has been proposed and developed. First, the system used conventional filtration to refine the water coming from the municipal water. Second, the system used four sensors such as pH, TDS, turbidity, and chlorine sensors, to monitor and maintain water quality standards. The collected data will be processed and analyzed using IoT technology, providing insights into the quality of water in real time. Additionally, the system is designed to activate an alarm if water quality falls outside the acceptable range, allowing for quick and effective intervention. Third, chlorination process will follow if the measured chlorine content falls behind or exceed the quality level. Chlorine and its compounds, such as chlorine oxide and chloramine, are the most widely used strong oxidants in disinfection techniques. Chlorine effectively combats bacteria and protozoa that give rise to cysts [7].

The project aims to demonstrate the effectiveness of using IoT technology for water monitoring and treatment, particularly in Oman government water supply systems. By developing a reliable and efficient water monitoring and treatment system that uses IoT technology, the system provides a viable solution for ensuring access to clean and safe water. This final project will contribute to the broader field of IoT technology, highlighting the potential for smart water treatment systems to be used in other regions of Oman. This project a will benefit the people, communities, organizations, and government of Oman achieving sustainable development, socio-economic development, health and survival, and a healthy ecosystem.

4. MATERIALS AND METHODS

Hardware and Software Requirements

Arduino Mega 2560 - contains 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, 54 digital input/output pins (of which 15 can be used as PWM outputs), a USB port, a power jack, an ICSP header, and a reset button.

Arduino IDE – it is an open-source software used to write programs for Arduino.

Blynk App - It enables to use a variety of provided applications to create stunning interfaces for the projects.

Chlorine sensor – measure the chlorine content in water. Chlorine measurement is crucial to ensuring water quality because chlorine is one of the sterilization methods used on drinking and industrial water.

Esp8266 wifi module – it is a microchip that allows the microcontrollers to connect to the internet.

LCD Display – a Liquid Crystal Display to display information on the screen that can be used to view or monitor the water quality if in case the internet is not available.

pH Sensor - A pH sensor is a scientific device used to accurately measure the acidity and alkalinity in water and other liquid substances. It is used for monitoring the quality of water, either it is acidic, neutral or alkaline.

Total Dissolved Solids (TDS) sensors measure the amounts of TDS in water, which can be used to determine the quality of the water.

Turbidity Sensor - it is an electronic component that measures the amount of light that is scattered by the suspended solids in water [8]. It is used for monitoring and/or detecting the quality of water. It measures the clarity of water, either it is low turbidity or high turbidity. High turbidity means that the water is dirty and low turbidity means the water is clear.

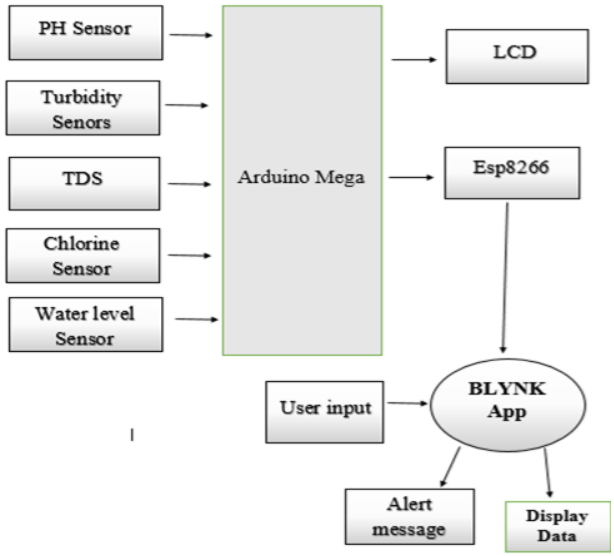

Figure 1. Block Diagram

Figure 1 shows the block diagram of the Water Quality Monitoring and Treatment System. The main heart of the system is an Arduino Mega microcontroller. The system uses four sensors to measure the parameters of water, such as PH, turbidity, total dissolved solids, and chlorine. The system also uses a water level sensor to monitor the level of water in the tank and to avoid overflows. This device contributes to an early warning system by providing advance notice of any potential overflow of water in a water tank at an unexpected time. The LCD is used for viewing or monitoring the water quality parameters that need to be tested as an alternative solution for viewing the water quality parameters for direct checking or if the internet fails. In order to guarantee seamless internet accessibility for smartphones, the employed wireless tool must not only be innovative but also creative, cost-effective, and optimized for the intended purpose. Users of internet wireless must be able to access information regardless of their location or mode of connection [9]. The researchers utilized the esp8266 wifi module in order to have an internet connection. With access to the internet using a smartphone, the Blynk App is used for controlling and monitoring the parameters mentioned. An alert message will pop-up if the level of the measured value falls below or exceeds the acceptable value. The water quality parameter and recommended limits for safe water is tabulated below.

Parameters	Quality Level,	Maximum Level,	Unit
pH	6.5 to 8.5	9	mg/L
Turbidity	1	<5	NTU
TDS	120 - 600	1000	mg/L
Chlorine level	0.5 mg/L after at least 30 minutes contact at pH <8	5	mg/L

Table 1 Parameters and Recommended Limits for Water Quality

(*Source: Special Zone Economic Authority, Duqum (June 2018))*

The water is safe for use if the previously mentioned parameters fall within the recommended level limits. The water is safe for consumption if these parameters are outside the allowable range. The amount of acid or alkali in water is determined by its pH value. Based on Table 1, the recommended limits for pH content is 6.5 to 8.5 mg/L. During the development of program using Arduino Integrated Development Environment (IDE), the following threshold value were set. If the pH content is <6.5, the system will produce sounds to alert the user. If the pH is within the range of 6.5 to 7.5, it means that the pH content is acceptable. On the other hand, if the pH content is >7.5, again the system will notify the user through alert.

The TDS meter measures the number of total dissolved solids like salts, minerals, and metals in the water. As the number of dissolved solids in the water increases, the conductivity of the water increases, and that allow the researchers to analyze the total dissolved solids in ppm(mg/L) of water. As can be gleaned on the table, the range of TDS content in the water at quality level is 120-600 mg/L, and 1000 mg/L at maximum. The turbidity of water is measured by the Nephelometric Turbidity Unit (NTU). It can be described as a fluid's opaqueness

brought on by suspended particles. The turbidity content of water at quality level is 1, with a maximum level of 5 mg/L based on the Table 1. On the hand, the chorine sensor was used to measure the chlorine content of water. As a disinfectant, chlorine eliminates pathogens like norovirus, salmonella, and campylobacter. The chlorine content at quality level is 0.5mg/L at pH content <8, after at least 30-minutes contact.

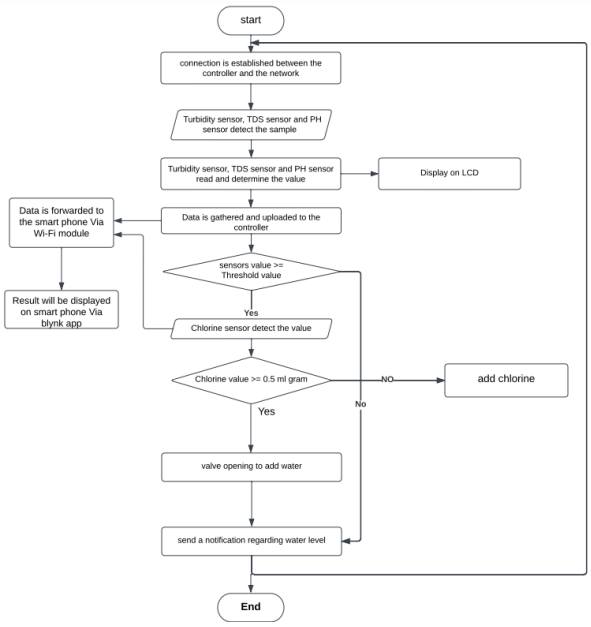

Figure 2. System Flowchart

This project is an IoT-based designed to monitor the water quality and treat using chlorination. This proposed system will be applied in tanks at home that is coming from the Municipal water. The main goal of the project is to provide healthy and clean water suitable for human consumption using the Arduino Mega as a microcontroller. The researchers utilize four sensors; pH sensor, turbidity, TDS and chlorine sensors. During testing, the researcher employed three different types of water: bottled, tap water, and dirty to measure and observe the values of these parameters. Table 2 presents the actual measured values of three different types of water.

Parameters	Measured values during actual testing		
	Bottled Water	Tap Water	Dirty Water
pH	6.8	7.5	9
Turbidity	1	4	5
TDS	118 ppm	517ppm	542ppm
Chlorine	0.5mg/L	1mg/L	4mg/L

Table 2. Measured Value of Water Quality Parameters

As can be observed from the table, the measured pH content for bottled water is 6.8 mg/L, the turbidity is 1, and the TDS is 118 ppm. Based on the measured value of the parameters of the bottled water, it shows that the water is safe for human consumption according to the data presented in Table 1. The researchers also measured the quality of tap water based on the parameters. The pH content is 7.5 mg/L, the turbidity is 4 NTU, and the TDS is 517 ppm. The data shows that the quality of the parameters measured in tap water is at its maximum level, and it is safe to use. During the analysis of the dirty water, the researcher found out that the pH content is 9, which is above the maximum level. This means that the water has some contaminants and is not safe for human consumption. The measured turbidity content is 5, and the TDS is 542 ppm. The measured value implies that the water is not suitable for consumption.

On the hand, the chorine sensor was used to measure the chlorine content of water. According to the result, the measured value of chlorine content in the three different types of water being tested is 05.mg/l, 1mg/l, and 4mg/L respectively. The data shows that the chlorine content of bottled water and tap water is within the range of the quality level of water that is safe for human consumption. Chlorine as a disinfectant eliminates pathogens like norovirus, salmonella, and campylobacter. The proposed system has the capability of automating the chlorination process by dispensing chlorine to the water tank, every 30 minutes if the pH content level falls below 6.5 mg/L or exceeds 8.5mg/L. The valve will open and dispense the required chlorine content. This will regulate the chlorine content of a water to make it safe for consumption.

Figure 3. Testing

Figure 3 shows the image during the actual testing using pH sensor, Turbidity, and TDs sensor. As can be observed, the 4 x 16 LCD was used to observe the content of the parameters of water being discussed.

5. CONCLUSION

Based on the findings, it is concluded that the proposed water monitoring and treatment system is a low-cost system that will benefit the people, community, organization, and Oman government. The system monitors water quality parameters, such as PH, turbidity, total dissolved solids, and chlorine content, and can monitor and control the water quality and level of the water tank by using the Blynk app. It is an effective and efficient solution for monitoring and treating water quality. However, it is recommended to expand the application of the proposed system by analyzing the chemicals available in tap water that cause illnesses such as nausea, vomiting, and diarrhea. These chemicals are lead, copper, and arsenic. With this project, it will help the community and the government ensure and maintain clean and safe water for human consumption

REFERENCES

[1] Z. KILIÇ, “Su Kirliliği Nedenleri, Olumsuz Etkileri ve Önleme Yöntemleri,” *İstanbul Sabahattin Zaim Üniversitesi Fen Bilim. Enstitüsü Derg.*, vol. 3, no. 2, pp. 129–132, 2021.

[2] R. Roy, “An Introduction to water quality analysis,” *ESSENCE – Int. J. Environ. Rehabil. Conserv.*, no. 2, pp. 94–100, 2018, doi: 10.31786/09756272.18.9.2.214.

[3] C. Z. Zulkifli *et al.*, “IoT-Based Water Monitoring Systems: A Systematic Review,” *Water (Switzerland)*, vol. 14, no. 22, 2022, doi: 10.3390/w14223621.

[4] S. A. Sani, A. Ibrahim, A. A. Musa, M. Dahiru, and M. A. Baballe, “Drawbacks of Traditional Environmental Monitoring Systems,” *Comput. Inf. Sci.*, vol. 16, no. 3, p. 30, 2023, doi: 10.5539/cis.v16n3p30.

[5] A. Shabiimam M., K. Tehsin, P. Anas, and S. Shifa, “Treatment of Water Using Various Filtration Techniques : Review Study,” *Treat. Water Using Var. Filtr. Tech. Rev. Study*, vol. 1, no. November 2018, pp. 229–235, 2019.

[6] M. S. U. Chowdury *et al.*, “IoT based real-time river water quality monitoring system,” *Procedia Comput. Sci.*, vol. 155, pp. 161–168, 2019, doi: 10.1016/j.procs.2019.08.025.

[7] S. Sharma and A. Bhattacharya, “Drinking water contamination and treatment techniques,” *Appl. Water Sci.*, vol. 7, no. 3, pp. 1043–1067, 2017, doi: 10.1007/s13201-016-0455-7.

[8] S. Pooja, B. R. Kusuma, and M. S. Priya, “Monitoring of Air and Water Quality,” vol. 8, no. 11, pp. 205–208, 2020.

[9] N. Mazalan, “Application of wireless internet in networking using NodeMCU and Blynk App,” *Semin. LIS 2019*, no. December, 2019.