

Temperature and salinity monitoring system for Shrimp Pond water

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ABSTRACT

Shrimp pond productivity is highly dependent on water quality, which is traditionally monitored manually through labor-intensive sampling and testing. This study proposes an IoT-based smart monitoring system to automate the assessment of water quality parameters such as temperature and salinity. The system employs an ESP32 microcontroller integrated with DS18B20 and salinity sensors. Sensor data are displayed in real time via a 4x20 LCD and the Blynk application. Two relays are included to automatically activate the aerator when temperature defined thresholds. Field testing over four days demonstrated sensor accuracy with error rates below 3%, stable data transmission, and effective automation. This system offers a reliable and efficient solution for shrimp farmers to monitor and manage water quality, potentially enhancing aquaculture productivity.

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1. INTRODUCTION

Indonesia is the second largest archipelagic country in the world, with the longest coastline after Canada, measuring approximately 95,161 km [1]. Its strategic location in the tropical region with two consistent seasons makes Indonesia highly potential for the development of the marine and fisheries sector, particularly in shrimp aquaculture. Shrimp, especially the Vannamei species (*Litopenaeus vannamei*), is one of the country's primary fishery export commodities, contributing around 3.5% to the national Gross Domestic Product (GDP) in 2020 [2]-[3]. However, the success of shrimp farming heavily depends on the quality of pond water. Substandard water conditions may lead to stress, reduced growth, and even mass mortality in shrimp populations [4]. Key water quality parameters include temperature, pH, salinity, and turbidity. Currently, the monitoring of these parameters is still largely conducted manually through sampling and laboratory testing, which is time-consuming, labor-intensive, and prone to human error [5]. This indicates the need for a more efficient and accurate monitoring system.

Technological advancements, particularly in the Internet of Things (IoT), offer significant opportunities to automate the monitoring of water quality parameters. Through IoT, data collected from various sensors can be transmitted in real-time to user devices via internet connectivity [6]. The application of IoT in aquaculture has been explored in several studies, such as Wahyu & Bahrul (2021), who developed a water quality monitoring system for ornamental fish ponds using the ESP32 microcontroller [7]. Similarly, Pauzi (2020) designed a shrimp pond water monitoring system using Arduino Uno and ESP8266, with data visualized through the Blynk application [8]. Nevertheless, previous systems have not yet integrated automatic salinity monitoring or actuator-based control mechanisms based on real-time water conditions. In fact, salinity stability is crucial in shrimp farming, as shrimp are highly sensitive to fluctuations in salinity and dissolved oxygen levels [9]. Therefore, there is a need for a more comprehensive monitoring system that includes real-time measurement of temperature, pH, turbidity, and salinity, along with automated control features [10]-[15].

This study aims to design and implement a shrimp pond water quality monitoring system based on ESP32 and IoT technology. The system utilizes DS18B20 temperature sensors and salinity sensors. All data are displayed in real-time via a 4x20 LCD and the Blynk mobile application. Additionally, two relays are automatically controlled: the first activates the aerator when the temperature exceeds a defined threshold. This system is expected to provide an efficient, accurate, and cost-effective solution to assist farmers in maintaining optimal shrimp pond water quality.

2. METHOD

For the design and assembly of this tool, it is done by adjusting to the needs of the entire system. System design is used to determine the components of the tool to be made. So that the final result of the component will be in accordance with what the tool needs, Figure 1 is a block diagram of the working system scheme, which has 2 inputs, 3 outputs.

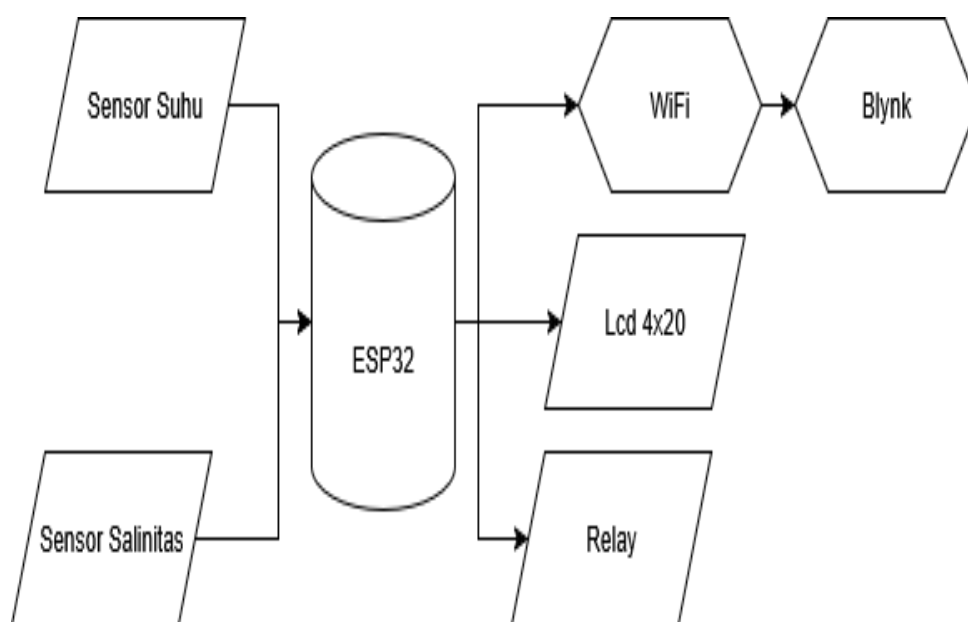


Figure 1. Block Diagram

For the design and assembly of this tool, it is done by adjusting to the needs of the entire system. System design is used to determine the components of the tool to be made. So that the final result of the component will be in accordance with what the tool needs, Figure 1 is a block diagram of the working system scheme, which has 2 inputs, 3 outputs. Based on Figure 1 of the entire system, the function of each component is as follows: 1) The TDS sensor is used to detect the amount of dissolved solid particles in water, both organic and inorganic, commonly referred to as Total Dissolved Solids. 2) The DS18B20 sensor is used to measure temperature in degrees Celsius with high precision. 3) The NodeMCU ESP32 microcontroller serves as the main control unit responsible for managing the overall operation of the system. 4) The relay functions to control the activation of paddle. 5) The 4x20 character LCD is utilized to display real-time data obtained from the sensors. 6) The Blynk application is used for remote, real-time monitoring of sensor data via an online platform.

The working principle of the device involves monitoring water quality parameters using several sensors, including the DS18B20 temperature sensor and salinity sensor, all of which produce analog voltage signals that are processed by the ESP32 microcontroller. The data is then displayed on an LCD and transmitted to the Blynk application via a Wi-Fi connection. If the temperature is greater than or equal to 30°C, Relay 1 is activated. The complete operational cycle is illustrated in Figure 2, which presents a flowchart as a visual representation of the system's sequential processes and logic. The flowchart allows for a clear and structured explanation of the sequential stages involved in the device's operation.

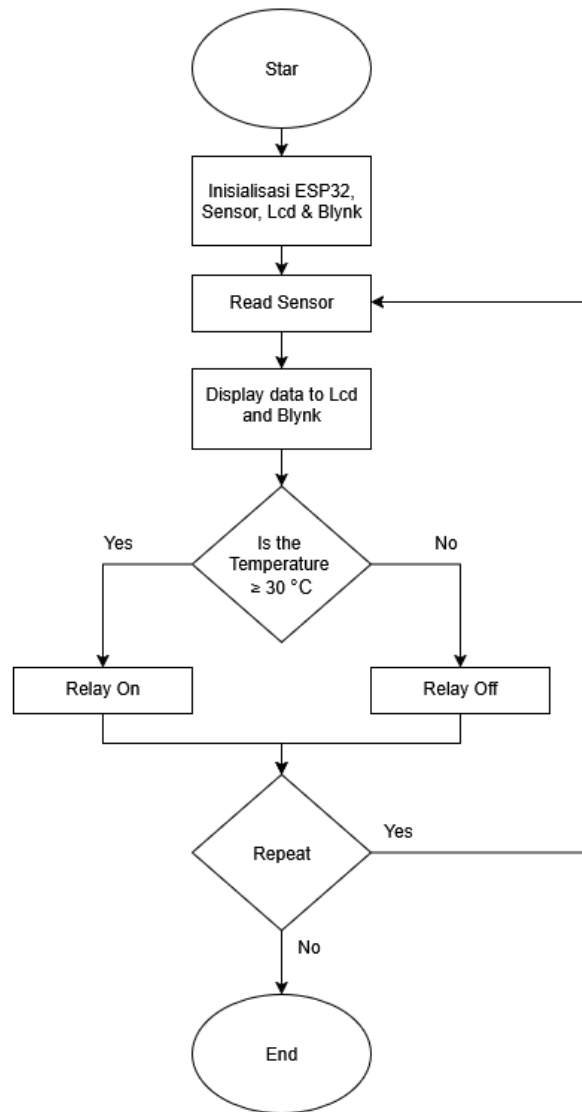


Figure 2. Flowchart of proposed system

3. RESULTS AND DISCUSSION

The smart monitoring system developed in this research was tested to evaluate the accuracy of its sensors, the reliability of data transmission, and the effectiveness of the monitoring and control functions in real aquaculture environments. The sensors involved included salinity and temperature sensors, all integrated with an ESP32 microcontroller and interfaced via the Blynk application for real-time observation.

Each sensor underwent preliminary calibration to ensure accuracy prior to field deployment. The salinity sensor, calibrated against manual measurements using a refractometer, demonstrated a maximum error of 0.4% while the DS18B20 temperature sensor, being a digital sensor with internal calibration, consistently provided stable readings without requiring manual adjustments. Data from each sensor were simultaneously displayed on a local LCD module and transmitted to the Blynk cloud platform. Comparative analysis between LCD and Blynk readings revealed minor discrepancies. The largest percentage error occurred in the salinity sensor (2.1%), while temperature errors were lower at 0.5% respectively. These differences are likely attributed to network latency or analog-to-digital conversion mismatches during wireless transmission.

Field tests were conducted over four consecutive days from 11:00 to 16:00 at a shrimp pond in Nagari Malai V Suku, Padang Pariaman. Data were collected and analyzed to assess environmental fluctuations and system responses. Figure 3 shows the experimental results in field.

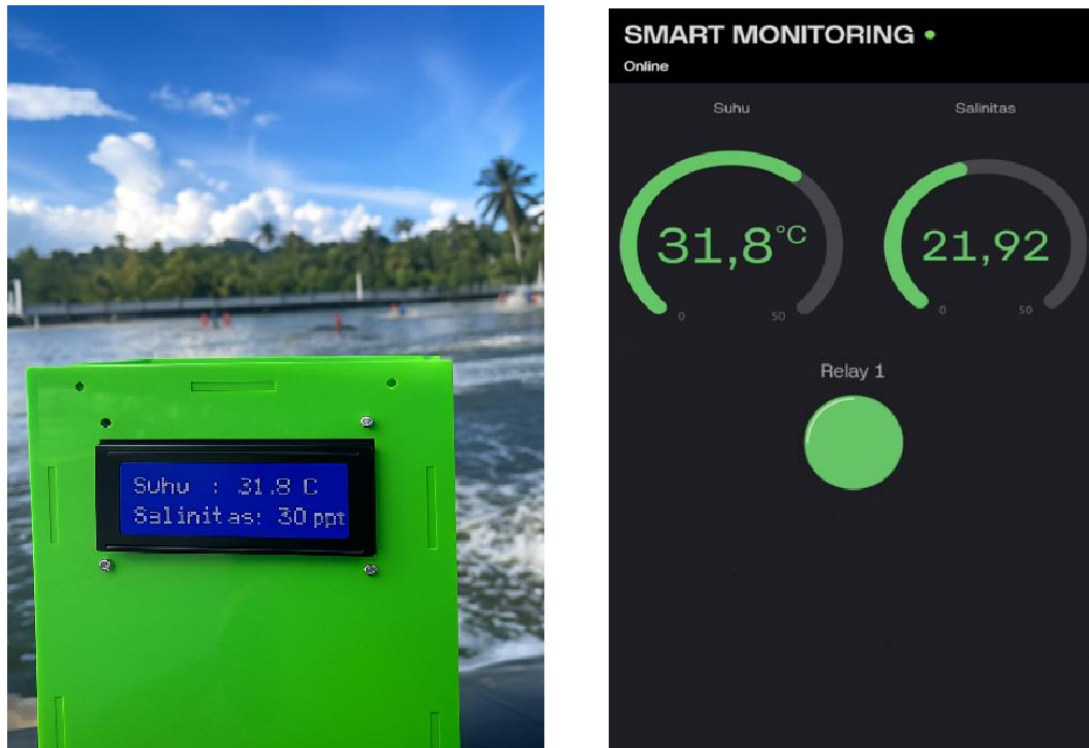


Figure 3. Experimental results

Temperature variations exhibited typical diurnal patterns, peaking around midday (up to 30°C) and gradually decreasing in the afternoon.. Salinity levels remained relatively stable, although slight declines were noted during peak sunlight, possibly due to evaporation. Figure 4 shows the temperature and salinity data during the experiment. The experimental results support the hypothesis that an IoT-based water quality monitoring system can deliver accurate and real-time insights into shrimp pond conditions. The integration of multiple sensors with wireless communication platforms like Blynk enables continuous monitoring without manual intervention, thus improving operational efficiency and decision-making for aquaculture practitioners. Despite some limitations, such as minor transmission errors and environmental interference with the turbidity sensor, the system proved robust and reliable in field applications. This work demonstrates the potential of scalable, low-cost smart aquaculture solutions and opens avenues for further enhancements, including machine learning integration for predictive analytics and water quality forecasting

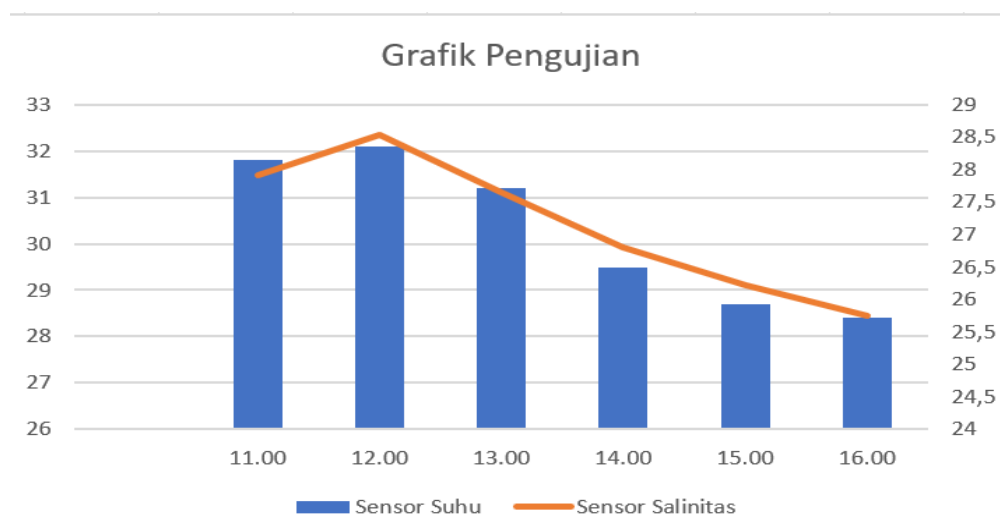


Figure 4. The temperature and salinity data during the experiment

4. CONCLUSION

Based on the design, testing, and analysis conducted in this study, it can be concluded that the smart water quality monitoring system for shrimp ponds has successfully met the objectives stated in the introduction. The integration of salinity and temperature sensors with the ESP32 microcontroller and the Blynk application allows for accurate, real-time monitoring and automatic control in response to water condition thresholds. The system demonstrated high sensor accuracy, with average error rates remaining below 3%, and performed reliably during four days of field testing. It responded effectively to environmental changes, particularly during peak sunlight hours, when temperature and turbidity levels rose. The relay control system functioned as intended, automatically activating based on predefined thresholds. This research shows that IoT-based monitoring offers a promising alternative to manual water quality testing, which is time-consuming and prone to human error. Furthermore, the implementation of this system can increase operational efficiency and support better decision-making in shrimp aquaculture. Future developments may include enhancing sensor durability (particularly turbidity sensors in aquatic environments), implementing data logging with cloud storage, and integrating predictive analytics using machine learning for proactive water management strategies..

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