Iot-Based Smart Controller (Sponcer) To Optimize Freshwater Fish Production In Pagelaran, Pringsewu, Lampung

Rizki Devi Anggita[1], Styawati[2]

[1,2] Universitas Teknokrat Indonesia, Jl. Zainal Abidin Pagaralam No.9-11 Labuhan Ratu, Bandar Lampung, Indonesia

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****Correspondence Email:***
Rizki_devi_anggita@teknokrat.ac.id

Abstract
An Internet of Things (IoT) based control system for optimal fish production in Pagelaran, Pringsewu, Lampung is a modern fish farming solution that uses IoT technology to automatically monitor and assess various fish environmental parameters. The system is equipped with various sensors that can measure critical parameters such as water level, pH, turbidity, and water temperature. This data is sent in real-time to a web-based application, allowing users to continuously monitor conditions remotely through devices connected to the internet. This helps maintain ideal fish environmental conditions for growth, reduces the risk of disease, and increases productivity. One of the striking features of this system is its automatic feed regulation capacity. With this system, feed is provided timely and accurately according to the needs of the fish, which is very important to ensure optimal growth. The purpose of developing an IoT-based system in Pagelaran, Pringsewu, Lampung is to increase productivity and fish production in the area. It is expected that with more careful monitoring and wiser feed handling, fish production can be increased in terms of both quantity and quality. In short, IoT-based system controllers not only improve operational efficiency but also reduce environmental damage. Farmers can reduce excessive resource use and lower operational costs by minimizing manual intervention and using technology for smarter pond management. It is expected that this system will become a model for more modern, efficient, and environmentally friendly fish farming practices, not only in Pagelaran, Pringsewu, Lampung but also in other areas.

1. Introduction

Lampung Province is known to have great potential in freshwater aquaculture, with a pond area of 37,985 hectares and a pond area of 13,751 hectares. In addition, there are also significant floating cage and net areas, covering 174 hectares and 321 hectares respectively. This potential makes Lampung one of the leading fisheries producing provinces. Among the regencies in Lampung, Pringsewu Regency has quite promising freshwater fisheries potential. In 2012, Pringsewu was ranked third in freshwater fish production in Lampung Province, with a contribution of 9.53 percent. With a cultivation area of 501 hectares, fish production in Pringsewu reached 7,965.73 tons in 2016, with a productivity of 15.90 tons per hectare. Pringsewu Regency was chosen as the focus because freshwater fish is one of the leading commodities in this region. Although each sub-district in Pringsewu has potential for cultivation land, its utilization has not been optimal. Of the total potential land area of 581.50 hectares, only 305.25 hectares have been utilized. Cultivation carried out in Pagelaran Sub-district includes freshwater fish breeding and rearing (Saputra & Samsugi, 2024).

In 2016, the largest freshwater fish production in this sub-district was gourami, with a total production reaching 2,615.08 tons. Meanwhile, tilapia ranked third in terms of production, with a total of 230.03 tons. Specifically in Pagelaran, tilapia production reached 56.80 tons (Alita et al., 2024). Cultivating freshwater fish also requires attention to water quality, water level and feeding. The water quality in fish maintenance containers is often unstable, especially in terms of changes in the acidity level (pH) of pond water. Pond water that does not meet standards can endanger the growth and survival of freshwater fish (Rahmanto et al., 2020). Pond water with a pH that is too acidic or alkaline can cause failure in fish farming. In addition to pH, water temperature also affects the mortality rate of fish. Good water quality is very important in freshwater fish farming, so when carrying out semi-intensive or intensive cultivation, monitoring of pond water conditions must be carried out continuously. However, this monitoring is often still carried out traditionally, such as checking water conditions based on color, measuring temperature, and pH using litmus paper. This method has the disadvantage of being impractical and prone to human error, especially for novice farmers. Therefore, technology or tools are needed that can monitor water temperature and pH levels at any time with fast and precise accuracy. (Nursobah et al., 2022).

In addition to pH and water temperature, the water level in fish ponds during the rainy season is also an important factor that needs to be monitored. If the water level is not controlled, especially during heavy rain, it can cause flooding or overflowing ponds, potentially damaging pond infrastructure and endangering fish (Blynk, 2024). Suboptimal water level management can result in significant losses for fish farmers (Pratama et al., 2022). Manual fish feeding also presents its own challenges. Inconsistent feeding, both in terms of time and quantity, can affect fish growth and feed efficiency (Samsugi et al., 2023). Mistakes in feeding can result in uneaten feed settling at the bottom of the pond, which ultimately has a negative impact on water quality. (Zulkarnain, 2024).

The method that can be used to optimize fish pond management, especially in high-potential areas such as Pringsewu Province, requires more than just water quality monitoring and an automatic feeding system. In addition, a protection system is also needed that can protect fish ponds from external sources. One way to increase the security of fish ponds is to use a PIR (Passive Infrared) sensor. The purpose of the PIR sensor is to detect activity around the pond. When the sensor detects unusual activity, such as the presence of a dog or someone approaching the boundary outside the specified time, the system will notify the boundary owner through a connected web application site or other relevant applications. The implementation of this PIR sensor is very important to prevent potential problems that could arise from fish theft, pond damage by dishonest people, or other unwanted incidents. (Widodo et al., 2023).

In addition, by integrating PIR sensors into the monitoring system, fish farmers can focus more on increasing productivity because the security of their ponds is well maintained. This technology, which includes water quality monitoring, feed weighing automation, and a PIR sensor-based security system, provides a comprehensive solution in one integrated platform. This system allows real-time monitoring of critical fish health parameters such as pH, temperature, water level, and water quality, as well as feeding arrangements. In addition, access and control of the system via the website allows fish farmers to monitor and manage ponds remotely more effectively and efficiently. The application of this technology is expected to increase operational efficiency, reduce the risk of failure, and increase fish production in Pringsewu Regency and its surroundings (Khosasi & Wijaya, 2020).

1.1 Literature Review

a. According to Khoiru Nurdina et al., 2023 a breakthrough in Internet of Things (IoT)-based technology designed to help the freshwater fish farming sector is the Smart Pond Controller prototype. This technology is designed to automatically check and regulate water quality in ponds, eliminating the need for more ancient and inefficient methods. The Smart Pond Controller measures important influencing indicators such as pH, temperature, and water level, by utilizing various sophisticated sensors. Fish farmers can now focus more on pond management thanks to the implementation of this technology, which eliminates the need for laborious manual checks.
b. According to Renaldi et al.,2023 the ability of this system to transfer data from sensors to an android-based mobile platform in real-time is one of its main features. This information can be they can check the condition of their ponds using devices connected to the internet, thanks to this feature. In addition, the user-friendly interface of this platform allows fish farmers to respond quickly to changes in conditions that can endanger fish. The automation features of the Smart Pond Controller make pond management easier overall and make monitoring easier.
c. The Smart Pond Controller is also equipped with a PIR (Passive Infrared) sensor for security as a monitoring and automation capability. The PIR sensor is used to detect movement around the fish pond. If there is any suspicious activity, such as a stray dog or a person wandering outside the specified time, the system will notify the pet owner through a connected platform so that confiscation can be carried out quickly. This protective feature ensures that the fish's body is protected from external threats and provides a sense of security for the fish.
d. According to Yunior & Kusrini, 2021 increasing the effectiveness of freshwater fish farming and reducing the risk of losses that often arise due to undetected changes in environmental conditions is the main goal of developing the Smart Pond Controller. Success in the fish farming sector depends on consistent and well-maintained water quality. Fish farmers can maintain water quality more actively with the help of this equipment.

2. Research Methods

This research method uses an experimental approach focused on the development and testing of an Internet of Things (IoT)-based system to optimize fish welfare. The first stage includes a literature study and needs analysis to understand relevant IoT technology and the state of fish farming in Pagelaran, Pringsewu, and Lampung. Based on the analysis results, this system consists of hard components such as pH, temperature, air pressure, and turbidity sensors, as well as an automatic feed dispenser. This system is supported by Soft, a web-based application that allows real-time data management via an internet connection.

After the analysis is complete, the hard and soft components are implemented and integrated to ensure that the system can function according to design. This system is installed in a fish class to assess sensor accuracy, automated workflow, and its ability to reduce manual intervention.

The collected data are analyzed quantitatively and qualitatively. Quantitative analysis is used to evaluate sensor accuracy, automatic feeding efficiency, and its impact on fish growth, water quality, and operational cost reduction. Qualitative analysis is conducted to understand user perceptions regarding the ease and benefits of the system in pond management. Validation of the results is carried out by comparing the performance of the IoT-based system with conventional fish farming methods using parameters of fish productivity, pond environmental quality, and resource use efficiency.

2.1 Prototype Design

The iot-based Smart Pond Controller prototype for optimizing Fresh Fish production will be installed on the edge of the pond located in Pagelaran, Prengsewu, Lampung with Mr. Evran Wijaya as the resource person as well as the managing partner. The purpose of this implementation is to gradually increase the productivity of prototype workers in a stable working environment. In this way, the prototype can be applied in an environment that matches the conditions that will arise during practical use. It is hoped that the results of this implementation will provide useful information for the development of tools or systems used by the author's research, and can develop freshwater fish feeding tools even better.

2.2.1 Circuit Schematic

This is an IoT-based control system that uses the ESP32 microcontroller as the controlling device. The Wi-Fi capability of the ESP32 enables data transmission to a server or web application. In this system, various sensors such as pH, TDS, ultrasonic, PIR, and humidity sensors are connected to the ESP32 to monitor the water condition in real-time. The temperature sensor is used to measure the water temperature, while the PIR sensor detects activity near the column for security. The purpose of the ultrasonic sensor is to measure the water pressure or level, while the pH and TDS sensors measure the water quality in the pool. Shown in Figure 1. Schematic view of the circuit**.**

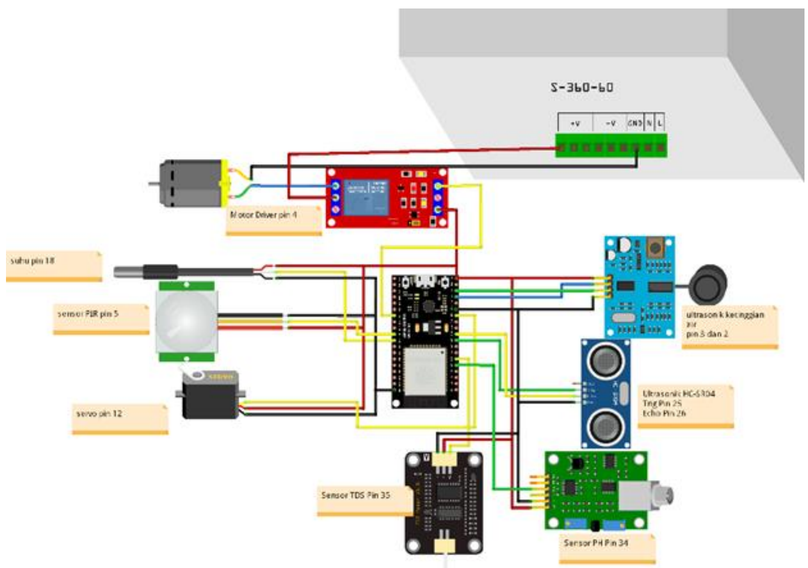

Figure 1. *Schematic circuit*

Figure 1. describes the data from the sensors used. The servo motor defined by the ESP32 is used to create mechanisms such as automatic opening and closing of the feed according to a schedule. In addition, a DC motor is connected to the drive motor and controlled by a relay, allowing automatic control over the various components of the system.

The system is equipped with an adapter or power supply that converts AC power into DC power to power the electronic components. This integration of sensors and actuators creates an efficient automated system that not only monitors but also independently determines the condition of the fish eggs. With the use of IoT technology, users can monitor and control pond conditions remotely, increasing the effectiveness and efficiency of fish farming.

To summarize, this is an example of an advanced automated system that can increase fish production yields while reducing the need for human intervention. The system also ensures that the colony's environmental conditions are always ideal for fish growth by reducing operational delays through technology-based maintenance and development.

2.2.2 Flowchart

This IoT-based Automatic Feeding system flowchart illustrates the workflow of the system starting from initialization to servo and relay control. In the initial stage, the ESP32 and sensors (DS18B20, pH sensor, TDS sensor, PIR, Ultrasonic HSR-04, and A02YYUW) are initialized, then the ESP32 is connected to the Wi-Fi network. After initialization is complete, the system reads data from all sensors, which include measurements of water temperature, pH levels, water turbidity, motion detection, feed height, and water level. The sensor data is then sent to the application via the Wi-Fi network for real-time monitoring by the user. Next, the system waits for the time input from the app. If time input is given, the servo and relay will be activated according to the predetermined duration. If there is no time input, the system returns to the sensor monitoring process. After the inputted time is completed, the servo and relay are automatically turned off, and the system returns to the sensor reading stage to continue the cycle.

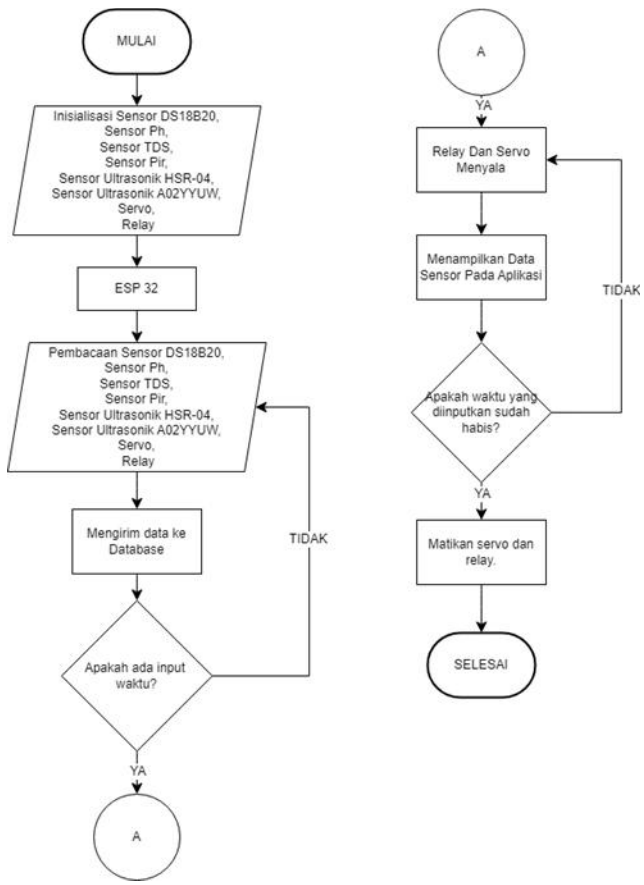

Figure 2. Flowchart

2.2.3 Mobile Application Design

Figure 3. shows a screenshot of the mobile application associated with the SPONCER project: Smart Pond Controller project. There is a “Welcome” message at the top that greets users of the app. Below that, there are logos representing several related entities, including Universitas Teknokrat Indonesia, the Ministry of Education and Culture of the Republic of Indonesia, and the Ewak Pond Fish Farming Group from Pagelaran, Pringsewu. These logos show the collaboration between educational institutions, government and community groups in the project.

Figure 3. Initial login view

In addition, in the center of the screen there is text mentioning the involvement of Universitas Teknokrat Indonesia and the Directorate General of Higher Education, which reinforces the role of higher education institutions in supporting IoT-based innovation. Users can continue by pressing the "Next" button to enter the next section of the application. This page serves as the initial interface before users can access features related to fish pond monitoring, such as water quality monitoring and feeding.

Figure 1. shows the results of the SPONCER mobile application which focuses on the Feeding Schedule for fish in the pond. At the top, there is information regarding the daily amount of feed dispensed in this case it is still recorded as about 0.00 kg. In addition, the app also shows 100% for the current feed, indicating no feed has been used or exhausted. Below this information, there is an indicator showing that an event has been detected. This indicator can be used in conjunction with the PIR sensor to detect activity around the object, including fish theft.

Figure 4. Feeding display

The app also provides many function buttons on the bottom side, namely Add Schedule, Calibrate, History, and Water monitoring, which make it easy for users to customize the feeding schedule, calibrate the time, view the feeding history, and check the water quality. At the very bottom, the app displays the current history or feeding schedule, along with some details such as the feeding times at 11:05:00, 11:14:00, and 18:04:00, each with one kg of feed. This allows users to view fish feeding accurately and on time.

An additional feature for the "Feeding Schedule" page is to automatically add a fish feeding schedule to the SPONCER application. Users can set the feed time by entering the time in the form of hours, minutes, and seconds. After determining the correct time, the user can use the Set Time button to confirm the time adjustment. In addition, users can also select the amount of feed to be given according to their needs. Once all the information has been collected, the user can use the Cancel or Save button to confirm the current feeding.

Figure 6. 2nd feeding display

Once the schedule is saved, the system will display the scheduled time and feed amount at the bottom of the screen. In this example, the weighing was done at 21:27:00 with a weight of approximately 1 kg. This feature allows the user to manage the feeding automatically, ensuring the fish are fed at the right time with the right amount.

The presented interface application shows the calibration feature of the feed amount system. This feature aims to help users accurately determine how long it takes to weigh one kilogram of feed, which in this case takes fifteen seconds. At the top is a "Change Time" button that allows the user to adjust the calibration time in the event of a change in feeding speed. This is very important to ensure that the automated system operates according to the requirements for the feed fish in the column.

Figure 7. Feed history display

With this calibration feature, the SPONCER system can help optimize the fish feeding process automatically and precisely. Users can ensure that the feeding made in each cycle is in accordance with the specified needs. This step not only reduces feed waste but also silently contributes to increasing the efficiency and productivity of fish farming. Finally, this feature supports the main goal of the SPONCER system, which is to modernize and optimize fish production in Pagelaran, Pringsewu, and Lampung. The SPONCER application interface in the water monitoring section provides several important parameters related to the quality of the water in the pond. The water level is around 7.3 meters, which helps ensure that the pond has enough water volume to support fish life. In addition, the water turbidity level of 3736 ppm indicates the presence of a large number of particles in the water that can negatively impact the surrounding water quality and fish health. To prevent water pollution, excessively high temperatures must be addressed. In addition, the pH of the water is slightly alkaline at 3.3, indicating a very acidic nature in the water. This needs to be corrected immediately as the ideal pH range for fish is usually between 6.5 and 8.5 so that optimal growth can be minimized.

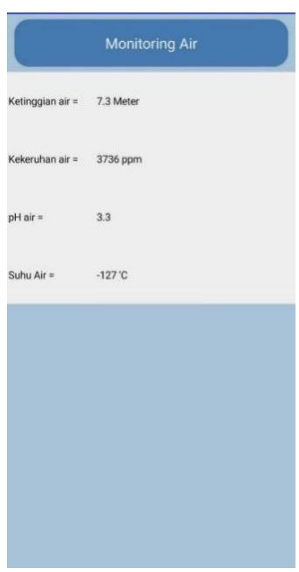

Figure 8. Water Monitoring

However, the pool water temperature reading dropped to -127°C, which clearly indicates a faulty sensor reading or invalid data. This sensor temperature value is unlikely to occur in natural pool conditions, therefore a more in-depth examination of the temperature sensor is required to obtain a more accurate reading. The overall system allows the user to monitor the pool water quality in real-time and respond quickly if any issues arise, ensuring that the environment remains healthy and in ideal conditions.

2.2.4 Tool Block Diagram

The block diagram of the system This fish feeding system shows how the main components in the system interact with each other. The ESP32 acts as a control center that connects various sensors and output devices such as servo motors and relays. The sensors used in this system include the DS18B20 to measure water temperature, a pH sensor to monitor water acidity, a TDS sensor to measure turbidity or dissolved solids, a PIR sensor to detect movement, and an HSR-04 Ultrasonic sensor to measure feed height and A02YYUW to measure water level. All of these sensors are directly connected to the ESP32, which then processes the data and sends the results to the application connected via Wi-Fi. At the same time, input from the application is used to control the servo motor, which functions to move the feed launcher to the right and left, and the relay to turn the feed launcher on and off. This block diagram provides a clear picture of the data flow and control of the devices in the designed fish feeding system.

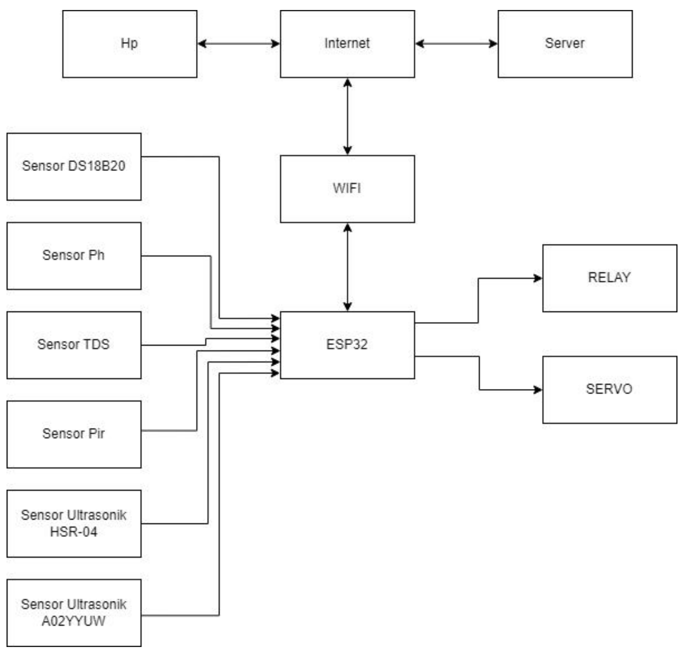

Figure. 9 Block Diagram

3. Result and Discussion

3.1 Discussion

SPONCER (Smart Pond Controller) is an Internet of Things (IoT) based technology innovation designed to improve the efficiency and productivity of fish farming, especially in Pagelaran, Pringsewu, Lampung. The purpose of this system is to reduce the problems faced by fish farmers related to water quality and to manage feed efficiently. SPONCER is featured in several freshwater fish farms in Pagelaran. This system uses various sensors to monitor important parameters such as pH, turbidity, height, and water flow. Data collected from the sensors is then analyzed in real time and stored in a mobile application, allowing farmers to monitor pond conditions without the need for personal inspection, which saves time and effort.

In addition, choosing an automated feed delivery system results in higher efficiency in feed usage. Automatic control of the schedule and amount of feed given has been proven to reduce waste, thereby reducing operational costs. Fish farmers in Pagelaran said that fish raised with SPONCER showed better growth, with reduced mortality rates and increased fish weight at harvest. Other benefits of SPONCER include an integrated data management application that helps customers collect information about pond conditions and feeding. Structured data allows for easier analysis of fisheries and production processes. With this system, pond administration and management become more efficient and professional.

Overall, the use of SPONCER in Pagelaran, Pringsewu, Lampung, opens up great potential to optimize seafood production through the use of IoT technology. SPONCER provides a solution that addresses the most pressing problems in fish farming, and improves the safety of livestock around the area, with an automated system that can monitor water quality and feed usage.

3.2 Test Results

3.1.1 Test Results Ultrasonic sr04

The HC-SR04 ultrasonic sensor on the SPONCER is designed to automatically detect feed. The sensor is placed on the top of the clamp and detects ultrasonic signals. When the wave touches the surface feed, it returns to the sensor, which then reduces the time it takes for the wave to compare the sensor and the surface feed.

Table 1. Testing of Ultrasonic Sensor HC-SR04 (feed detection sensor)

No	Initial Feed Height (cm)	Readable Distance (cm)	Remaining Feed Height (cm)	Feed Presentation (%)	Information
1	90	5	85	90	Full feed
2	90	20	70	80	Feed remaining 80%
3	90	35	55	60	Feed remaining 60%
4	90	50	40	40	Feed remaining 40%
5	90	75	15	20	Feed is almost out
6	90	90	0	0	Feed is out

The table above shows the test results of the HC-SR04 ultrasonic sensor, which is used to detect the height of the feed in the container. The test was carried out using an initial feed height of at least 90 cm, where the sensor detected the distance of the feed reading from 5 cm to 90 cm. The results show that when the distance is 5 cm, the feed produced reaches 85 cm, or about 90%, indicating that the feed is still quite small. When the sensor detects the distance, the percentage produced continues to decrease. The remaining feed is only 15 cm or 20%, indicating that the feed is almost finished, and the detected distance is 75 cm. When the detected distance reaches 90 cm, there is no more feed left, indicating that the feed is finished. The description in the table helps explain the condition of the feed based on the detected distance and provides a clear illustration of the feed status

3.1.2 Test Results TDS

The purpose of this study was to assess the effectiveness of the TDS (Total Dissolved Solids) sensor integrated into the Smart Pond Controller (SPONCER) system in detecting turbid water in freshwater ponds. The results showed that the TDS sensor can detect water pollution effectively. In polluted water, TDS measurements showed higher particle concentrations in the water. As water quality deteriorated, TDS measurement levels increased significantly, indicating higher dissolved solids, which correlated with increased turbidity.

Table 2. TDS Sensor Testing (turbidity sensor)

Water Condition	TDS Sensor Reading (ppm)	Visual Turbidity
Clean water	150 ppm Clear water	few dissolved particles
Moderate Turbidity	450 ppm Slightly cloudy	dissolved particles starting to be visible
Very cloudy water	800 ppm Very cloudy	many dissolved particles visible

Based on the results, the TDS sensor provides an appropriate response to changes in water quality. TDS levels are high under humid conditions due to the presence of fine particles in the water. Conversely, in environments with more polluted water, TDS levels increase, reducing the accuracy of the sensor in detecting fine particles and causing failure. The TDS sensor used in the SPONCER system is effective in detecting fish contamination levels in the water. This sensor can provide accurate data to help monitor water quality in real time, which is very important in maintaining fish health and increasing fish production.

3.1.3 DS18B20 Sensor Testing

This study was conducted to assess the performance of the DS18B20 temperature sensor integrated into the Smart Pond Controller (SPONCER) in detecting the water temperature of freshwater fish ponds in Pagelaran, Pringsewu, and Lampung. The purpose of this experiment was to determine the accuracy of the DS18B20 sensor in detecting contaminated water in fish ponds. In addition, testing was conducted to determine the consistency of sensor performance in various changing water conditions throughout the day, such as morning, afternoon, and evening. This study also aims to ensure that the DS18B20 sensor can function properly and reliably in a pond water environment, so that the results of this study can be used for real-time water monitoring needs.

Table 3. DS18B20 Sensor Testing (temperature sensor)

No	Time	Sensor DS18B20 (°C)	Digital Thermometer (°C)
1	Morning (06:00)	25.2	25.0
2	Afternoon (12:00)	30.8	29.8
3	Evening (17:00)	27.4	27.0

According to the results table, the DS18B20 sensor provides accurate results when detecting water temperature. This sensor has successfully detected water conditions at various times of the day, including morning, afternoon, and evening. The temperature readings generated by the DS18B20 sensor have stability and reliability in freshwater pond environments, which can be relied on for real-time temperature monitoring.

3.1.4 PH Testing

This test aims to evaluate the performance of the pH sensor integrated into the Smart Pond Controller (SPONCER) system to detect the pH level of freshwater fish pond water in Pagelaran, Pringsewu, Lampung. Water pH is an important factor in maintaining ideal conditions for freshwater fish growth, so accurate measurements are needed. The test was carried out using several tools, namely a pH sensor integrated into the SPONCER system, standard pH buffers for sensor calibration with pH values of 4, pH 6, and pH 9, and a fish pond with a volume of 1000 liters as a test medium. In addition, a digital pH meter was used to verify the results of the pH sensor test. Before the process began, the pH sensor was calibrated using standard buffers to ensure accurate results. After calibration, the pH sensor was placed at a specific location in the water, and testing was carried out at various time intervals to determine the performance of the sensor under various conditions.

Table 4. pH Sensor Testing

Time Measurement	Reading pH Sensor
Morning (06:00)	7.3
Afternoon (12:00)	7.0
Evening (19:00)	7.5

Based on the results, the pH sensor in the SPONCER system can detect the pH of the air in the fish with high accuracy. This sensor has been proven to be consistent in providing stable pH readings in various ambient water conditions. With the addition of real-time pH monitoring features, the SPONCER system can help fish farmers improve water quality, which is an important factor in reducing waste and improving fish health. The use of a pH sensor in SPONCER allows monitoring of changes in water quality that can negatively impact fish production, thereby increasing efficiency and productivity in fish farming.

3.1.5 Ultrasonic Testing A02YYUW

The purpose of this study is to evaluate the performance of the A02YYUW ultrasonic sensor, which is integrated in the Smart Pond Controller (SPONCER) system to detect turbid water. This sensor is useful for monitoring the level of the pond and detecting potential flooding that can affect the condition of the pond. Here are the results of using the A02YYUW Ultrasonic sensor to detect the water level in the pond.

Table 5. Testing A02YYUW Ultrasonic (water level sensor)

No	Time	Actual Water Level (cm)	A02YYUW Sensor Reading (cm)
1	07.00	78	78
2	12.00	78	75
3	17.00	78	77

The A02YYUW ultrasonic sensors used in the SPONCER system are capable of detecting pool levels with high accuracy and consistency. The sensor provides accurate results over a wide range of water levels, allowing the SPONCER system to effectively monitor water quality and provide alerts if there are any problems. With this real-time monitoring of water levels, fish farmers can take immediate action in the event of water levels approaching critical limits, helping to prevent losses due to overflow or flooding in fish ponds.

3.1.6 Pear Sensor Testing

The purpose of this research is to evaluate the performance of the PIR (Passive Infrared) sensor integrated in the Smart Pond Controller (SPONCER) system to detect movement around the pond. This sensor is used to detect potential threats, such as fish, as well as human activity or objects in the surrounding area.

Table 6. PIR Sensor Testing (motion detection sensor)

Testing Conditions	Distance from Sensor (cm)	Sensor Response
Man walks closer	60	Detected
Human walking away	90	Detected
Small animal approaching	30	Not Detected

The use of PIR sensors in the SPONCER system shows that they are effective in detecting relevant events that could potentially pose a threat, such as fishing. It is capable of accurately detecting human activity in various settings and conditions, making it an ideal solution for ensuring fish safety. With the integration of PIR sensors in the SPONCER system, fish pond owners can get early warnings in case of suspicious activity around the pond, thereby increasing security and reducing costs associated with fish theft.

3.1.7 Pear Sensor Testing

This study was conducted to evaluate the performance of a mobile application integrated with the Smart Pond Controller system. (SPONCER) SYSTEM. The app is used to provide automated data collection and real-time monitoring of water quality, including parameters such as water level, water temperature, pH, and turbidity.

The process began with the installation of the SPONCER app on various Android devices, which were then connected to the SPONCER system via Wi-Fi. Tests were conducted by monitoring data from the feed and water quality sensors continuously for 24 hours, to obtain data displayed in real-time on the app. During the test, the app was selected to ensure that the data collected was accurate, with no errors or omissions in the sensor data collection process.

Table 7. Mobile Application Testing

Tested Features	Testing Condition	Test Result
Feed Monitoring	Auto feed on, feed out detected	Real-time feed data displayed
Water Temperature Monitoring	Temperature stable (27°C) and rising (30°C)	Accurate real-time temperature data is displayed
Water pH Monitoring	pH normal (7.0) and changing drastically (6.5)	Real-time accurate pH data displayed
Water Level Monitoring	Elevation stable and close to overflowing	Real-time water level data displayed
Application Stability	Used for 24 hours	Stable without crash or lag

4 Conclusions

The IoT-based automatic fish feed control system under development can provide an efficient solution for freshwater fish feed management. Using an ESP32 microcontroller as the central sensor, multiple connected sensors can monitor water conditions in real-time, including parameters of water level, water turbidity, water pH and water Temperature, as well as available feed capacity. In addition, the system also allows remote control using a web application, which makes it easier for users to maintain and adjust the column conditions without having to be physically present. The integration of servo motors and DC motors enhances the system's performance in carrying out automated functions such as feed changes, which are done quickly and according to the needs of the fish. Overall, the system increases productivity and efficiency in fish farming while reducing the need for human intervention.

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