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SYSTEM FOR MONITORING CONSUMABLE WATER QUALITY BASED ON INTERNET OF THINGS

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Abstract

Access to clean and consumable water is a critical factor for public health, but not all communities have the tools to monitor water quality in real-time. To address this issue, this study proposes the development and implementation of an Internet of Things (IoT)-based water quality monitoring system. The system is designed to measure key water quality parameters such as pH, Total Dissolved Solids (TDS), turbidity, and temperature, using an ESP32 microcontroller. This microcontroller is connected to a variety of sensors and integrated with the Blynk application, which allows users to monitor the data through their mobile devices. The system also incorporates a rule-based decision-making method that classifies the water as consumable or not, based on predetermined standards. The IoT-based system ensures smooth data transmission to the Blynk app, and the decision-making process is accurate and reliable. This system provides a practical and efficient solution for real-time water quality monitoring, especially for communities lacking advanced water quality monitoring tools. It enables users to assess water quality remotely, offering a significant improvement in public health monitoring and management.

Keywords: ***water quality monitoring, internet of things (iot), esp32, ph, tds, turbidity, rule-based, blynk***

INTRODUCTION

Water is an essential basic need for the survival of humans, animals, and plants. The most primary and vital use of water is for drinking. A lack of ions in the body can lead to death due to dehydration. For human life, water is necessary for various household activities such as drinking and cooking (Udin et al., 2021). Good water quality is crucial for supporting the health and well-being of the community. Water is sourced from various places such as springs, rivers, lakes, and rain, each with different characteristics. One of the main issues that often occurs is turbidity, which indicates that the water is not safe for consumption. Turbidity can be caused by fine clay particles from erosion or surface runoff, as well as organic or inorganic substances that have not been filtered (Yunita Arsyad et al., 2022). Water that is safe for consumption must have an acidity level of 6.5-8, according to the Minister of Health Regulation of the Republic of Indonesia, number 907/MENKES/SK/VII/2002, dated July 29, 2002, regarding the conditions and supervision of drinking water quality. Additionally, the turbidity level must be below 5 NTU (Nephelometric Turbidity Unit) (Latipah & Alamsyah, 2022). Contaminated water is dangerous for health because it may contain toxins above safe limits. Poor water quality can lead to various diseases, ranging from mild to fatal. Therefore, consumable water must be clear, not turbid, and not have a sour or salty taste, which indicates the presence of salts or organic/inorganic acids (Rasjid et al., 2022a).

With the increasing demand for clean, consumable water, there is a need for a system capable of monitoring water quality effectively and efficiently. The utilization of Internet of Things (IoT) technology becomes one of the solutions that enables real-time and continuous monitoring. Therefore, this research develops a predictive model that not only has a high level of accuracy but can also be integrated with existing IoT systems, allowing for quick and accurate information on water quality conditions and enabling prompt responses to any changes that occur (Fikry et al., 2025). To address this issue, a water quality monitoring system is needed, which can be monitored through devices with internet access. This system will use IoT (Internet of Things) technology with sensors to detect water quality parameters such as turbidity, pH, temperature, organic and inorganic substances in molecular, ionic, or micro-granular suspended forms. Data from the sensors will be transmitted in real-time, allowing for quick action if the water quality declines. With an IoT-based monitoring system, it is expected to create a healthier and safer environment for the community. The implementation of this system is vital for human health, the sustainability of ecosystems, and better water resource management. This study aims to design a predictive model that not only has a high level of accuracy but is also compatible with existing IoT systems, enabling real-time monitoring and a fast response to changing conditions.

METHOD

Research Implementation Timeline

This research on the *"IoT-based Consumable Water Quality Monitoring System"* will be conducted from July 2024 until completion at Malikussaleh University, Bukit Indah, Lhokseumawe.

Data Collection

The data used in this study will be a comparison between consumable drinking water, such as bottled water (e.g., Aqua), and water from spring sources (wells) or tap water that has been filtered using traditional filters and tap filters (Zernii). The data will be collected through direct measurements using water quality sensors integrated with an IoT system. The collected data includes the following parameters:

- pH level (acidity and alkalinity),
- Temperature (°C),
- Turbidity (in NTU - Nephelometric Turbidity Units),
- Total Dissolved Solids (TDS) in ppm (parts per million) or mg/L (milligrams per liter). This data will be transmitted and stored on a server for further analysis.

Research Type

This research is focused on the development of an IoT-based Consumable Water Quality Monitoring System using the ESP32 microcontroller. The aim is to monitor the quality of consumable water in real-time and online, utilizing Internet of Things (IoT) technology and employing the Blynk application as the monitoringtool.The system is designed to provide accurate and reliable information about water quality, accessible to users at any time and from anywhere. The data obtained from the sensors will be sent to the cloud via an internet connection, enabling real-time data analysis and quick decision-making. The implementation of this system is expected to enhance water quality control and resource management, significantly contributing to public health preservation.

System Analysis

System analysis includes the assessment of key components, the developed features, and the effectiveness of the system in achieving its primary goal of real-time water quality monitoring to ensure its consumability.

Hardware Requirements Analysis

Hardware refers to the physical components of the system that can be seen and touched. These components are capable of executing software instructions. The hardware used for managing the system includes two main devices: a laptop and an Android smartphone, along with several supporting components.

- Laptop: Used for programming, testing, and data analysis.
- Android Smartphone: Used for real-time monitoring of data via the Blynk application.
- ESP32: Serves as the microcontroller that connects the sensors with the communication module.
- Turbidity Sensor: Measures the clarity of the water.
- TDS Sensor: Measures the total dissolved solids in the water.
- pH Sensor: Measures the acidity or alkalinity of the water.
- Temperature Sensor: Measures the temperature of the water.
- LCD 16x2: Used to display the water's consumability status.

Software Requirements Analysis

Software is a vital component in the design and creation of the system being developed. One of the main functions of the software is to process data. The software tools used to build the system are as follows:

- Windows 11: Serves as the operating system for the laptop, used for programming, testing, and data analysis.
- Blynk Application: An IoT platform used for storing, analyzing, and displaying sensor data in real-time.
- Arduino IDE: Used for programming and uploading code to the microcontroller.

RESULTS AND DISCUSSION

System Implementation Results

At this stage, the results of implementing the IoT-based consumable water quality monitoring system show that all hardware and software components function optimally. The system, built using the ESP32 microcontroller, pH sensor, TDS sensor, turbidity sensor, temperature sensor, and internet connectivity, is able to read water quality parameters in real-time. The measurement data is displayed directly on the LCD and Blynk application and is automatically recorded to Google Spreadsheet for documentation and further analysis. The system also provides convenience for users in monitoring water quality from various sample types through mobile devices. Overall, the implemented system works as planned and supports the goal of efficient and accurate monitoring of consumable water quality.

System Monitoring Test Results

From the results of the system monitoring tests, the designed devices have proven to function well in monitoring water quality. The testing was conducted by monitoring various types of water samples, including bottled drinking water (e.g., Aqua), tap water (well water), ice water, hot water, and water with food coloring added. Each parameter measured, namely temperature, pH, turbidity (in NTU), and TDS (in ppm), is displayed in real-time on the Blynk application and automatically saved to Google Spreadsheet for data recording and analysis purposes. Based on the testing, the system was able to accurately distinguish between consumable and non-consumable water according to the established standards. Overall, the tested system has proven to be effective and aligned with the research objective, which is to provide a practical and user-friendly IoT-based water quality monitoring solution.

pH Sensor Testing

The pH sensor testing (SEN0161) was conducted to ensure that the sensor can accurately measure the acidity or alkalinity levels of water. During this phase, testing was performed using several types of water samples, ranging from bottled drinking water, tap water, well water, to water that had been dyed with food coloring. Each measurement result was compared with the standard pH value for water to determine if the water falls within the acceptable pH range for consumption, which is between pH 6.5 and 8.5. From the test results, the pH sensor was able to detect changes in pH values across different types of water with considerable stability. The difference in pH values between the samples was clearly detected, indicating that the sensor was functioning properly.

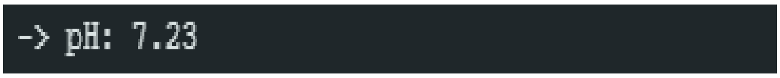

Figure 1 pH Sensor Serial Monitor Results

TDS Sensor Testing

The TDS sensor testing (SEN0244) was conducted to evaluate the sensor's ability to measure the total dissolved solids (TDS) concentration in water, which is one of the key parameters in determining the consumable water quality. The testing was performed using various water samples, including bottled drinking water, tap water, well water, and water that had been dyed. The results of the testing showed that the TDS sensor was able to detect variations in TDS levels across each type of water quite effectively. The values recorded also corresponded with the characteristics of each sample, where bottled drinking water showed a low TDS value, while well water and turbid water showed higher TDS values. Overall, the TDS sensor in this system proved to be stable and accurate, making it reliable for water quality monitoring.

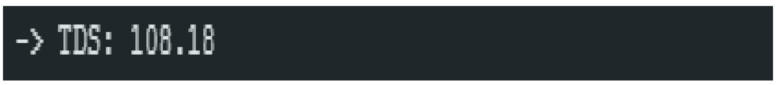

Figure 2, TDS Sensor Serial Monitor Results

Turbidity Sensor Testing

The turbidity sensor testing (SEN0189) was conducted to assess the sensor's ability to detect water turbidity levels, which is an important parameter in determining the suitability of water for consumption. During the testing phase, various water samples were used, including bottled drinking water, tap water, well water, turbid water (mixed with soil), and water with food coloring added. The results showed that the turbidity sensor was able to distinguish turbidity levels across each water sample quite effectively. The NTU values recorded were consistent with the visual condition of the samples, where clear water provided a low NTU value, while turbid water showed a high NTU value. Overall, the turbidity sensor performed with good stability and accuracy, effectively supporting the water quality monitoring process.

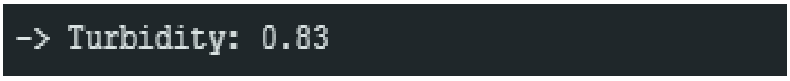

Figure 3, Turbidity Sensor Serial Monitor Results

Temperature Sensor Testing

The DS18B20 temperature sensor was tested to ensure its accuracy and stability in measuring water temperature under various conditions. The testing was conducted using water samples with varying temperatures, ranging from ice-cold water (low temperature), room temperature drinking water, to hot water.

The test results showed that the temperature sensor was able to detect temperature changes quickly and consistently. Every temperature change in the water samples was accurately detected, and the measurement results were consistent with the actual conditions. Therefore, the temperature sensor used in this system has proven to function well and can be relied upon for continuous monitoring of water temperature.

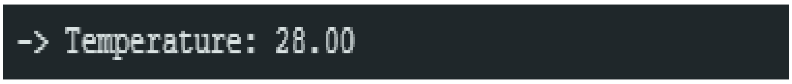

Figure 4 Serial Monitor Results for the Temperature Sensor

Data Transmission Testing to the Blynk Application

The data transmission testing to the Blynk application aims to ensure that all sensor reading data is received and displayed in real-time through the Blynk platform on a mobile device. The testing was carried out by running the system under various conditions, both when initially connecting to the Wi-Fi network and when data readings were taken periodically. The test results showed that the data transmission process proceeded smoothly and stably. Each measured parameter, such as temperature, pH, TDS, and turbidity (NTU), was successfully displayed on the Blynk application dashboard without any significant delays. Additionally, the Blynk application also provides convenience for users to monitor the water quality conditions anytime and anywhere through an internet connection. Therefore, the data transmission feature to the Blynk application has been thoroughly tested and supports the effective remote monitoring functionality.

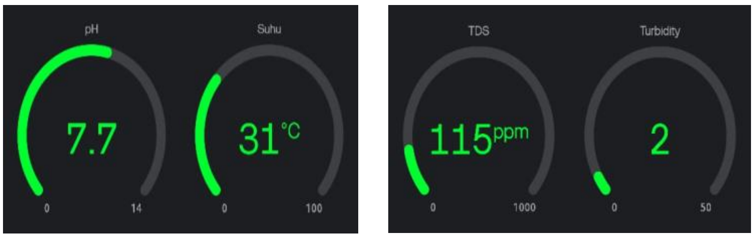

Figure 5 Results of Sensor Data Transmission to the Blynk Application

Overall System Testing Results

The overall system testing results indicate that the IoT-based drinking water quality monitoring system that was designed operates effectively and in accordance with the objectives of the research. The testing was conducted using various types of water samples, including bottled drinking water (Aqua), tap water (well water), ice water, hot water, and water with added food coloring. Each sensor used—temperature, pH, TDS, and turbidity—was able to accurately and stably measure the water quality parameters. The IoT-based water quality monitoring system developed in this study has been successfully implemented and tested through a series of tests on various types of water. The system consists of several key components, including the ESP32 microcontroller, water quality measurement sensors (pH, TDS, turbidity, temperature), and the Blynk-based monitoring application connected through a Wi-Fi network. The pH sensor used is capable of accurately measuring the acidity or alkalinity of water with sufficient accuracy. During testing, the pH sensor showed consistent readings with relatively small measurem ent differences compared to standard pH references. This indicates that the pH sensor is reliable for use in water quality monitoring systems. The TDS sensor is used to measure the Total Dissolved Solids (TDS) level in water in ppm (parts per million). This sensor works well in detecting differences in ion concentrations in various types of water, including tap water, bottled drinking water, and water that has been dyed. The test results show that the TDS sensor can identify increases in dissolved solids, such as in turbid or dyed water, where TDS values tend to be higher.

The turbidity sensor used is based on an optical sensor that measures the light scattering in water. The measurement results show that the turbidity sensor is quite sensitive to changes in turbidity levels, although measurement accuracy is influenced by environmental lighting and calibration conditions. Therefore, before testing, manual calibration was performed using clear water (as a zero reference) and a solution with a specific turbidity level. The sensor was able to differentiate between clear water, turbid water, and dyed water quite well. The temperature sensor used is the DS18B20, which has the advantage of high accuracy and stability in readings. This sensor can detect water temperature with very low error and is durable for use in various temperature conditions, such as hot or cold water. All data from the sensors are processed by the ESP32 microcontroller. The system uses a rule-based decision-making method to assess the water's suitability based on the following thresholds:

- pH: 6.5 – 8.5
- TDS: $<$ 500 ppm
- Turbidity (NTU): $<$ 5 NTU

The decision-making mechanism is performed automatically by the program running on the ESP32. After each data collection, the system evaluates whether each parameter meets the criteria. Based on the combination of these results, the system will classify the water as Safe for Consumption or Not Safe for Consumption. The test results show that the rule-based decision support mechanism functions according to the predefined logic. For example, bottled drinking water like Aqua is always classified as Safe for Consumption, while water containing dyes or turbid water with high TDS will be classified as Not Safe for Consumption. The system was also tested for real-time data transmission to the Blynk platform via a Wi-Fi connection. All measured parameters are displayed directly in the Blynk app, which can be accessed through a smartphone. The test results show that data transmission occurs stably without significant delays. The data transmission interval can be adjusted flexibly, allowing users to monitor the water quality periodically as needed. Additionally, the data is automatically stored in Google Spreadsheet for documentation and further analysis.

Overall, the system demonstrates reliable performance in terms of measurement accuracy, data processing speed, network connection stability, and the reliability of rule-based decision-making. The system is also capable of handling various types of water samples, including bottled drinking water, tap water, filtered water, hot water, cold water, and dyed water. Thus, the IoT-based water quality monitoring system developed in this study can be considered to have fulfilled its function as a tool to monitor and evaluate the suitability of consumable water automatically and practically. This system can also be easily adopted for use in households, small industries, or larger-scale applications with adjustments to the hardware and software components.

CONCLUSION

Based on the design, implementation, and testing results of the IoT-based water quality monitoring system, the following conclusions can be drawn: The IoT-based water quality monitoring system designed and implemented using the ESP32 has been proven capable of integrating pH sensors, TDS sensors, turbidity sensors, and temperature sensors to read water quality parameters in real-time. The system can process the obtained data and then send the measurement results to the Blynk application stably. The rule-based decision-making process applied is effective and able to classify the water status (Safe for Consumption or Not Safe for Consumption) with good accuracy. This system also provides users with convenience in monitoring water quality through mobile devices. The testing results on various water samples, such as bottled drinking water (Aqua), tap water (well water), hot water, cold water, and water dyed with food coloring, showed that the system was able to accurately, consistently, and appropriately classify water suitability according to the established standards. Therefore, this system is deemed suitable to be used as a practical, efficient tool for monitoring consumable water quality, and can be applied in various environments, both household and small-scale industries.

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