

# Optimization of Shrimp Cultivation Through Internet of Things Based on Water Quality Monitoring

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**Abstract:** Shrimp farming is a highly profitable sector of the fishing industry. However, manual water quality monitoring remains a barrier to improving farming efficiency. Manual monitoring not only requires a large workforce, but is also prone to human error and is less responsive to changes in environmental conditions. This study developed an Internet of Things (IoT)-based water quality monitoring system capable of monitoring pond water quality parameters in real-time and efficiently. This system is equipped with temperature sensors DS18B20, pH sensors, salinity sensors, turbidity sensors, and dissolved oxygen (DO) sensors. The data from the sensor readings is sent to the server via the internet and displayed on the monitoring website interface. The system is also integrated with Telegram notifications to provide early warnings in the event of significant changes in water quality parameters. Test results show that this system is capable of monitoring water quality accurately and in real-time, thereby reducing dependence on manual labor. The data stored in the database can also be used for further analysis to improve shrimp farming management and productivity.

**Keywords:** IoT, Shrimp Farm, Real-time Water Quality Monitoring, Telegram Notification Sensor, Shrimp Farming, Fisheries Management

## 1. INTRODUCTION

Ponds are artificial ecosystems that play an important role in Indonesia's fisheries sector, especially as a medium for cultivating high-value commodities such as shrimp and milkfish. These two types of fish are chosen because of their high protein content, their taste, which is popular with the public, and their affordable prices. Stable market demand makes pond cultivation a major source of income for coastal communities while contributing to national food security [1]. Although shrimp ponds have high economic potential, water quality monitoring is still done manually, relying on direct observation, which is inefficient and prone to error. This can lead to delays in detecting environmental changes that affect cultivation yields. To overcome these obstacles, this study proposes an IoT-based monitoring system capable of monitoring parameters such as salinity, temperature, pH, and oxygen levels in real-time. Data is sent to a website and Telegram, enabling more efficient remote monitoring. This system is expected to reduce dependence on manual labor and increase shrimp pond productivity [2].

## 2. LITERATURE REVIEW

Research [3] in Bone Regency, South Sulawesi, formulated a strategy for managing vaname shrimp farming in the face of parasitic diseases. The methods used included measuring water quality and interviewing relevant stakeholders. The analysis was conducted using a descriptive

approach and Analytic Hierarchy Process (AHP). The results showed that water quality management was a top priority, supported by increased farmer knowledge, feed management, the use of certified fry, and the implementation of biosecurity. Research [3-4] designed an IoT-based shrimp pond water quality monitoring system in the Bangka Belitung Islands. Water quality is a crucial factor in vaname shrimp farming, but manual monitoring is still common. The developed system enables real-time monitoring of temperature, pH, and salinity through sensors connected to an Android application. Test results showed an error rate of 0.14–0.31% for temperature, 3.05–6.62% for pH, and 1.95–4.27% for salinity. This technology improves monitoring efficiency and reduces the risk of water quality deterioration [5]. developed a pond water quality monitoring system based on a Wireless Sensor System (WSS) integrated with a CPM1A PLC. This system uses Arduino and pH, salinity, temperature DS18B20, and dissolved oxygen sensors, with data transmission via the nRF24l01+ module. Test results show the accuracy of each sensor to be 94.06% pH, 78.15% salinity, 90.53% DO, and 99.42% temperature, with a data transmission range of up to 405 meters without obstacles. The system is also capable of automatically controlling water wheels and pumps through integration with a PLC, thereby improving the efficiency of pond management.

Development of Sim Card an Arduino-based shrimp pond water pH monitoring system with SMS Gateway. This system uses Arduino Mega to read data from pH sensors, display it on an LCD, and send notifications via SMS when there is a change in pH from normal conditions. The average pH detected is 7.68, with a reading accuracy of up to two decimal places. This system has proven to improve monitoring efficiency and help farmers prevent adverse effects caused by undetected pH changes [6]. An IoT-based vaname shrimp pond water quality monitoring system using NodeMCU Wemos D1 Mini. This system utilizes SEN0161 pH sensors, DS18B20 temperature sensors, and HC-SR04 ultrasonic sensors, with monitoring results sent to the Telegram application in real time. Test results show high accuracy in data readings and the system's effectiveness in facilitating efficient pond water quality management, thereby supporting optimal shrimp growth [7].

Developing an ATmega328 microcontroller-based automatic pond water quality control system with salinity, temperature, and pH parameters. This system uses a DS18B20 sensor, salinity sensor, and pH sensor, and is equipped with an automatic pump and heater. Test results show that the system is able to maintain parameters within optimal limits efficiently, thereby supporting maximum vaname shrimp growth [8]. Water quality greatly affects the health and growth of vaname shrimp. As a solution to the decline in water conditions, a hybrid system was developed to maintain stable water parameters. Research shows daily fluctuations, with temperature, salinity, brightness, and pH being lower in the morning than in the afternoon [9]. Water quality in ponds directly affects the growth of farmed organisms. Water conditions that meet standards support optimal growth, while poor quality can cause stress and reduce appetite. Therefore, maintaining parameters such as temperature, dissolved oxygen, pH, and salinity is very important to prevent crop failure [10].

According to [11], the optimal temperature for shrimp farming is 26–30°C, which is important for metabolism, moulting, and daily activity. Sudden temperature changes of  $\pm 2^\circ\text{C}$  can cause stress and inhibit growth. The ideal pH is in the range of 6.5–8.5; outside this range, it can reduce the shrimp's resistance. Dissolved oxygen (DO) levels above 5 ppm are required for shrimp and microorganism respiration, while DO levels below 3 ppm can cause stress and increase mortality. Optimal salinity ranges from 15–25 ppt; high salinity >25 ppt inhibits moulting, and too low <10 ppt increases the risk of disease. Monitoring is an activity to ensure that a program runs according to plan, identify obstacles, and determine solutions so that the process remains in accordance with procedures [12]. The IoT is a concept that connects physical and virtual objects via the internet to enable real-time data exchange and remote control. According to Casagras, IoT is a global infrastructure that utilizes communication and data collection capabilities between devices [13].

ESP-32 is an open-source Wireless Fidelity (Wi-Fi) microcontroller with cost-effective, interactive features and

supports programming in C language through ESP-IDF, suitable for various IoT applications [1]. This system is equipped with several sensors, including a DO sensor that measures dissolved oxygen levels as an indicator of aquatic ecosystem health [14], a pH sensor to determine the acidity or alkalinity of liquids through a glass electrode connected to the microcontroller [15], and a turbidity sensor that measures water turbidity based on the intensity of light scattered by suspended particles [16]. The DS18B20 digital temperature sensor is used to measure temperature with high accuracy using 1-Wire communication [17], while the Total Dissolved Oxygen (TDS) sensor detects the total amount of dissolved solids (ppm) in water through electrical conductivity [18]. All data from the sensors is displayed via an Liquid Crystal Display (LCD) that utilizes light reflection or transmission [19]. The components of this system are assembled using a breadboard to facilitate assembly without permanent soldering. Resistors are used as electrical current regulators in circuits with units of Ohms [20]. The device is programmed through Arduino IDE using object-oriented C++ programming language. For remote monitoring purposes, this system is connected to a website that functions as a control and information medium through a browser [21].

### 3. METHODOLOGY

This research went through six main stages. First, in the preparation stage, problems in shrimp farming related to water quality were identified and literature studies were conducted to understand important parameters such as temperature, pH, dissolved oxygen, salinity, and turbidity. Second, data collection was carried out through interviews and direct observation at the pond location to obtain a real picture of the field conditions. Third, the system design stage was carried out by determining the hardware and software requirements, including the selection of sensors, ESP32 microcontrollers, and the design of a Telegram and website-based communication system. Fourth, implementation was carried out by building a system prototype, integrating sensors, and testing real-time data transmission to the monitoring platform. Fifth, system evaluation was carried out by comparing the measurement results with manual methods to ensure data accuracy and validity. Finally, the refinement stage was carried out based on the evaluation results and feedback, including system improvements and the preparation of documentation as a reference for further development [22].

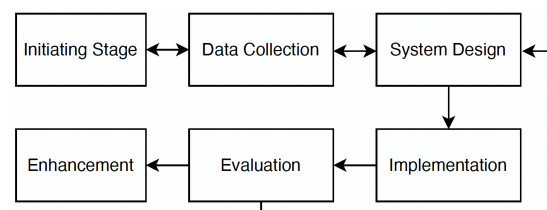


Figure 1. Research method

#### 3.1 Hardware Requirements Analysis

The following are the requirements in system design as shows in table 1.

Table 1. Hardware design requirements

No.	Hardware	Number	Function
1	ESP-32	1	As the Processing Brain
2	Sensor DO	1	As Input for Dissolved Oxygen Values
3	Sensor pH	1	As pH Input Value
4	Sensor Turbidity	1	As Input for Water Turbidity Values
5	Sensor TDS	1	As Salinity Value Input
6	Sensor DS18B20	1	As Water Temperature Input Value
7	LCD	1	As Value Output
8	Jumper Cable	8 M	As a Connector between ESP-32 and Circuit
9	Breadboard	1	As a Place to Assemble Circuits
10	Box	1	As a Place to Store Circuits
11	Adapter	1	As a power source

**3.2 Software Requirements Analysis**

In this study, researchers required various software programs to support the design, implementation, and analysis of the developed system. The software was used for microcontroller programming, sensor data monitoring, and information visualization and processing to ensure that the system ran according to the designed specifications as shows in table 2.

Table 2. Software requirements

No	Software	Function
1	Arduino IDE	As Compiler Code for Microcontrollers
2	Telegram	User Notification / Farmer
3	Website	Monitoring System

**3.3 Overall Tool Assembly**

Figure 2 below shows a prototype of a water quality monitoring system for shrimp ponds.

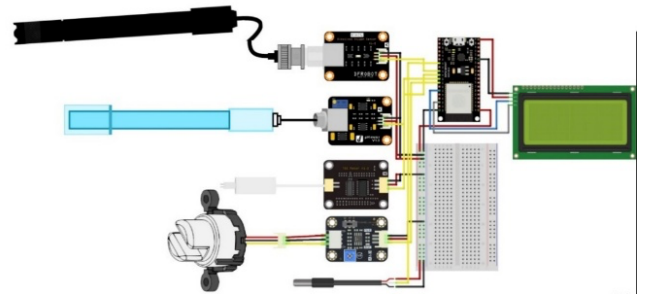


Figure 1. Water quality monitoring equipment for shrimp farms

Figure 2 illustrates the water quality monitoring system for shrimp ponds based on the IoT. This system is designed using several main sensors, including pH, TDS, turbidity, temperature DS18B20, and DO sensors. All sensors are connected to an ESP32 microcontroller as a control center that collects, processes, and transmits data in real-time. The monitoring results are displayed on a 16x2 LCD for local visualization and also sent to a web-based monitoring platform and Telegram application. By utilizing internet connectivity and an interactive interface, this system is able to provide accurate and remotely accessible information, thereby supporting efficiency and effectiveness in shrimp pond water quality management.

**4. RESULTS AND DISCUSSION**

After designing according to the system analysis, the results of hardware implementation for Water Quality Monitoring in Shrimp Farms Based on IoT The following are the results of hardware design for Water Quality Monitoring in Shrimp Farms Based on the Internet of Things. After completing the design process according to the planning in the system analysis as shows in figure 3.

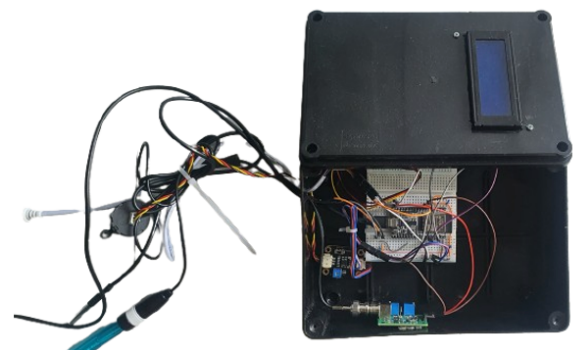


Figure 3. Water quality monitoring equipment in shrimp farms

This displays a monitoring system that can be accessed via a website to monitor the water quality conditions in shrimp ponds in real time. This system was developed as part of research on IoT-based Water Quality Monitoring in Shrimp Ponds.

#### 4.1 Software Testing Results

Software testing was conducted directly using a system designed to evaluate performance based on specified test parameters. The test results showed that the system was capable of monitoring via a website and sending real-time notifications via the Telegram application.

##### 4.1.1 Website Monitoring Testing

Website monitoring is designed to present sensor data in real time in an informative and attractive display. Data will be continuously updated as long as the device is connected to the internet and automatically stored in a database for monitoring and analysis purposes as show in figure 4.

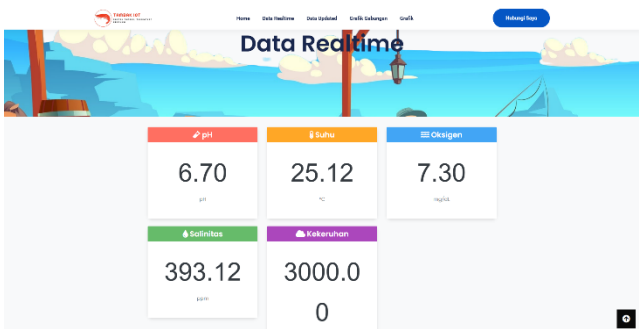


Figure 4. Website monitoring

##### 4.1.2 Telegram Notification Testing

The water quality monitoring system in shrimp ponds is equipped with an automatic notification feature via Telegram whenever there is a change in status. These notifications provide information on water conditions as shows in figure 5.

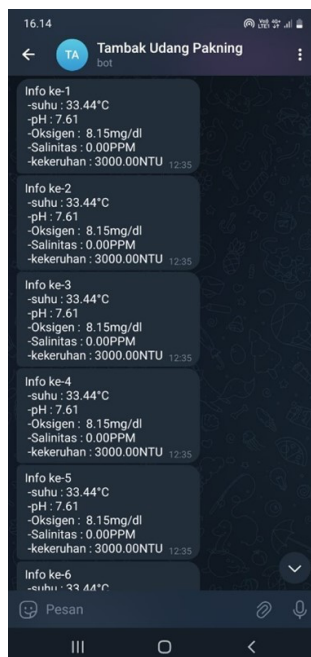


Figure 5. Notifications on telegram

#### 4.1.3 Hardware Testing Results

During the hardware testing phase, researchers conducted a series of tests on five sensors, namely dissolved oxygen sensors, pH sensors, turbidity sensors, DS18B20 temperature sensors, and salinity sensors, as well as conducting comprehensive testing on the entire system that had been designed.

Table 3. Device testing results

NOMOR	pH	SUHU	OKSIGEN	SALINITAS	KEKERUHAN	TANGGAL
1774	0.00	31.62	0.00	0.00	-4353.80	2025-01-06 14:20:06
1775	0.00	31.69	4.62	48.62	-3901.59	2025-01-06 14:19:58
1776	0.00	31.62	4.89	54.37	-596.51	2025-01-06 14:19:52
1777	0.00	31.69	6.75	74.34	-516.62	2025-01-06 14:19:46
1778	0.00	31.62	0.24	2.73	-4296.49	2025-01-06 14:19:40
1779	0.00	31.62	1.25	14.21	-2832.80	2025-01-06 14:19:31
1780	0.00	31.69	3.62	40.97	-1355.85	2025-01-06 14:19:23
1781	0.00	31.69	0.29	4.11	-4229.40	2025-01-06 14:19:17
1782	0.00	31.62	6.01	67.34	-1009.41	2025-01-06 14:19:09

Test results show that the developed system is capable of monitoring water parameters with a good level of accuracy. The sensor successfully measures water parameters in real-time, with data sent to a web-based platform and Telegram for remote monitoring. The implementation of this IoT-based system is expected to improve monitoring efficiency and reduce manual labor involvement in shrimp farming.

## 5. CONCLUSION

Based on the results of the study, the IoT-based shrimp pond water quality monitoring system can improve monitoring efficiency by providing real-time data without the need for manual measurements on site. This system also successfully reduces dependence on manual labor, as important parameters such as temperature, turbidity, pH, dissolved oxygen, and salinity can be monitored directly through a website and Telegram notifications. Further development, it is recommended to add parameters such as ammonia (NH<sub>3</sub>) levels to expand the scope of data. Integrating the system with automatic controls, such as aeration or water replacement, can improve operational efficiency. In addition, the use of renewable energy such as solar panels can support the sustainability and independence of the system.

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