Research Article

Implementation of Real-Time Reservoir Water Turbidity Monitoring System with Automatic Alarm and Control Using Blynk

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Abstract: The quality of reservoir water can deteriorate due to the accumulation of particles such as mud, sand, and microorganisms, making the water cloudy and unusable. This condition is difficult to monitor directly, especially in reservoirs located at high altitudes. This research developed a real-time IoT-based reservoir water turbidity monitoring system equipped with alarms and automatic drain features through an application. The system is designed using the ESP32 microcontroller, the SEN-0175 turbidity sensor, the HC-SR04 ultrasonic sensor, the buzzer, the DN20 solenoid valve, and the Blynk platform. The turbidity sensor is capable of detecting increased turbidity from 2 NTU to 50 NTU. The ultrasonic sensor shows high accuracy with an average error of 0.41%. The buzzer activates automatically when the turbidity exceeds 25 NTU. The solenoid valve responds to application commands within 2 seconds. The app can display real-time data, notify, and control drainage. This system has been proven to be effective in monitoring water quality, providing early warnings, and facilitating the process of draining reservoirs.

Keywords: Monitoring system, water turbidity, Blynk, Internet of Things, early warning system.

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1. Introduction

Water is an essential element for the survival of all creatures on earth, where water plays an important role in the life of humans, animals, and plants. Therefore, the role of water cannot be replaced in supporting life [1]. For human life, water is needed for various household needs such as drinking, cooking, washing, bathing, and other needs. The availability of a clean water supply system is very important and prioritized so that the needs of people, both those living in urban and rural areas, can be met [2].

The water sources used by the community are quite diverse, such as water from home pumps, PDAM services, or from rivers. In addition, there are still those who use the rainwater that is collected [3]. Water consumption activities by humans are sustainable, but the current challenge is an imbalance between water availability and a progressive increase in needs, and the quality of water for domestic purposes is declining [4]. Therefore, to maintain the continuity of water availability, a water backup system is needed through extraction from drilled wells using pump technology, which will then be stored in reservoirs to ensure that the supply remains available despite disruptions to the distribution system or pump device.

Water reservoirs are an important infrastructure component that is currently widely used by the community and institutions as a container for storing clean water to meet daily needs. There are two main categories of reservoirs, namely underground reservoirs and roof reservoirs. Underground reservoirs are generally positioned around well areas and require a pumping system to distribute water to various points of consumption [5]. In contrast, rooftop reservoirs, which also require a pump for water replenishment, utilize the principle of gravity to directly drain water and other devices.

By utilizing the force of gravity, roof reservoirs can minimize reliance on water pumps, which means they are more efficient in terms of energy and operational costs. Based on these advantages, rooftop reservoirs are more often selected and implemented than underground reservoirs [6].

The location of the placement of the roof reservoir at a certain altitude can cause difficulties in monitoring water conditions directly, so a system that is able to control and monitor in real-time is needed when reservoir water experiences turbidity and a decrease in water quality. Water turbidity is usually caused by the presence of suspended particles such as sand, mud, and clay floating in the water [7]. In addition, the growth of mold, mildew, and bacteria can occur, resulting in water becoming cloudy and smelly [8]. Often unknowingly, clean water used in daily activities such as bathing, cooking, or oral hygiene can be contaminated by bacteria due to a lack of attention in maintaining the cleanliness of the water reservoir. Water reservoirs that are rarely cleaned can cause various health problems, such as skin irritation, itching, dull skin, and even indigestion, such as diarrhea, vomiting, and so on, caused by unclean water.

Several studies have been conducted in the context of similar studies. Maulinda developed an apartment water tank monitoring system through an Android application, aiming to provide a practical solution for managers to monitor water quality and quantity in real-time, while increasing residents' awareness of water use efficiency. The system uses a turbidity sensor (SEN0189) to measure water clarity and an ultrasonic sensor (HC-SR04) to detect water capacity [9]. However, the study has limitations such as a lack of field testing and the potential for WiFi signal interference that can hinder data transmission.

Hapsari et al discuss the development of an IoT-based system to monitor water levels and quality in reservoirs [10]. The system uses a water level sensor and a turbidity sensor connected to the ESP32 microcontroller, as well as the Blynk app for real-time monitoring and control. The goal of the research is to improve the efficiency of water management through automated monitoring and control. However, the study faced obstacles such as potential internet connection issues affecting system response, variations in sensor accuracy, and the need to speed up pump control responses to improve efficiency.

Dida & Watiasih develop an IoT-based water reservoir control and monitoring system that can be accessed via smartphones [11]. The system uses a turbidity sensor SEN0189 to measure water clarity and an HC-SR04 ultrasonic sensor to measure water capacity. The water filling control is regulated by the Mamdani-type fuzzy logic method based on the height and clarity of the water. This research has shortcomings, such as a lack of testing in various environmental conditions and data security aspects that need to be improved.

Delwizar et.al. designed a prototype of an Internet of Things (IoT)-based water clarity monitoring system using turbidity sensors (SEN0189) and ultrasonic sensors (HC-SR04) [12]. The system measures the clarity of the water in the reservoir and displays real-time data through the Blynk app that can be accessed via smartphone. The main goal is to provide effective water quality monitoring to improve water management, especially in Samarinda, Indonesia, which often faces pollution due to floods. The study also suggests the use of larger containers and more accurate sensors for better measurement results in the future.

Based on the studies that have been described earlier, the system developed is limited to monitoring without a warning alarm for users and a control function to drain the reservoir. Therefore, this study aims to develop *a real-time* monitoring system for reservoir water turbidity with alarms that can be controlled using Blynk. This study utilizes turbidity sensors to detect water turbidity and ultrasonic sensors to detect water levels. The system uses a buzzer to provide a warning if the water is too cloudy and needs immediate cleaning. In addition, this system is also equipped with a solenoid valve that functions to control the drain channel in the reservoir. The ESP32 microcontroller plays a role in processing data from the sensor and then sending it to the monitoring application. It allows monitoring of water conditions through a smartphone using the Blynk application. Blynk was chosen as the IoT platform in this study because of its flexibility in IoT device integration, ease of creating user interfaces, and the ability to transmit data in real-time, send automatic notifications, and remotely control devices such as solenoid valves via smartphones.

2. Theory

2.1 Monitoring System

A monitoring system is a mechanism or device designed to monitor, collect, and analyze data in real-time or periodically from a process, device, or environment[13]. The goal is to ensure that the system or process runs according to the desired parameters and to detect any changes, errors, or disruptions that require corrective action.

2.2 Water Turbidity

Water turbidity is an indicator of water quality that indicates the level of clarity or transparency of water. This condition occurs due to suspended particles or other materials that block the passage of light through water. These particles can be organic or inorganic matter, such as mud, sand, clay, algae, bacteria, or other chemical substances [15].

Table 1. NTU Value Standards According to the Ministry of Health

Category	**Turbidity Range**	**Information**
Clear	< 10 NTU	The water is very clear and suitable for use.
Pretty Cloudy	Between 10 – 25 NTU	The water is starting to get cloudy, but it still meets quality standards.
Very Cloudy	> 25 NTU	Water is not suitable for use and requires immediate action.

Table 1 contains the categories of water turbidity levels that refer to the provisions of the Ministry of Health. The NTU (Nephelometric Turbidity Unit) value is used to determine the feasibility of water for hygienic and sanitation purposes. Water is categorized as clear if the turbidity value is below 10 NTU, which indicates that the water is clean and safe to use. The moderately turbid category includes a turbidity value between 10 to 25 NTUs, which indicates that the water is starting to become turbid but still meets quality standards and is safe to use. Meanwhile, water is categorized as very turbid if the turbidity value exceeds 25 NTU, which means the water is no longer suitable for use without further treatment.

2.3 Water Reservoir

A water reservoir is a container that functions to store water and plays an important role in sustainably maintaining water availability. The varied capacity of the water reservoir allows its use to be adapted to specific needs, be it for households, industry, or agriculture. In addition, the use of water reservoirs helps to manage water resources more efficiently, reduce dependence on direct water sources, and minimize potential water shortages in the future [16].

2.4 SoC ESP32 Microcontroller

ESP32 is a system-on-chip (SoC) microcontroller developed by Espressif Systems. The microcontroller has powerful processing capabilities, complete wireless connectivity features, and high power efficiency, making it a popular choice for Internet of Things (IoT) applications [17].

2.5 Turbidity Sensor

The Turbidity Sensor is a tool that functions to detect the level of turbidity of water by utilizing the optical properties of water to light. Water turbidity is generated by suspended particles that are invisible to the naked eye, such as mud or fine dirt, that block the passage of light. This sensor works by comparing the intensity of the reflected light with the light transmitted through the water [18].

2.6 Ultrasonic Sensor

Ultrasonic sensors are devices that use ultrasonic sound waves to measure distance or detect the presence of objects. These waves have frequencies higher than human hearing ability, generally exceeding 20 kHz. This sensor consists of two main parts: the transmitter that produces ultrasonic waves, and the receiver that captures the reflection of those waves from the surrounding objects [19].

2.7 Buzzer

Buzzers are electronic components that function to convert electrical vibrations into sound. This component consists of a coil attached to a diaphragm. As an electric current flows through the coil, an electromagnetic field is formed. This field causes the coil to move back and forth according to the direction of the current and the polarity of the magnet, thus moving the diaphragm and producing air vibrations that sound like sound [20].

2.8 Solenoid Valve

A solenoid valve is an electromechanical device used to control the flow of liquids or gases by opening or closing the flow path using a solenoid mechanism [21]. A solenoid is a wire coil that can create a magnetic field when it is subjected to an electric current. When the current flows, the magnetic field will pull the plunger (or piston) inside the valve, so that the valve can open or close, depending on the type, commonly referred to as normally open or normally closed [22].

2.9 Blynk App

Blynk is a Cloud IoT platform designed for iOS and Android devices, and is used to control various devices such as Arduino, Raspberry Pi, and the like over an internet connection. Blynk presents a digital dashboard that allows users to easily create graphical interfaces, simply by dragging and dropping widgets [11].

3. Method

3.1 Types of Research

This research adopts a Research and Development (R&D) approach to design and develop a water turbidity monitoring system in reservoirs that is equipped with an alarm and can be controlled through the Blynk application [23]. The R&D method was chosen because of its ability to support repeated testing to evaluate the performance of the system under various conditions, such as variations in water turbidity levels or changes in water volume in the reservoirs valve.

3.2 Design and Designing

The system design and design process aims to create a system that works according to what is desired and needed. At this stage, the design and design of the system consists of:

3.2.1 System Schematics

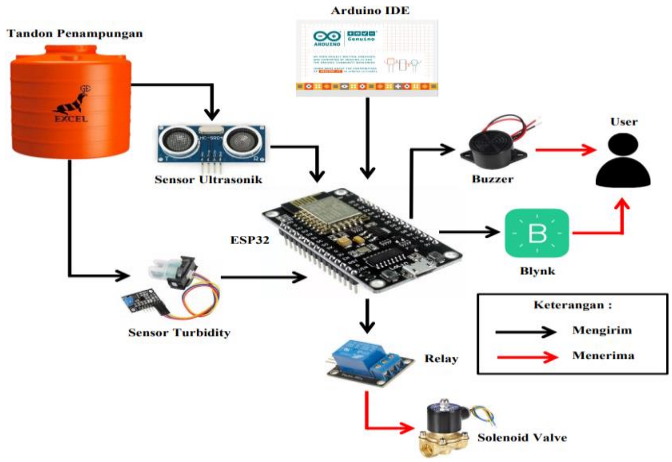

Figure 1. System Schematics

Figure 1 shows the schematic of the system used to understand the design of the system to be designed. The system utilizes turbidity sensors to detect the level of turbidity of the water, as well as uses ultrasonic sensors to measure the level of water level in the reservoir. Both sensors are connected to the ESP23 microcontroller. The microcontroller will read the input from the turbidity sensor, as well as the input from the ultrasonic sensor. If the turbidity level reaches a predetermined limit, the buzzer will activate and sound as a warning, indicating that the reservoir needs to be drained and sterilized immediately. In addition, there is a solenoid valve that acts as a water flow control valve, which is used to empty the reservoir. The feature in the Blynk application that has been provided, users can easily monitor the level of turbidity and water level in the reservoir. The user also has full control to open and close the solenoid valve as needed.

3.2.2 System Architecture

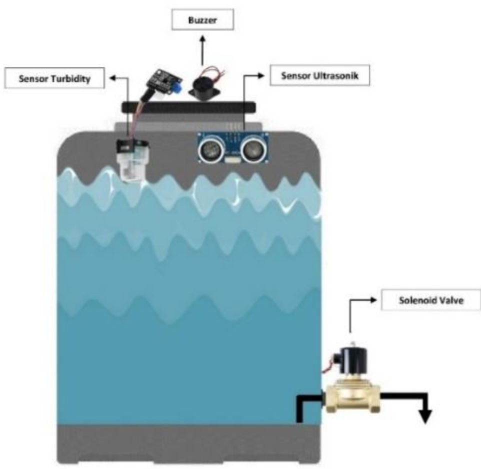

Figure 2. System Architecture

The system architecture contains the outline of the flow of the components. The architecture of the system consists of 4 main components, namely turbidity sensors, ultrasonic sensors, buzzers, and solenoid valves. A detailed description of the system architecture can be seen in Figure 2.

3.2.3 Flowchart System

The system flowchart describes the workflow of the process of monitoring and controlling water turbidity in reservoirs in real-time. The system flowchart can be seen in the following Figure 3.

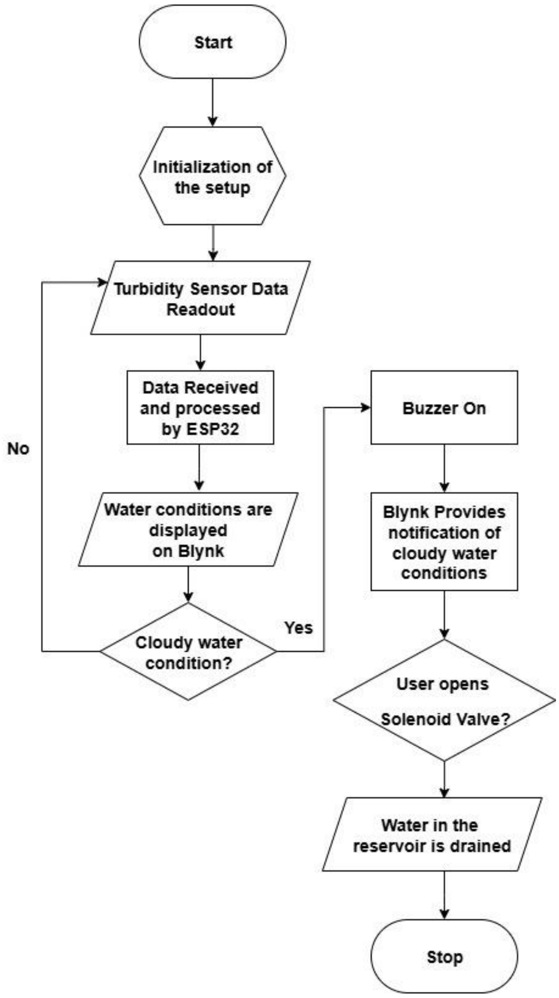

Figure 3. System Flowchart

The reservoir water turbidity monitoring system depicted in the flowchart that can be seen in Figure 3 starts with the initialization and setup of the device, where the turbidity sensor is ready to read the water quality data. The turbidity sensor then measures the level of turbidity of the water in the reservoir, and the resulting data is sent to the ESP32 microcontroller for processing. Once processed, the readings are displayed in real-time in the Blynk app over a Wi-Fi connection, allowing users to monitor water conditions. If the water in the reservoir is not cloudy, the system will continue to read the data repeatedly. However, if the turbidity level exceeds the specified limit, the system will activate the buzzer as a warning. At the same time, the Blynk app will send notifications to users about murky water conditions. The user then has the option to open the solenoid valve through Blynk. If the user decides to open the solenoid valve, the turbid water in the reservoir will be drained automatically, so that the reservoir can be filled with cleaner water. Once the draining process is complete, the system returns to its starting position and is ready to return to monitoring the water conditions in the reservoir. The system allows users to monitor and control water quality efficiently and automatically without the need for manual intervention.

4. Results and Discussion

This research resulted in an IoT-based reservoir turbidity and water level monitoring system that is equipped with a warning alarm and can be controlled through the Blynk application. The Arduino IDE is used to program the ESP32 microcontroller, which regulates the communication between sensors, buzzers, and solenoid valves with the application. The Blynk app is used as the main interface for users to monitor data in real-time and remotely control solenoid valves. The Blynk application is used in conjunction with hardware to implement the monitoring system in real-time.

4.1 Hardware

The hardware design is carried out by assembling all components, including the ESP32, turbidity sensor, ultrasonic sensor, buzzer, solenoid valve, step-down, and relay.

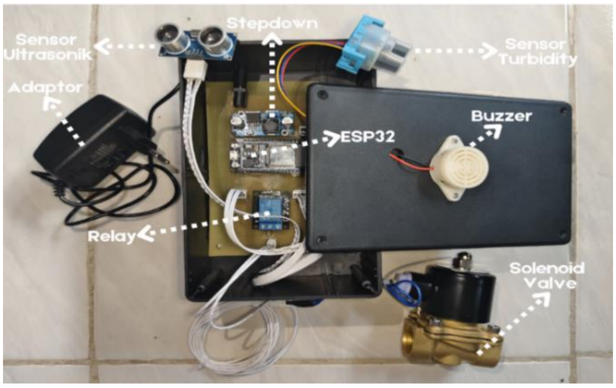

Figure 4. Network Systems

Figure 4 shows the design of the water turbidity monitoring system in the reservoir. The system is designed to detect turbidity levels and water levels in real-time, as well as provide alerts if needed. The components in this circuit work in an integrated manner with a microcontroller to control the flow of water, activate alarms, and transmit data to the monitoring application.

4.2 Monitoring Applications

The result of designing the user interface of the Blynk application for the system to be created. On the interface display, there are two main indicators displayed in the form of a Gauge Widget, namely the turbidity indicator and the water level indicator. On the left, there is a turbidity indicator that displays the turbidity level of water in the Nephelometric Turbidity Unit. Meanwhile, on the right, there is a water level indicator showing how high the water level in the reservoir is in centimeters. In addition, there is an OFF button that is used to control the draining of the reservoir water.

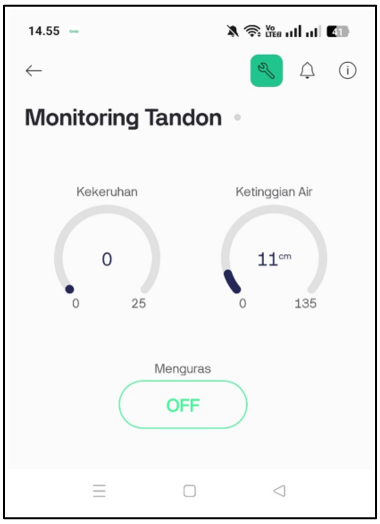

Figure 5. Reservoir Water Monitoring Application

4.3 Hardware Functional Testing

Hardware functional testing focuses on evaluating the performance of the hardware used in these systems. This testing is carried out to ensure that the hardware can operate according to the goals and needs that have been set.

Table 2. System Hardware Component Specifications

No.	Component	Function	Information
1	ESP32	Primary microcontroller for sensor data processing and WiFi connectivity to the Blynk app	Works well
2	Sensor Turbidity	Detecting the level of turbidity of water in NTU units using optical principles	Works well
3	Sensor Ultrasonik	Measuring the water level in a reservoir using ultrasonic waves	Works well
4	Solenoid Valve	Automatically controls reservoir water drain based on system commands	Works well
5	Buzzer	Provides an audio warning alarm when turbidity exceeds the threshold	Works well

Functional testing of the hardware can be seen in Table 2. In this test, the data obtained from various components, such as turbidity sensors, ultrasonic sensors, solenoid valves, and buzzers, are compared to the corresponding measuring instruments or reference standards. This process involves testing in various operational conditions to determine the extent of the accuracy of the data generated by each component.

4.4 ESP32 Microcontroller Testing

Hardware testing begins by testing the main component of the ESP32 by connecting to TCP/IP. The ESP32 NodeMCU test was carried out by connecting the ESP32 with Wi-Fi and checking the pins used as inputs and outputs to run the device.

4.5 Turbidity Sensor Accuracy Testing

Validation of turbidity sensor accuracy is carried out through gradual testing by adding a turbidizing liquid in a volume variation of 100-1000 ml.

Table 3. Turbidity Sensor Test Results

No.	Turbid Fluid Volume (ml)	Turbidity Value (NTU)	Water Conditions	Information
1.	100	0	Clear	Running system
2.	200	0		Running system
3.	300	2		Running system
4.	400	11	Pretty Cloudy	Running system
5.	500	19		Running system
6.	600	21		Running system
7.	700	23		Running system
8.	800	25	Very Cloudy	Active Alerts
9.	900	28		Active Alerts
10.	1000	50		Active Alerts

Table 3 shows the results of the turbidity sensor test using a turbidity liquid in a volume variation from 100 ml to 1000 ml. The data shows that the sensor can detect gradual changes in turbidity, with alarm activation occurring at a value of ≥25 NTU, indicating very turbid water conditions. Based on the data obtained is used to produce the following graph.

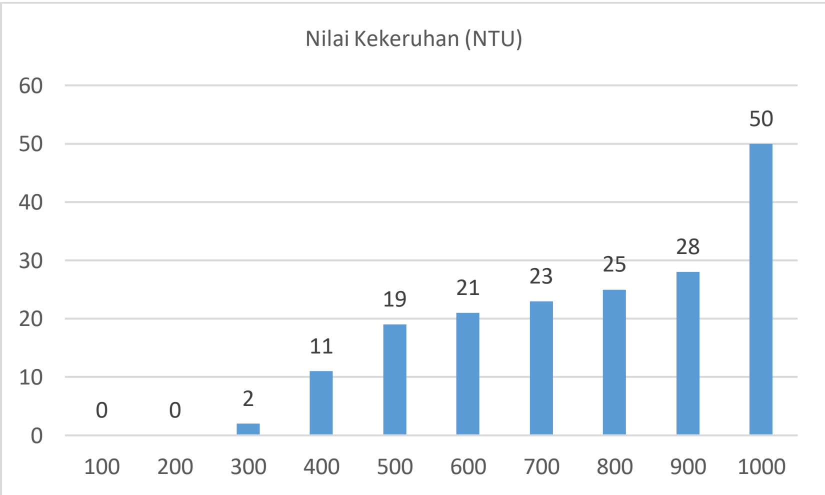

Figure 5. Turbidity Sensor Graph

Figure 5 illustrates that the measured turbidity value of water in NTU (Nephelometric Turbidity Units) increases as the volume of turbidity fluid increases. At a volume of 100 ml to 200 ml, the turbidity value is still at 0 NTU, which indicates that the water condition is still clear and no significant changes have been detected by the sensor. The turbidity value began to be detected at a volume of 300 ml with several 2 NTU and continued to increase gradually until it reached 50 NTU at a volume of 1000 ml.

4.6 Ultrasonic Sensor Accuracy Evaluation

Ultrasonic sensor accuracy testing was carried out by comparing sensor readings to manual measurements using a ruler meter at 10 different water levels (10%-100%).

Table 4. Validation of Ultrasonic Sensor Accuracy

No.	Level Air	Ultrasonic Sensor	Ruler Meter	Error Percentage (%)
1.	10%	28,1	28,3	0,2
2.	20%	25,8	26	0,2
3.	30%	23,5	23,7	0,2
4.	40%	20,9	21,4	0,5
5.	50%	18,6	19,1	0,5
6.	60%	16,1	16,8	0,7
7.	70%	15,5	14,5	1,0
8.	80%	12,4	12,2	0,2
9.	90%	9,7	9,9	0,2
10.	100%	8	7,6	0,4
	Average Sensor Reading Error			0,41

Table 4 shows the consistency of the ultrasonic sensor readings with a maximum difference of 1.0% from the reference measurements. Statistical analysis shows a high accuracy rate with an average error of 0.41%. The data obtained is used to generate the following graph.

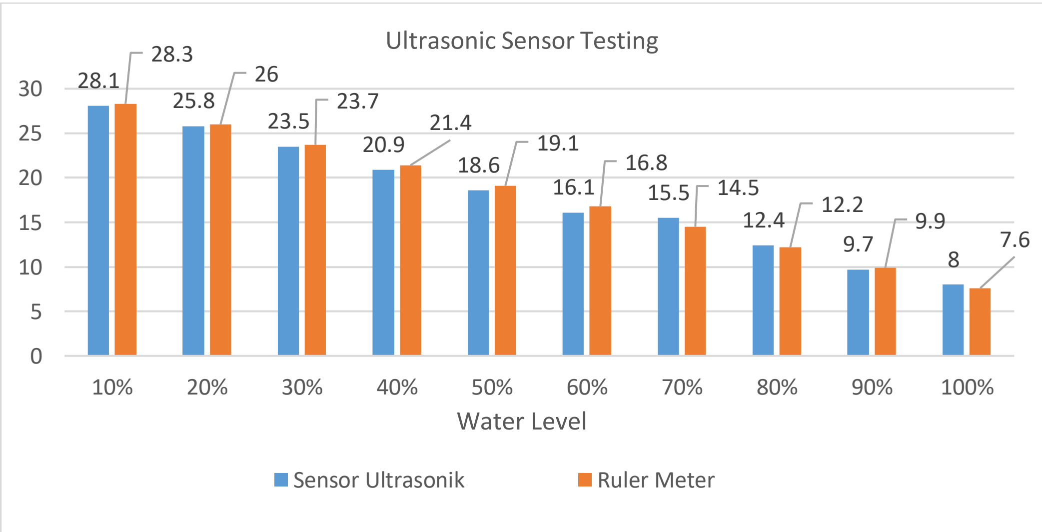

Figure 6. Ultrasonic Sensor Graphics

The graph in Figure 6 shows the results of the ultrasonic sensor test compared with manual measurements at different water levels. The graph shows that the ultrasonic sensor reading values are very close to the manual measurement values at each water level, with a relatively small difference.

Table 5. Buzzer Responsiveness Test Results

No.	Trigger Conditions	Information
1.	Clear Water	Inactive
2.	The Water Is Quite Cloudy	Inactive
3.	The Water Is Very Cloudy	Active

4.7 Warning System Responsiveness Testing

This test was carried out to determine the response of the buzzer as a warning indicator of the level of turbidity of the water. The buzzer is designed to activate only in water conditions that have passed a certain turbidity limit. Table 5 shows that the evaluation of the buzzer system was performed on three different water conditions: clear, moderately cloudy, and very cloudy. The buzzer is only active in very cloudy water conditions (≥25 NTU), indicating the selectivity of the proper warning system. The buzzer response time is recorded <1 second after the turbidity threshold detection is exceeded.

4.8 Solenoid Valve Responsiveness Testing

Solenoid valve testing is carried out to determine the response and speed of the valve's work in opening and closing the water flow according to the command from the system. The solenoid valve shows consistent responsiveness with an actuation time of 2 seconds for open/close operation. There is no leakage in the closed position and optimal flow in the open position. Solenoid Valve System Testing is shown in Table 6.

Table 6. Solenoid Valve System Testing

Operating Conditions	Response Time (sec)	Valve Status
Open Command	2	Perfect Open
Close Command	2	Closed Meetings

5. Conclusions

This research successfully implemented an Internet of Things (IoT) based reservoir water turbidity monitoring system integrated with the Blynk platform for real-time monitoring. The system developed is able to accurately detect the level of turbidity of water using turbidity sensors with clear categorization (<10 NTU), moderately turbid (10-25 NTU), and very turbid (>25 NTU) according to Ministry of Health standards.

The system components show satisfactory performance, where the ultrasonic sensor achieves an accuracy rate of 99.59% in water level measurement, the buzzer provides a warning response of less than 1 second when the turbidity threshold is exceeded, and the solenoid valve operates with a response time of 2 seconds for automatic drain control. The Blynk platform has proven to be effective as a monitoring interface with the ability to display real-time data, send push notifications, and enable remote control via smartphone.

An alert system that includes alarms and application notifications provides information redundancy that improves operational security. This implementation creates a technological solution for domestic water quality management that can operate automatically with minimal human intervention. This system not only serves as a monitoring tool, but also as a water management system that can help maintain the cleanliness and health of users through clean water that is suitable for use.

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