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Design And Development Of A Quality And Quantity Water Monitoring System For Water Tank Based On Internet Of Things

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Abstract

In the context of urban life, the quality and quantity of water stored in tanks play an indispensable role. However, concerns over the lack of effective monitoring of water conditions in tanks have garnered significant attention. This research aims to design a monitoring system utilizing Internet of Things (IoT) technology to ensure continuous monitoring of water quality and quantity within tanks.

The study zeroes in on developing a solution that overcomes the limitations of traditional methods, known for their time and cost constraints. This solution hinges on a real-time monitoring system that integrates sensors and the NodeMCU ESP32 microcontroller. Measurements of water quality parameters, such as turbidity and total dissolved solids (TDS), along with assessments of water quantity through tank volume, are integrated into the system. Software development is carried out using the Arduino IDE platform.

Through this research, an increased awareness of the importance of monitoring water quality in tanks is anticipated, and this solution is expected to make a significant contribution to the development of efficient and effective monitoring technology. Thus, a crucial step toward more accurate and up-to-date water monitoring in urban environments can be achieved.

Keywords: *Water Quality, Water Quantity, ESP32, Monitoring System, Internet of Things.*

1. Introduction

Water tanks are often used as a solution for storing water for daily needs, but frequently users are unaware of the quality and quantity of water stored in these tanks. Problems with water quality and quantity in tanks can arise from various factors such as inadequate supervision of stored water quality, inability to monitor the quantity of water in the tanks, and limited knowledge about maintaining water quality. Thus, monitoring the quality and quantity of water is crucial to ensure sustainable water resource utilization.

Traditional monitoring methods such as manual sampling and laboratory testing can be time-consuming, expensive, and limited in scope. Moreover, these methods do not provide real-time data, making it challenging to promptly respond to changes in water quality and quantity. Therefore, there is a growing need for innovative monitoring systems that can offer real-time data on water quality and quantity. The current development of Internet of Things (IoT) technology also presents an opportunity to address these issues by creating a monitoring system for water quality and quantity in tanks.

Monitoring the quality and quantity of water in tanks plays a crucial role in raising awareness among the community or tank owners about the potential contamination or pollution of stored water. This allows preventive measures to be taken when indications of water source contamination within the tanks arise. This is particularly significant because contamination issues are often not easily detected, especially since water tanks are typically placed in hard-to-reach and less visible locations due to their elevated positioning.

2. Research Methodology

2.1. Monitoring

Monitoring, which can be translated as surveillance, is an activity aimed at observing the progress of program or project implementation. Through monitoring, it can be determined whether a program or project is proceeding according to plan or deviating from it[1].Monitoring encompasses a cycle of activities involving data collection, review, reporting, and actions based on the obtained information.

Monitoring can be carried out using various tools such as direct observation, interviews, documentation, and visual applications. The purpose of monitoring is to uncover errors or mitigate larger risks and to provide an evaluation of necessary actions. The monitoring process is divided into three stages: data collection, data analysis, and presentation of monitoring data in the form of images, tables, and more.

2.2. Water Quality

Water quality is the term used to describe the characteristics of water that can affect its ability to meet human and ecosystem needs. In a general context, water quality must meet specific standards, including not containing pollutants that could harm human health and the environment, as well as having acceptable taste, odor, and color. Additionally, water quality must adhere to the requirements set by local regulatory bodies, such as the drinking water quality standards established by the Ministry of Health.

As outlined in the Indonesian Ministry of Health Regulation number 32 of 2017 concerning Environmental Health Quality Standards and Health Requirements for Hygiene, Swimming Pools, Aqua Solutions, and Public Baths, its annex explains that water for hygiene and sanitation purposes is used for personal cleanliness maintenance, such as bathing and brushing teeth, as well as for washing food items, eating utensils, and clothes. Furthermore, water for hygiene and sanitation purposes can also serve as the source of drinking water.

Table 1: Physical Parameters in the Environmental Health Quality Standard for Water Media for Hygiene and Sanitation Purposes[2].

No.	Required Parameter	Unit	Quality Standard (maximum level)
1	Turbidity	NTU	25
2	Color	TCU	50
3	Total Dissolved Solid	mg/l	1000
4	Temperature	°C	air teperature ± 3
5	Taste	-	tasteless
6	Odor	-	odorless

2.3. Water Quantity

Water quantity refers to the amount or volume of water in reservoirs or water storage facilities[3]. This concept encompasses various aspects such as water sources, water usage, the water cycle, and water management. Water sources can be obtained from surface water bodies such as rivers, lakes, and reservoirs, as well as groundwater which serves as a primary water source for human and industrial needs.

2.4. Internet Of Things (IOT)

The Internet of Things represents a technological revolution shaping the future of computing and communication, encompassing everything from wireless sensors to nano technologies. Its purpose is to establish connections among various types of objects and devices on a daily basis, contributing to a vast network and a substantial database[4].

In the IoT system, common hardware devices such as cameras, fire sensors, smoke sensors, gas sensors, or temperature sensors are employed as its supportive elements. Additionally, there are several software technologies utilized in IoT, including information processing and security technology. The IoT architecture itself comprises three layers, namely the perception layer, network layer, and application layer.

2.5. NodeMCU ESP32

The NodeMCU ESP32 is a microcontroller introduced by Espressif Systems and serves as the successor to the ESP8266 microcontroller. This microcontroller features a built-in Wi-Fi module, which greatly facilitates the creation of Internet of Things applications. Moreover, the NodeMCU ESP32 is equipped with an onboard antenna and USB port, streamlining user activities such as programming and debugging.

The common programming language for ESP32 is C, hence the majority of API libraries are also provided in the C language. However, this microcontroller can also be easily programmed in C++. Some Arduino libraries can be used with the C++ programming option, although certain modifications might be necessary. Due to its open-source nature, as this chip is, anyone can develop an "operating system" for ESP32, leading to solutions available on the Internet for programming it in languages like LUA, JavaScript, and so forth[5].

2.6. Sensor

A sensor is any electronic device employed to measure physical quantities and convert them into electrical signals. The quantities referred to here can encompass temperature, air humidity, air pressure, and others[6].

Sensors find application across various domains, including industry, medical technology, vehicles, household appliances, and more. For instance, sensors can be utilized to monitor vehicle engine temperatures, measure blood oxygen levels in hospitals, regulate indoor temperatures, and detect human motion for security purposes.

2.6.1. Turbidity Sensor

The turbidity sensor is a device capable of detecting the level of cloudiness or haziness in water, which essentially cannot be visually observed[7].This sensor serves as a tool to measure water turbidity by analyzing the optical properties of water due to the scattering of light, and it can be expressed as a ratio of reflected light to incident light. The intensity of light reflected by a suspension is a function of concentration when other conditions are constant[8].

Fig. 1: Turbidity sensor

2.6.2. TDS Sensor

The Total Dissolved Solid (TDS) sensor is a detector of solid particles dissolved in water or liquids, as depicted in Figure 2. These solid particles encompass both organic and inorganic compounds. A higher TDS value indicates cloudier water, whereas a lower TDS value signifies clearer water.

Fig. 2: TDS sensor

2.6.3. Ultrasonic Sensor HC SR04

An ultrasonic distance sensor, also known as a sonar sensor, is a device that employs ultrasonic sound to detect objects in its vicinity and calculate the distance to those objects. The measurable range typically spans from 2 cm to 400 cm[6].

Fig. 3: Ultrasonic sensor

3. Result And Discussion

In the following stage, testing is conducted on each sensor connected to the microcontroller. Then, based on the results of this testing, it is observed whether the device can provide the expected output values.

3.1. Results from turbidity sensor

This test was conducted to observe the turbidity of water through a predetermined sample. The result of this test is the reading of the turbidity sensor value, which measures the level of water turbidity. In this test, it can be seen in Figure 4 below.

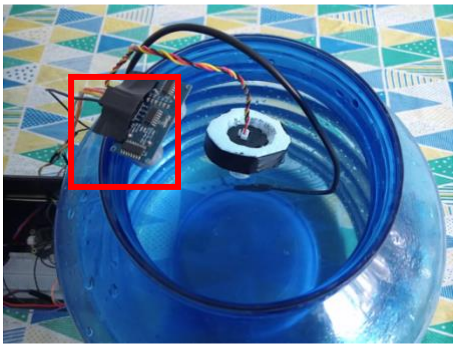

Fig. 4: Reading Turbidity Sensor on Water Tank Prototype

Fig. 5: Water Testing Sample for Turbidity Sensor

In Figure 5, three water samples are shown being tested; among them, sample A is mineral water, sample B is tap water from the municipal water supply (PDAM), and finally, sample C is a solution of dust and sand.
Table 2 presents the results of water turbidity testing using a turbidity sensor, which displays the measured turbidity values of the specified samples.

Table 2: Testing Water Turbidity Using Turbidity Sensor

No.	Sample	Test Result
1	A	5 NTU
2	B	77 NTU
3	C	2204 NTU

3.2. Result from TDS sensor

This testing was conducted to observe the level of dissolved substances in water through previously specified samples. The result of this test is the reading of the TDS sensor value, which measures the level of dissolved substances in water. This can be seen in Figure 6 below.

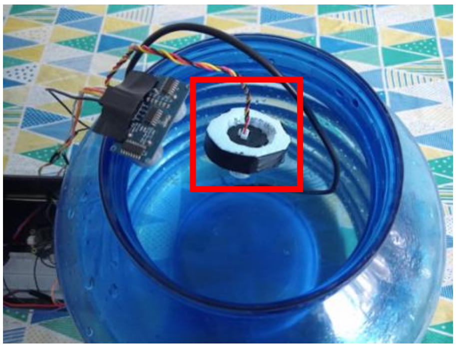

Fig. 6: Reading TDSSensor on Water Tank Prototype

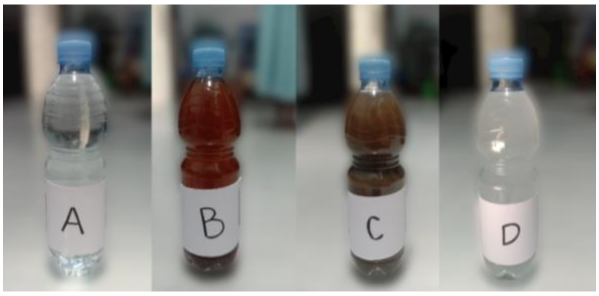

Fig. 7: Water Testing Sample for TDS Sensor

In Figure 7, four water samples that were tested can be seen. These include sample A, which is mineral water, sample B, which is a coffee solution, then sample C, a solution of dust and sand, and finally there is sample D, a salt solution.

Table 3 shows the results of testing the soluble substances in water through a TDS sensor, which displays the values of soluble substances in water measured from the specified samples.

Table 3: Testing of Dissolved Solids in Water Using TDS Sensor

No.	Sample	Test Result
1	A	2 ppm
2	B	10 ppm
3	C	15 ppm
4	D	330 ppm

3.3. Results from ultrasonic sensor

This test result was conducted to observe the tank volume from the readings of the ultrasonic sensor HC-SR04, which measures the water level. In this test, it can be seen in the following Figure 8.

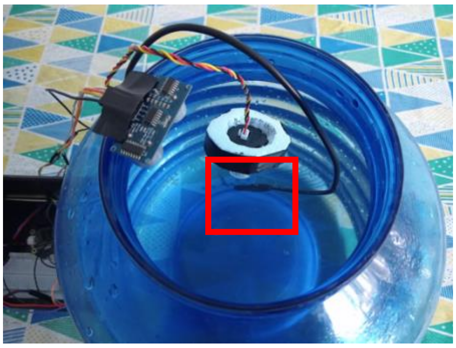

Fig. 8: Reading HC-SR04 Sensor on Water Tank Prototype

The following are the test results for water volume through the ultrasonic sensor HC-SR04 from the readings of water level values, which can be seen in Table 4.

Table 4: Testing Water Volume Using Ultrasonic Sensor

No.	Volume	Water Level on Sensor	Test Result
1	11 liters	22.39 cm	10.9 liters
2	6 liters	12.15 cm	6.1 liters
3	1 liter	5.2 cm	1.1 liters

3.4. Results feom monitoring on Blynk

In this test result, it was conducted to observe whether the sensor reading results and processing data from the NodeMCU ESP32 microcontroller can be sent via Wi-Fi to the Blynk application on the user's device, and whether they can be sent and viewed in real-time.

Fig. 8: Monitoring Display on Blynk

It can be seen in Figure 8, which displays real-time monitoring on Blynk when the microcontroller is powered on. Then, in Figure 9, water monitoring can be observed in the form of a graph, presenting an easily understandable visual for the user.

Fig.9: Monitoring Display in Graphic Form

3.4. Discussion

In the interface design of the Blynk application, there are three indicators obtained from measurements of Ultrasonic sensors, Total Dissolved Solids (TDS), and Turbidity. This interface is designed with the purpose of providing clear and intuitive visualization of the data generated by these three sensors.

The indicator from the Ultrasonic sensor is used to display the water level in the reservoir, while the TDS indicator depicts the concentration level of dissolved substances in the water. Furthermore, the turbidity indicator is used to measure the level of water cloudiness. Through this interface, users can easily monitor and comprehend the water conditions based on the measurement results from the three sensors used.

4. Conclusion

The conclusions that can be drawn from this research are as follows:

1. The monitoring system for water quality and quantity in this reservoir has been successfully implemented using the Internet of Things (IoT) as the data collection protocol for monitoring and displaying monitoring results in graphical form.
2. This monitoring system facilitates users in monitoring and enhances awareness about the importance of water quality in the reservoir. It also reminds users of the amount of water in the reservoir through the water quantity measurement.
3. By utilizing the Blynk application, real-time monitoring of water quality and quantity can be achieved.
4. Precision is crucial when conducting water quality monitoring to promptly detect and prevent issues or potential contamination in the reservoir.
5. The monitoring system can only be accessed through a private network, allowing only specific devices to connect.

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