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Designing Water Quality Monitoring Application Using Esp8266

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ABSTRACT

Water is the main need for human life. The decline in water quality due to household, industrial, and environmental waste requires a monitoring system that is able to work quickly, sustainably, and accurately. Continuous monitoring of water quality has an important role in supporting effective water resource management. This research develops an *Internet of Things (IoT)-based water quality monitoring system* by utilizing ESP8266 microcontrollers. IoT-based water quality monitoring systems in aquascapes are able to control the temperature and pH of the water so that they remain within the ideal range for fish life. In this study, how to design and build an Internet of Things based water quality monitoring system using ESP8266 microcontroller. The developed system is expected to be able to read water quality parameters in the form of pH values and water turbidity levels in real-time through integrated sensors, then send the data to the IoT monitoring application and Telegram notifications so that it can be easily accessed by users. Thus, the developed system is suitable for IoT-based water quality monitoring.

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1. Introduction

Water is the main need for human life. The decline in water quality due to household, industrial, and environmental waste requires a monitoring system that is able to work quickly, sustainably, and accurately. Along with the development of technology, Internet of Things (IoT)-based water quality monitoring systems have been widely developed and proven to be able to improve the efficiency of water condition monitoring in various fields.

Several studies have shown that WiFi-based microcontrollers such as ESP8266 can be used as the core of water quality monitoring systems. ESP8266-based water quality monitoring systems have been implemented to read water quality parameters such as turbidity and water pH in real-time [1], [3]. The implementation of water quality monitoring is also carried out in spring reservoirs and water reservoirs to determine the condition of clean water online and sustainably [4]. In addition, research on the aquaculture sector proves that pH and turbidity sensors can help the process of monitoring water quality in shrimp ponds, koi ponds, and ornamental fish aquariums [5]. Even IoT-based water quality monitoring systems in aquascapes are able to control the temperature and pH of the water to keep it within the ideal range for fish life [16] [19].

On the implementation side of the tool, various studies have designed water quality monitoring systems using turbidity sensors to detect the level of water clarity in aquariums and water reservoirs [9][11]. Several systems were also developed to monitor lake water quality and clean water distribution by integrating pH, turbidity, and water level sensors in a single IoT system [12], [15], [18]. To improve the effectiveness of monitoring systems, previous research also utilized IoT-based monitoring applications such as Blynk and Telegram.

The ESP8266-based water quality monitoring system is able to provide direct water condition notifications to users via Telegram [8]. In addition, monitoring clean water use using IoT-based flow and turbidity sensors has also been implemented to improve the efficiency of monitoring water use in households [17]. In the field of public water management, water quality monitoring systems are also applied to swimming pools and other public facilities to ensure that water quality parameters remain in accordance with health standards. This proves that IoT-based water quality monitoring systems can be widely used, both in the household environment, cultivation, and community clean water management.

Based on these various studies, it can be concluded that the water quality monitoring system based on ESP8266 and pH and turbidity sensors is able to provide real-time, accurate, and easily accessible water quality data. Therefore, this research focuses on the design and implementation of IoT-based water quality monitoring applications using ESP8266 and pH sensors as well as water turbidity, so that users can monitor water conditions automatically and continuously.

The main focus of this study is how to design and build an Internet of Things based water quality monitoring system using ESP8266 microcontrollers. The developed system is expected to be able to read water quality parameters in the form of pH values and water turbidity levels in real-time through integrated sensors, then send the data to the IoT monitoring application and Telegram notifications so that it can be easily accessed by users. With this system, water quality monitoring can be carried out automatically, continuously, and more efficiently than manual methods that have been used.

2. Research Methods

The research method used in the development of the Internet of Things (IoT)-based water quality monitoring system is the Prototype method. This method was selected because it provides a systematic and iterative approach to system development, allowing researchers to design, implement, evaluate, and refine the system continuously until it meets the desired requirements. Unlike conventional development methods that require all requirements to be finalized at the beginning of the project, the Prototype method enables developers to create an initial model of the system that can be tested and evaluated by users or stakeholders. Feedback obtained from these evaluations is then used to improve the system, ensuring that the final product effectively addresses the identified needs and challenges.

The Prototype method is particularly suitable for the development of IoT-based systems because it facilitates the integration of both hardware and software components through gradual testing and refinement. In the context of water quality monitoring, the system involves multiple interconnected components, including sensors, microcontrollers, communication modules, databases, and monitoring interfaces. Therefore, an iterative development process is necessary to ensure that all components function properly and communicate effectively with one another. Through repeated testing cycles, potential issues can be identified and corrected before the final implementation stage.

The application of the Prototype method to IoT-based water quality monitoring systems has been widely reported in previous studies, particularly in the development of systems utilizing ESP8266 microcontrollers and water quality sensors such as pH and turbidity sensors. These studies have demonstrated that the Prototype approach is effective in improving system reliability, sensor accuracy, and overall performance because it allows continuous evaluation throughout the development process. Furthermore, this method supports rapid development by enabling researchers to validate system functionality at an early stage and make necessary modifications without redesigning the entire system.

In this study, the Prototype method consists of several stages, including requirements identification, prototype design, system development, testing, evaluation, and refinement. Each stage contributes to the creation of a functional and reliable water quality monitoring system capable of collecting real-time data and transmitting it through IoT technology. As a result, the developed system can provide accurate and continuous monitoring of water quality conditions, supporting more effective environmental management and decision-making processes. [1], [2].

The problem identification stage plays a crucial role in ensuring that the developed system addresses actual conditions and requirements in the field. Through direct observation of water quality conditions, it was found that changes in pH levels and water turbidity are among the most important indicators for determining water quality. These parameters were selected because they can provide valuable information regarding the physical and chemical condition of water and can be measured continuously using appropriate sensors. The observation results also revealed the need for a monitoring system capable of providing real-time information to support faster and more accurate decision-making.

In addition, the literature study provided a strong theoretical foundation for system development. Various scientific journals and previous studies were analyzed to identify suitable sensor technologies, communication methods, and system architectures for IoT-based water quality monitoring. The review showed that the integration of pH and turbidity sensors with IoT technology enables efficient remote monitoring and data collection. The findings from this stage guided the selection of system components and design approaches, ensuring that the developed system was based on proven methods and technologies. As a result, the system design process became more structured and aligned with both practical requirements and current technological developments in water quality monitoring[3], [4], [10].

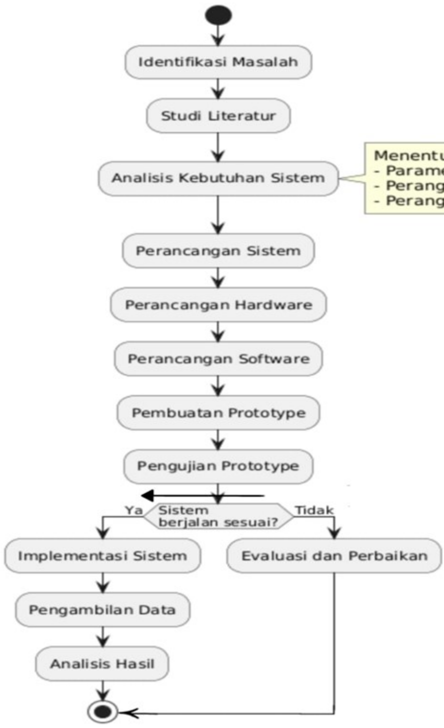

Figure 1. Research flowchart

After that, a system needs analysis is carried out to determine the hardware and software specifications to be used. At this stage, ESP8266 microcontrollers, pH sensors, turbidity sensors, and IoT and Telegram monitoring applications are determined as data processing and notification media. Previous research has shown that water quality monitoring systems in shrimp ponds and aquariums using data logging methods and Telegram notifications can improve the effectiveness of real-time water quality monitoring [5], [8].

The next stage is system design, which includes designing hardware and software. Hardware design includes the preparation of a series of sensors with microcontrollers, while software design is carried out using the Arduino IDE to process and transmit sensor data in real-time. Similar design methods have been applied to IoT-based water quality monitoring systems in lakes and aquascapes [12], [16].

After the design is completed, a prototype of the water quality monitoring system is made, then followed by prototype testing to ensure that the system can work as needed. If the system has not run optimally, then the evaluation process and system improvement are carried out until the appropriate results are obtained. This system evaluation and implementation approach is also used in reservoir water quality monitoring and clean water distribution systems based on ESP8266 and ESP32 [18].

The final stage of this method is the implementation of the system in the field, followed by the process of data collection and analysis of research results. With this Prototype method, the water quality monitoring system can be developed flexibly and in a targeted manner according to the research objectives.

3. Results and Discussion

At the stage of implementing this research, an Internet of Things-based water quality monitoring system was successfully designed and implemented using ESP8266 microcontrollers, pH sensors, turbidity sensors, and TDS sensors. The system is able to read water quality parameters in real-time and send the data to the Telegram monitoring application and notifications.

The series of tools used in this study consist of ESP8266 NodeMCU as a data processing center, TDS sensor to measure the level of solutes in water, temperature sensor to determine water temperature, and turbidity sensor to detect water clarity level. The integration between these components allows the system to carry out automatic and continuous monitoring of water quality.

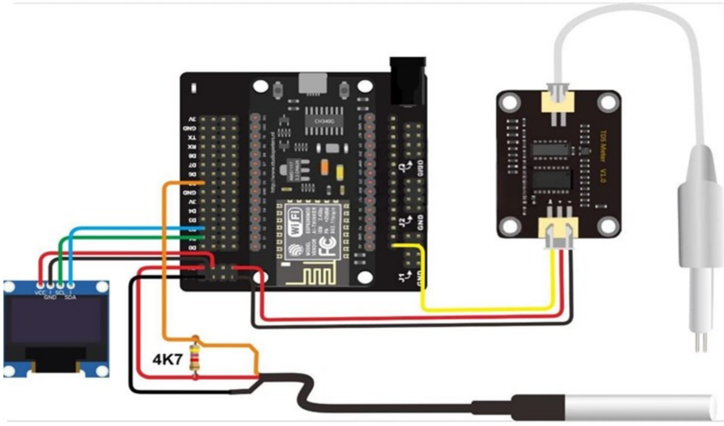

Figure 2. Schematic of the ESP32-based Smart Health Heart Rate Monitoring system and MAX30100 sensor

The hardware set of these systems is structured based on pre-designed schematics. The schematic shows the relationship between the pH sensor, turbidity sensor, and TDS sensor with the ESP8266 microcontroller, as well as the connection to the internet network.

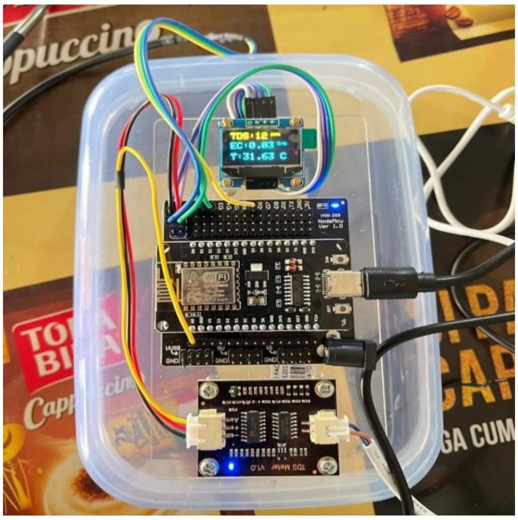

Figure 3. A range of tools and hardware used in the IoT-based Smart Health Monitoring heart rate system.

Once the system is implemented, the resulting water quality data is displayed through an IoT-based monitoring application. In addition, the system also sends water condition information directly to Telegram so that users can monitor water quality remotely.
At the research stage, the Internet of Things (IoT)-based water quality monitoring system was tested using four types of water samples, namely warm water, Aqua bottled water, gallon water, and Le Minerale bottled water.

Each water sample is monitored using a Total Dissolved Solids (TDS) sensor and a temperature sensor, then the reading results are automatically sent to the user via Telegram notifications using the Telegram Bot integrated with the ESP8266 NodeMCU. The use of Telegram as a notification medium allows users to obtain real-time water quality information, without having to check directly to the device. The information submitted includes TDS values in ppm units and water temperature in degrees Celsius (°C).

Figure 4. Telegram Notification Display of Warm Water Monitoring Results

Based on the results of the test on warm water, the system sends Telegram notifications with a TDS value of 199 ppm and a water temperature of 39.8°C. A high temperature value indicates the characteristics of warm water, while a relatively larger TDS value compared to other water samples indicates a higher solute content. This proves that the sensor is able to detect changes in temperature and solute concentrations well, as well as send the data to Telegram accurately.

In the test using Aqua bottled water, the system displayed a TDS value of 78 ppm with a water temperature of 26.5°C. These values indicate that bottled water has a lower solute content and a temperature close to room temperature. Telegram notifications were successfully received without delay, signaling the stability of data communication between the NodeMCU and the Telegram application.

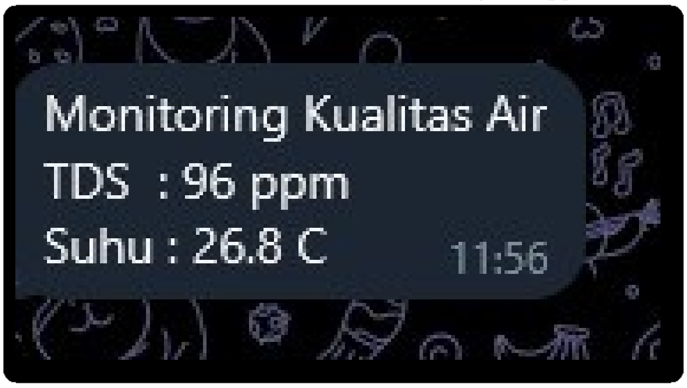

Figure 5. Telegram Notification Display of Gallon Water Monitoring Results

The test results on gallons of water showed a TDS value of 96 ppm with a water temperature of 26.8°C. A slightly higher TDS value compared to Aqua bottled water indicates a difference in mineral content in different types of water. The system is able to read the difference and display it through Telegram messages in real-time.

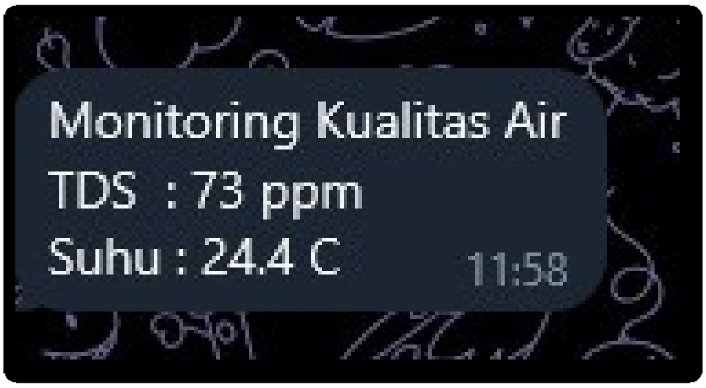

Figure 6. Telegram Notification Display of Le Minerale Bottled Water Monitoring Results

In Le Minerale's bottled water test, the system recorded a TDS value of 73 ppm and a water temperature of 24.4°C. This value is the lowest compared to other samples, indicating the characteristics of water with lower dissolved mineral content and cooler temperatures. Telegram notifications successfully display the data in a format that is consistent and easy for users to understand.

Based on these four tests, it can be concluded that the IoT-based water quality monitoring system is able to read the differences in the characteristics of each type of water and send the results to Telegram in real-time. The use of Telegram as a notification medium has proven to be effective because it is lightweight, easily accessible, and able to present water quality information quickly and sustainably. These results are in line with previous research that stated that Telegram's integration of IoT systems improves the efficiency of remote monitoring and the ease of users in obtaining water quality information [6], [8], [16], [19].

4. Conclusion

Based on all stages of research that have been carried out, from design to system testing, it can be concluded that:

1. An Internet of Things (IoT)-based water quality monitoring system using ESP8266 microcontrollers as well as pH, turbidity, and TDS sensors has been successfully designed, implemented, and tested with good results. The system is able to read water quality parameters in real-time and display data through an IoT-based monitoring application.
2. The integration of the system with the Telegram notification service allows users to obtain information on water quality conditions quickly and remotely. This notification feature makes the monitoring process more practical, efficient, and responsive compared to conventional monitoring methods that are carried out manually.
3. The results of the study show that the use of IoT technology in water quality monitoring systems can improve measurement accuracy, speed of information delivery, and ease of data access for users.
4. The developed system can be applied to various needs, such as aquariums, fish ponds, and clean water reservoirs, so that it can help maintain the stability and feasibility of water quality in a sustainable manner.

Based on the results of design, implementation, and testing, it can be concluded that the designed IoT-based water quality monitoring system is in accordance with the research objectives and is feasible to be applied in real time in environments that require continuous water quality monitoring.

Acknowledgments

Based on the research that has been conducted, there are several suggestions for further development, including:

1. Researchers are further advised to use sensors with a higher level of accuracy to make the measurement results more precise.
2. Subsequent research can develop a system with the addition of other health parameters, such as body temperature or oxygen levels in the blood.
3. It is recommended to conduct testing on a larger number of respondents so that the results of the study are more valid and representative.
4. Researchers can then integrate the system with mobile applications that are more interactive and user-friendly.

It is necessary to carry out long-term testing to find out the stability and reliability of the system in daily use.

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