JSCE (Journal of System and Computer Engineering)
Vol.7, No.2, April 2026, pp. 175-190
ISSN (online): 2723-1240
DOI : https://doi.org/10.61628/jsce.v7i2.2633



# Design and Implementation of a Shrimp Pond Monitoring Information System Using Internet of Things and Android Application

**Rozalina Amran [1,a,*]; Nurul Fitrihasari Ramadhani[2,a]; Vitalia Eka Wardani.G[3,a]**
[1] *Data Sciences, Science Department, Institute Technology Bacharuddin Jusuf Habibie, Indonesia*
[2,3] *Universitas Hasanuddin, Jl. Perintis Kemerdekaan KM.10, Makassar 90245, Indonesia*

**Abstract**

*Shrimp ponds are a place built to cultivate shrimp, with a tropical climate that makes Indonesia one of the largest shrimp producers, both saltwater, freshwater and brackish water shrimp. For shrimp farming business people, it is one of the profitable business opportunities because it is easy to maintain and produces fantastic profits. Maintenance for shrimp pond cultivation can be done by checking water quality using litmus paper, a digital pH meter or a chlorine test kit. However, this method is still considered less efficient because water is taken from the pond repeatedly over time, which wastes time and energy, in addition, changes in water quality in the pond can occur at any time, causing shrimp death and causing farmers to fail to harvest. In this study, water temperature, water pH, and water current sensors were used to monitor water quality. Then the data from the water quality detected by the sensor will be received by the Esp32 microcontroller and then send the data to firebase. Firebase plays a role in storing and sending data to Android so that it can be displayed on a smartphone. Poor data values will cause a notification to appear on the farmer's smartphone so that the farmer does not need to check the pond location repeatedly.*

***Keywords***— *Shrimp ponds, Sensors, Esp32 Microcontroller, Firebase, Android*

## 1. Introduction

Indonesia has enormous natural wealth. Such as being rich in various types of plants and animals in the sea. The sea waters in Indonesia are wider than the land. This provides a very profitable business opportunity in the fisheries sector. One of the businesses that is currently popular is the shrimp pond cultivation business. (Baena-Navarro et al., 2025) A shrimp pond is a place or reservoir built to cultivate shrimp, both freshwater shrimp, brackish water, and salt water. Shrimp is a type of filtering animal so that the quality of water in a shrimp farm (acidity and salt content) greatly determines the results obtained by the farmer. (Jan et al., 2021)

Environmental conditions in ponds are one of the main problems because the needs of shrimp life are highly dependent on the pond environment. Pond environmental conditions are closely related to the quality of water in shrimp ponds which consist of several parameters, namely salinity 10-10-33ppt, temperature 26-30o C, DO (Dissolved Oxygen) 4-7.5ppm, acidity (pH) 6.5-8. However, the most important parameters that cause shrimp death are salinity, pH and temperature, therefore they must be monitored every day. (Kilawati et al., 2022)

The problem often faced by shrimp farmers is the poor water quality or not yet in accordance with the criteria for maximum shrimp cultivation. (Nagothu et al., 2025) This can cause a very high mortality rate in shrimp farming and result in crop failure. In shrimp farming, one of the obstacles for shrimp farmers is the way to check water quality which still uses manual methods. With water quality checks that are not regular or continuous, this can result in sudden changes in water quality without the knowledge of shrimp farmers, which has a negative impact on the shrimp farming process and results in farmers failing to harvest. The Internet of Things has been widely applied in several scientific and industrial fields, such as in the fields of health science, informatics, geography and several other scientific fields. Therefore, a good monitoring system is important, so that it can detect and provide accurate information to shrimp farmers. This can be conveyed by monitoring the android application directly to the shrimp pond business owner. (Wardhany et al., 2021)

Internet of Things has been widely applied in several scientific and industrial fields, such as in the fields of health science, informatics, geography and several other scientific fields. Therefore, a good monitoring system is important, so that it can detect and provide accurate information to the shrimp farmers. This can be conveyed by monitoring the android application directly to the owner of the shrimp pond business. (Chavhan et al., 2025) As time goes by and technology increases and always experiences improvements, this encourages people to create a technology using computer systems and microchips that can facilitate daily work, the system is called smart technology. With the existence of smart technology, it is hoped that people can be smart and intelligent in media so as to foster creativity and can have an impact in helping and making things easier for themselves and others. One of the most frequently used media is cloud storage. (Kirchhof et al., 2022)

Several studies have proposed water monitoring systems using approaches such as Arduino-based sensors, web-based platforms, and SMS gateways. However, existing systems are generally limited by narrow parameter coverage, lack of integrated multi-sensor architectures, and insufficient real-time accessibility. These limitations hinder comprehensive water quality assessment. Therefore, a structured gap analysis is conducted to systematically identify these shortcomings and establish the need for a more integrated and real-time monitoring solution.

**Table 1.** Research Gap Analysis of Previous Studies

| **Author(s) & Year** | **Main Contribution** | **Identified Gap** | **Impact of Limitation** | **Proposed Solution in This Study** | **Contribution (Novelty)** |
|---|---|---|---|---|---|
| Nuriman (2010) | Web-based water monitoring system using database | No integration of water quality sensors | Data does not reflect real-time physical conditions | Integration of multiple water quality sensors (pH, turbidity, temperature, flow) | Real-time monitoring based on actual sensor data |
| Wiranto & Hermida (2010) | Shrimp pond monitoring using DO and pH sensors with SMS Gateway | Communication limited to SMS, not real-time modern system | Delay in information delivery and inefficiency | Implementation of IoT and Android-based application | Real-time mobile-based monitoring system |
| Arhef (2016) | Arduino-based pH monitoring system | Single-parameter measurement (pH only) | Inability to represent overall water quality | Addition of multiple parameters (turbidity, temperature, flow) | Multi-parameter monitoring system |
| Ardiansyah (2016) | Water pH detection system | Lack of parameter integration | Limited water quality analysis | Integration of additional sensors | More comprehensive water quality analysis |

| | | | | | |
|---|---|---|---|---|---|
| Rohman et al. (2017) | IoT-based water level monitoring system | Focus only on water quantity, not quality | Cannot determine water suitability | Inclusion of water quality parameters | Water feasibility evaluation based on multi-sensor data |
| Fauzi et al. (2017) | Web-based monitoring of water level and temperature | Lack of key water quality parameters | Incomplete monitoring information | Addition of pH and turbidity sensors | Improved monitoring accuracy |
| Amin (2018) | Automated water level control system | No water quality monitoring | Does not support water quality assessment | Integration of water quality monitoring system | Combined monitoring and analysis system |
| Michael et al. (2018) | Automated fish pond monitoring system | Limited parameters used | Data is not comprehensiv e | Multi-sensor integration | More accurate and comprehensiv e monitoring |

Table 1 presents a comparative analysis of previous studies related to water monitoring systems, highlighting their main contributions, limitations, and the research gaps addressed in this study. Existing studies have demonstrated the implementation of various technologies, such as web-based systems, Arduino, SMS gateways, and IoT devices, for monitoring water conditions. However, most of these studies focus on limited aspects, such as monitoring only a single parameter (e.g., pH, water level, or temperature) or emphasizing water quantity rather than water quality. As a result, these approaches are not sufficient to provide a comprehensive assessment of water quality conditions.

Furthermore, the analysis indicates that previous studies generally lack integrated multi-parameter monitoring systems. For example, some studies successfully utilized pH or dissolved oxygen sensors, while others implemented temperature or water level monitoring. Nevertheless, the absence of simultaneous monitoring of critical water quality parameters, including pH, turbidity, temperature, and water flow, limits the accuracy and reliability of water condition analysis. In addition, several earlier systems still rely on web-based platforms or SMS communication, which may reduce accessibility and real-time responsiveness for end users.

Based on these limitations, this study proposes an IoT-based water quality monitoring system that integrates multiple sensors, including pH, turbidity, temperature, and water flow sensors, into a single platform. The collected data are visualized through an Android-based mobile application, enabling users to monitor water quality in real time and more efficiently. By combining multi-parameter sensing, mobile accessibility, and a structured waterfall development approach, this study is expected to contribute a more comprehensive and practical solution for shrimp pond water quality monitoring water quality monitoring compared with previous works.

This study aims to design and develop an IoT-based water quality monitoring system for shrimp ponds by integrating multiple sensors, including pH, turbidity, temperature, and water flow sensors. The system provides real-time monitoring through an Android-based application. Furthermore, this study evaluates the performance of the proposed system in terms of sensor measurement accuracy compared to standard instruments and its effectiveness in improving monitoring efficiency to reduce the risk of shrimp mortality caused by sudden changes in water quality.

## 2. Method

System developers are required to understand the software expected by the user and the limitations of the software. This information is usually obtained through interviews, discussions or direct severing. Information is analysed to obtain data needed by the user. The requirements specifications from the previous stage will be studied in this phase. (El-Khozondar et al., 2024) The system design is prepared. System design helps in finding the system hardware requirements and also helps in defining the overall system architecture. Then the system is developed in small programs called units, which are integrated in the next stage. Each unit is developed and tested for functionality called unit testing. Then after testing is carried out for each unit. (He et al., 2024) After integration, the entire system is tested to check for any failures or errors. The finished software is run and maintained. Maintenance includes fixing errors that were not found in the previous step. Improvement of the implementation of the system unit and improvement of system services as new. (Al-Shareeda et al., 2025)


**Figure 1.** Research Diagram Method

The microcontroller used is ESP32, a microcontroller introduced by Espressif System, which is the successor to the ESP8266 microcontroller. This microcontroller has a Wi-Fi module on the chip, making it very supportive for creating an Internet of Things application system. The ESP32-S2 Wi-Fi module offers a "system-on-chip" solution with 2.4 GHz Wi-Fi, with high integration, low power, and is an ideal choice for a variety of scenarios related to "wearable electronics", smart home, and the Internet of Things (IoT). The ESP32-S2 is unlike any other processor released so far, it is the first of its kind to come with a built-in USB (OTG) interface, a more advanced peripheral interface, Time-of-Flight Wi-Fi and hardware security features. (Das, 2025)

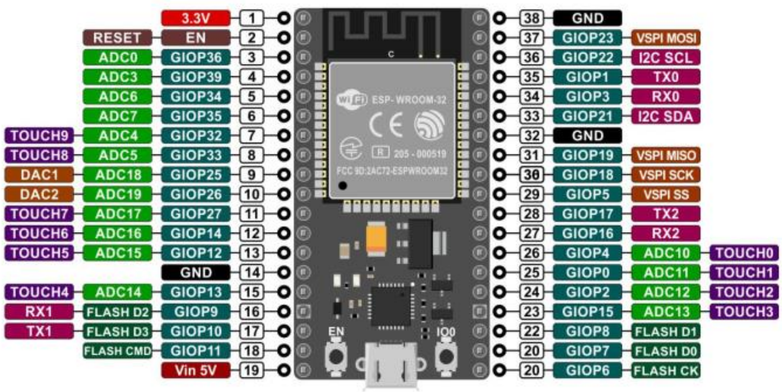


**Figure 2.** ESP32

### 2.1 Sensors

This tool uses several sensors, the sensor itself is a tool that detects and measures changes in the surrounding environment, be it changes in pressure, force, electrical quantities, light, movement, humidity, temperature and others. The sensors used in this study include:

#### 2.1.1 pH Sensor

The pH sensor is a module that functions to measure the pH of the acidity or alkalinity or base of a solution or detect the pH level of water where the output is in the form of analog voltage. (de Camargo et al., 2023) So, to convert the reading value must be entered into the formula in the program code created

#### 2.1.2 DS18B20 temperature sensor

This sensor is capable of reading temperatures with an accuracy of 9 to 12-bit, a range of -55°C to 125°C with an accuracy of (+/-0.5°C). Each sensor produced has a unique 64-bit code embedded in each chip, allowing the use of a large number of sensors through just one cable (single wire data bus/1-wire protocol).

#### 2.1.3 Water Flow Sensor

Flow sensor that is used to detect water flow. Whether it is a flow that has a certain pressure, water flow with very small pressure and minimal flow speed or for water flow in open places such as in ditches, rivers or irrigation channels. (Miller et al., 2023) This water flow sensor is also often referred to as a water meter, water flow meter or water flow meter. This sensor also has several types according to its function and installation purpose.

#### 2.1.4 ADS1115 Module

The ADS1115 module is a type of ADC that has a resolution of 16 bits, this means that this ADC has a high level of accuracy of the conversion result value compared to ADCs that have little resolution. In terms of function, the ADS1115 is used to measure various signals with a voltage range of 2v to 5v, and this is very good for measurements with 16-bit resolution. (Manoj et al., 2022)

### 2.2 Software

#### 2.2.1 Arduino IDE

Arduino IDE (Integrated Development Environment) is software used to program on Arduino, in other words Arduino IDE as a medium for programming Arduino boards. Arduino IDE can be downloaded for free on the official Arduino IDE website. (Alshami et al., 2024)

#### 2.2.2 Android Studio

Android Studio is the official Integrated Development Environment (IDE) for Android application development, which is based on IntelliJIDEA. In addition to being a reliable code editor and IntelliJ developer features, Android Studio offers many features that increase your productivity in creating Android applications, for example: Gradle-based build system Flexible, Fast and feature-rich emulator, Comprehensive framework and testing tools, etc. (Akintayo et al., 2024)

#### 2.2.3 Firebase

Firebase is a cloud storage and one of Google's services to make it easier for application developers to develop their applications. Firebase (BaaS 'Backend as a Service') is a solution offered by Google to make Developers' work easier. (Mohd Jais et al., 2024)

## 3. Results And Discussion

### 3.1 Deployment Diagram

Deployment diagram is a diagram that is used to map software to processing nodes. It shows the configuration of processing elements at run time and the software in it. This diagram is one of the most important diagrams in the software implementation level and is sometimes written before coding. By using a deployment diagram, we can determine the available space and time execution available by hardware. (Ayeni & Adesoba, 2025)

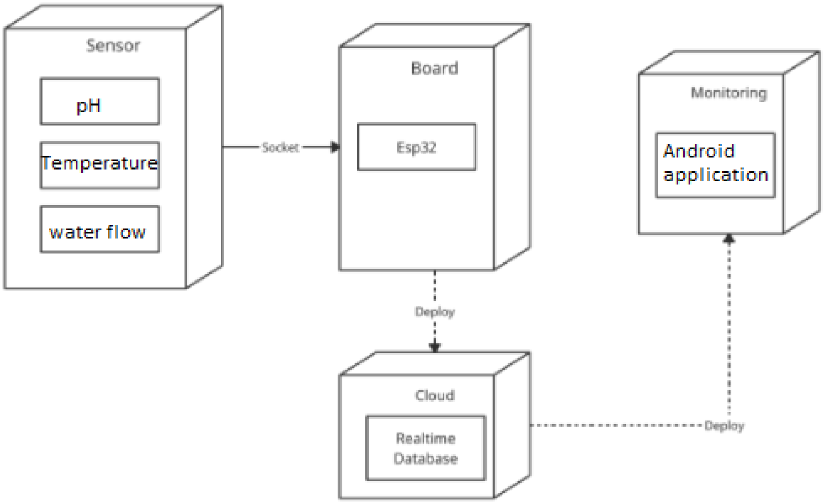


**Figure 3.** Deployment Diagram

### 3.2 System Design

Monitoring system will be built to monitor water quality in shrimp ponds that will be connected to android. (Kalamaras et al., 2025) The microcontroller will be given a command in the form of a program script so that the sensor can detect the quality of the shrimp pond every 5 seconds, then the data from each sensor will be stored in the cloud, so that farmers can see changes in temperature at any time, while the output from the sensor will be displayed on the shrimp farmer android application. The design can be seen in the following picture.

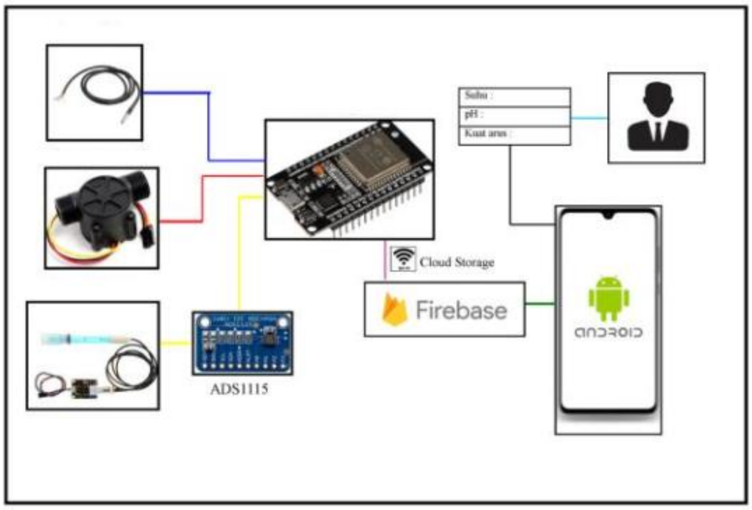


**Figure 4.** System Design

### 3.3 System Design

At this stage it will be explained how to implement the shrimp pond monitoring information system design, tool design, software, android application and database.

**Table 2**. System Design

| No | Tool | Function |
|---|---|---|
| 1 | pH sensor | pH value detection |
| 2 | Water Flow sensor | Water flow value detection |
| 3 | Temperature sensor | Temperature value detection |
| 4 | ESP32 | Microcontroller |

| | | |
|---|---|---|
| 5 | ADS1115 | convert analog data to digital |
| 6 | PCB Board | Connecting tools |

The previously designed tool will be placed in a container, because the tool will be installed in a pond filled with water, so we need an object to help it float, while the sensor can detect water quality, so a container is made using wood and cork, we can see in the following picture.

**Figure 5.** Hardware

### 3.4 Software

This software uses a software called Arduino IDE by entering the above variables and its function is that the include line is used to install the library to be used while the define line is used to define the variables used. (Ferrer-Cid et al., 2025)

```
#include <WiFi.h>
#include <FirebaseESP32.h>
#include <OneWire.h>
#include <DallasTemperature.h>
#include <Wire.h>
#include <ADS1115.h>

#define FIREBASE_HOST "https://vitalia-monitoringkualitasair-default-rtdb.firebaseio.com/"
#define FIREBASE_AUTH "2j8CLQoOWgdqRToErJBF3pocpTHF4P1EXvbTyD7z"
#define WIFI_SSID "Vitalia"
#define WIFI_PASSWORD "bismillahsukses"
```

**Figure 6.** Variable Arduino IDE

The application design that has been created and designed using Android Studio will be built and installed on the Android that will be used. The application will work when the tool is run. (Efendi et al., 2025) The sensor will detect the value of the water which will then be sent via the internet network and displayed via the Android application that has been installed previously, here is the appearance of the Android application that has been created.


**Figure 7.** Application View

### 3.5 Firebase

Firebase Realtime Database is a cloud-hosted database. Data is stored and executed in JSON format and synchronized in real time to each connected user. This serves to facilitate the management of a database on a fairly large scale. When creating cross-platform/multiplate form applications using the Android, iOS, and JS (JavaScript) SDKs, all users will share a Realtime Database instance and receive data updates simultaneously and automatically. This database is designed to store the detection values of each sensor so that farmers can check. (Ramadani et al., 2021)

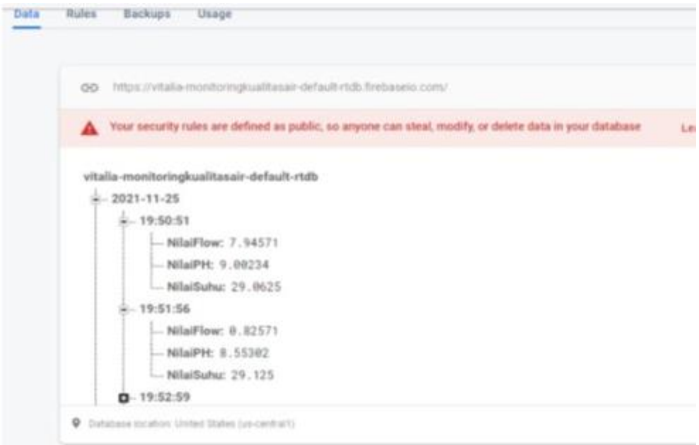


**Figure 8.** Firebase

### 3.6 System Testing

After the system design is finish, then testing is carried out on the design, namely a design using a water current sensor, water pH sensor, and water temperature integrated into the android application, this aims to determine whether the design can run well and is free from errors. (Natividad et al., 2023) System testing is an activity that aims to determine whether the system design that we have made is appropriate or not, find any deficiencies, and test whether each function can run well or not, in the implementation of a monitoring system for water temperature, water pH and water current strength in shrimp ponds based on smart technology, using 3 sensors, including a water current sensor, water pH sensor, and water temperature sensor. For testing, it can be done by installing the tool on the shrimp pond, to ensure that the system that has been created can work and function properly. (Georgantas et al., 2025)

**Figure 9.** System testing

Testing of pH sensors, ds18b20 sensors and water current sensors is done by inserting the sensors into the water in the shrimp pond, if the sensor detects the pH value, water temperature value, and water current value are not within normal limits, then the farmer's android will get a notification regarding the status of the pond, while if the sensor detects the pH value, temperature value, and water current value are within normal limits, then the application will display the status of the pond in a normal state. If the pond status is not normal, there are several possibilities that occur, including the following, (Anmi et al., 2025)

- the temperature is too low then the farmer will reduce the water in the pond by about 5-8 cm. if it is too high then the farmer will add water.
- the pH is low or high then the farmer will add lime ($CaCO3$, $CaMg(CO_3)_2$) to neutralize the acidity and alkalinity,
- the current in the pond is not detected or is lacking then the farmer will check the water wheel.

The electronic device design is in the form of an Esp 32 as a microcontroller, a temperature sensor to detect water temperature values, a current sensor to detect water current, a pH sensor to detect pH values. For more details, here is a table of test results for each device circuit along with its description.(Badderol & Abdullah, 2025)

### 3.7 Testing In the Shrimp Ponds

Data values of water pH, water temperature and water current in shrimp ponds within 3 days starting from Saturday to Monday. The sample data was taken at 3 times, namely morning, afternoon, and evening, every 2 hours because at that time the range of temperature values and pH values rose and fell. Data collection was carried out from 8:00 to 10:00 then during the day from 13:00 to 15:00 and at night from 19:00 to 22:00. For the graph of temperature, pH, and water current values on the first day we can see in the following picture.

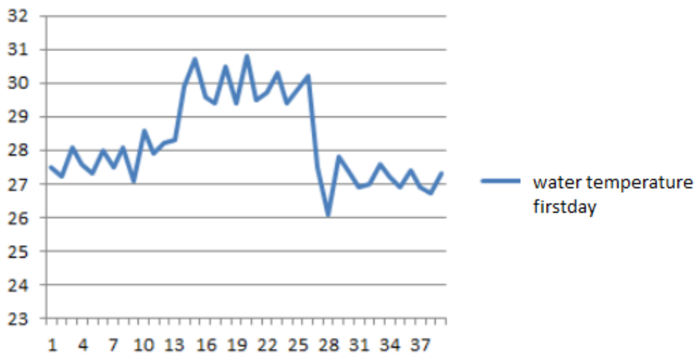


**Figure 10.** Temperature First day

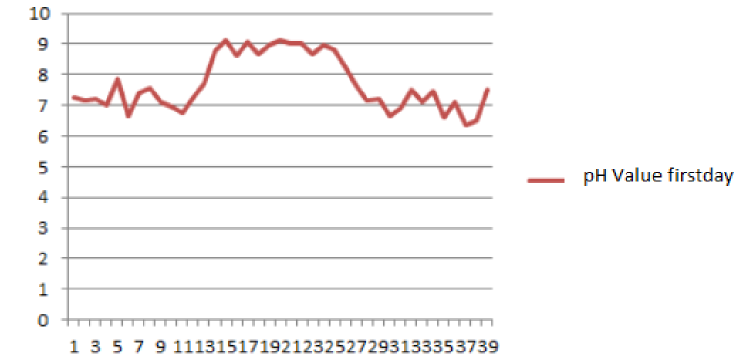


**Figure 11.** water pH First day

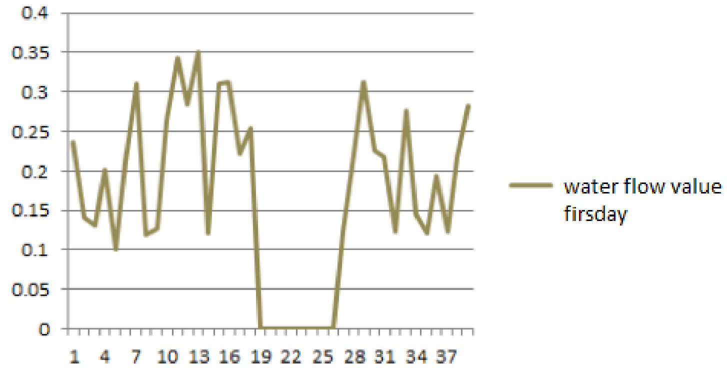


**Figure 12.** Water Flow First Day

While on Saturday at 8:00 to 10:00 the average temperature is 27.8°C, the average pH of the water is 7.2 and the average water flow is 0.22 M/L. During the day at 13:00 to 15:00 the average temperature is 29.9°C, the average pH of the water is 8.8 and the average water flow is 0.23M/L. At night at 19:00 to 21:00 the average temperature is 27.1°C, the average pH of the water is 7.0 and the average water flow is 0.19M/L.

From the data we can see that the temperature and pH values during the day increase. This is due to the activity of phytoplankton which takes CO2 from the water and produces oxygen, then the pH decreases at night until morning due to the respiration process and CO2 production by all organisms including phytoplankton. It should be noted that a good shrimp pond cultivation usually will not experiencing drastic changes in pH, this occurs because of the presence of a buffer solution. If there is a drastic change in pond pH, liming is necessary.

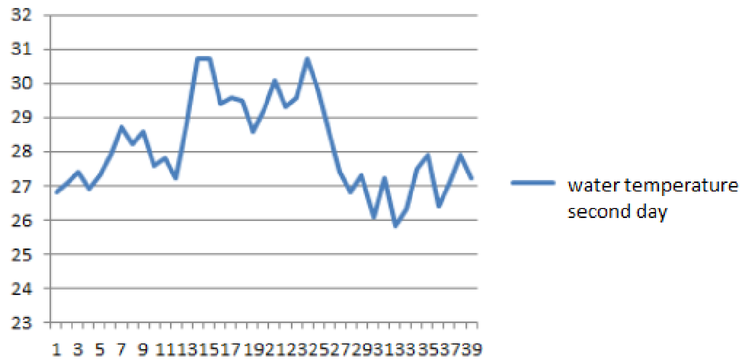


**Figure 13.** temperature Second day

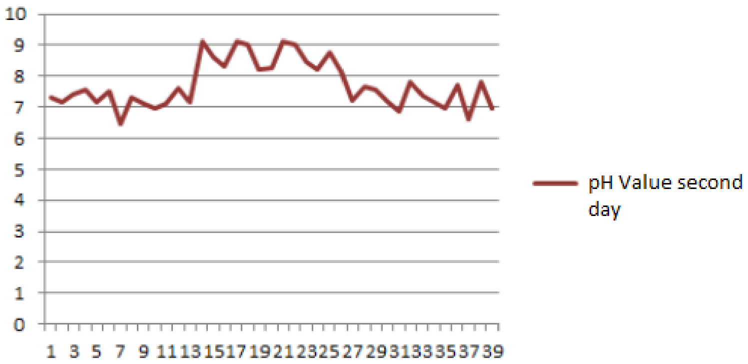


**Figure 14.** water pH Second day

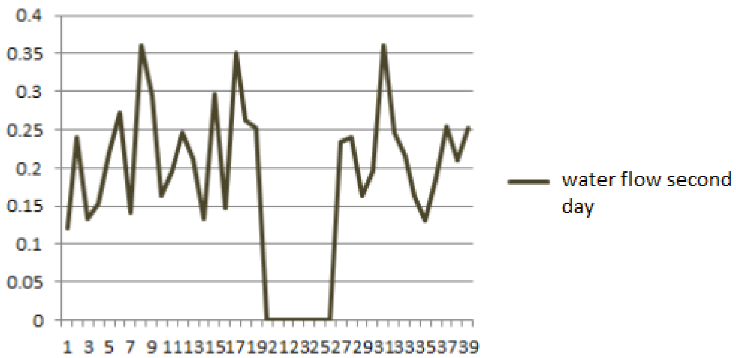


**Figure 15.** Water flow Second day

We can see that on Sunday at 8:00 to 10:00 the average temperature is 27.7°C, the average pH of the water is 7.2 and the average water flow is 0.21 M/L. During the day at 13:00 to 15:00 the average temperature is 29.6°C, the average pH of the water is 8.6 and the average water flow is 0.24 M/L. At night at 19:00 to 21:00 the average temperature is 26.9°C, the average pH of the water is 7.2 and the average water flow is 0.21 M/L.

From the data above, we can see that the current value did not change significantly while the temperature and pH values on the second day increased but decreased slightly from the previous day. This happened because the weather was rather cloudy on the second day. but the sunlight is still there compared to the previous day which had sunny weather. Although both days had temperature and pH values rising and falling, these values are still good values for shrimp farming.

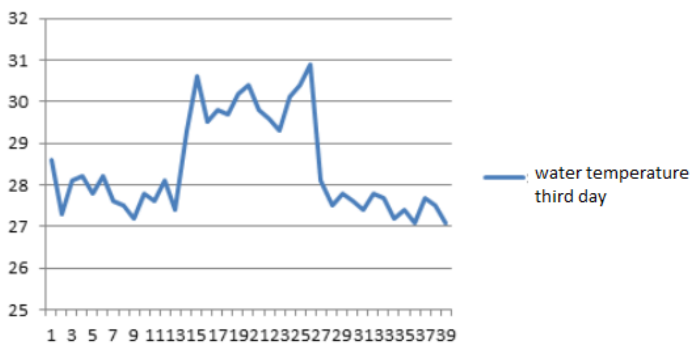


**Figure 16.** Temperature third day

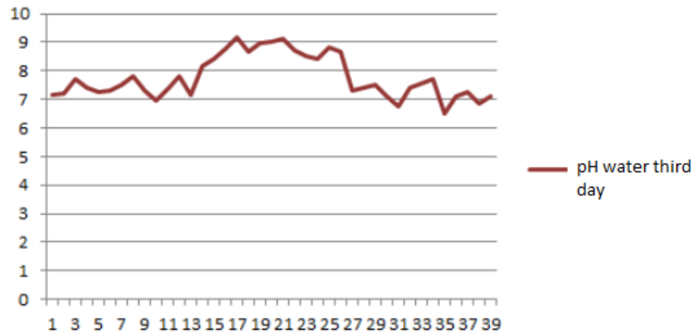


**Figure 17. Water** pH third day

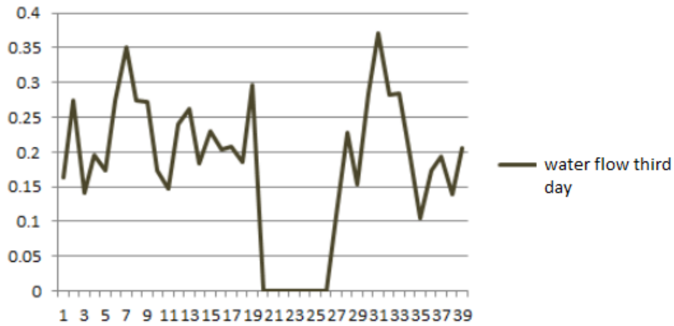


**Figure 18.** Water flow third day

We can see that on Saturday at 8:00 to 10:00 the average temperature is 27.8°C, the average pH of the water is 7.2 and the average water flow is 0.23 M/L. During the day at 13:00 to 15:00 the average temperature is 29.9°C, the average pH of the water is 8.8 and the average water flow is 0.19M/L. At night at 19:00 to 21:00 the average temperature is 27.1°C, the average pH of the water is 7.0 and the average water flow is 0.19M/L.

Furthermore, the data collection time was changed from initially 3 times, namely morning, afternoon and evening a day to 1 time a day, namely in the morning when the shrimp have not been fed, when the feed is spread and after the spread is done. This was done to find out whether there was an effect of changes in water quality before and after the data collection time was given at 07.00 to 09.30. The following data was taken on the 25th and 26th.

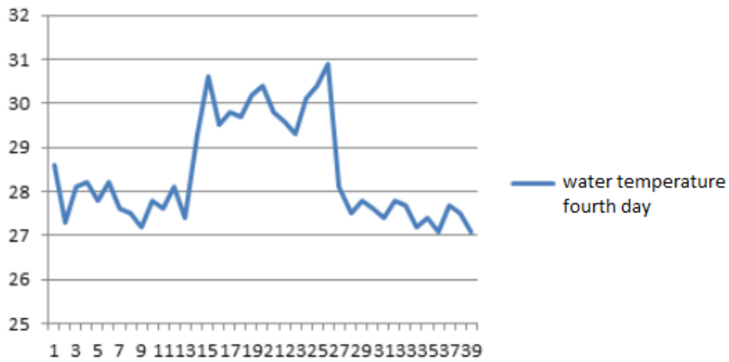


**Figure 19.** Temperature fourth day

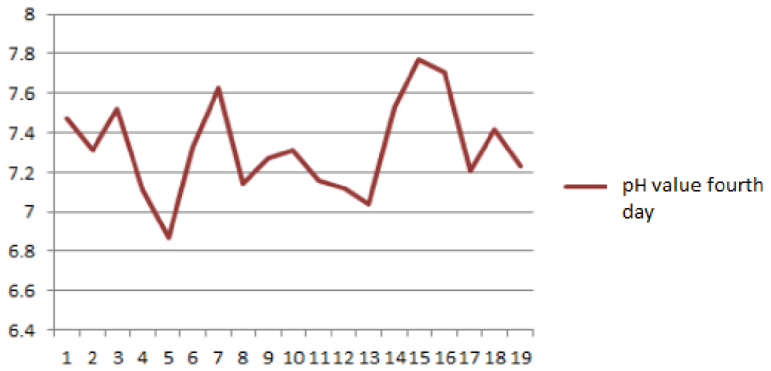


**Figure 20.** water pH fourth day

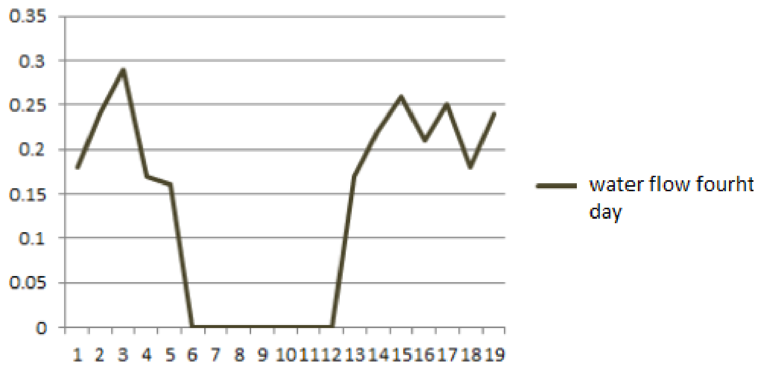


**Figure 21.** Water flow fourth day

From table 10 we can see that before feeding until after feeding the shrimp, the pH value, temperature and current strength are not too different from the previous days. Before feeding, the waterwheel will be turned off 15 minutes before feeding and turned on again 1 hour after feeding. This is to prevent the feed from being carried away by the water current without being eaten by the shrimp.

### 3.8 Validation and Reliability Analysis

To ensure the validity and reliability of the proposed system, an evaluation was conducted based on sensor measurement consistency and statistical analysis using data collected from day 1 to day 7.

#### 3.8.1 Sensor Data Consistency (Reliability)

Based on the observation results, the sensor readings for temperature, pH, and water flow show relatively stable and consistent patterns across different days and time periods (morning, afternoon, and evening). The recorded temperature values ranged between 26.8°C and 30.9°C, pH values ranged between 6.34 and 9.21, and water flow values ranged between 0.10 and 0.36 m/s. These ranges indicate that the system is capable of capturing variations in environmental conditions without producing extreme or inconsistent values.

The fluctuation patterns observed are logical and consistent with natural phenomena, where temperature and pH tend to increase during the day due to photosynthesis and decrease at night due to respiration processes. This pattern demonstrates that the system is able to reflect real environmental dynamics, indicating that the proposed monitoring system has good reliability in capturing actual changes in shrimp pond water quality.

#### 3.8.2 Statistical Analysis (Mean and Stability)

**Table 3. Data (day 1–7)**

| Parameter | Average Value | Range |
|---|---|---|
| Temperature (°C) | 28.5 | 26.8 – 30.9 |

| | | |
|---|---|---|
| pH | 7.8 | 6.34 – 9.21 |
| Water Flow (m/s) | 0.22 | 0.10 – 0.36 |

The statistical analysis of the collected data from day 1 to day 7 shows that the average temperature is 28.5°C with a range of 26.8–30.9°C, the average pH is 7.8 with a range of 6.34–9.21, and the average water flow is 0.22 m/s with a range of 0.10–0.36 m/s. These results indicate that all measured parameters remain within acceptable limits for shrimp pond conditions. Moreover, the relatively small variation between the minimum and maximum values suggests that the system is able to produce stable and consistent readings over time. This stability confirms that the monitoring system is reliable for continuous observation and can effectively represent actual environmental conditions in shrimp ponds.

**3.8.3 System Validity (Logical Validation Approach)**

Although direct comparison with laboratory-grade instruments was limited, the validity of the system can be evaluated through logical validation based on observed data patterns. The measured values consistently fall within the optimal range required for shrimp cultivation, and no abnormal or unrealistic readings were detected during the monitoring period. In addition, the system successfully captured dynamic environmental changes, such as daily fluctuations in temperature and pH. These results indicate that the system is capable of representing real-world conditions. However, future work will include calibration and comparison with standard measurement instruments to further improve system accuracy and validation.

**3.8.4 Discussion of System Performance**

The integration of multiple sensors with IoT technology and an Android-based application enables continuous and real-time monitoring of water quality parameters. This allows shrimp farmers to access environmental data at any time and respond more quickly to changes in water conditions. Compared to conventional manual monitoring methods, the proposed system offers significant advantages in terms of efficiency, responsiveness, and accuracy. By providing real-time information and early warnings, the system can help reduce the risk of undetected water quality fluctuations, thereby minimizing the potential for shrimp mortality and improving overall aquaculture management.

## 4. Conclusions

After the design, manufacture and testing of the temperature monitoring tool, the following can be concluded:

The monitoring system information tool for monitoring water temperature, water pH and water current strength in shrimp ponds based on smart technology, made using ESP32, temperature sensor, water current sensor and water pH sensor. The process of monitoring water temperature, water current and water pH based on android and cloud storage using firebase as a communication medium between the temperature sensor, current sensor, pH sensor and Esp32 with the client device (Android). Data from the temperature sensor, current sensor, and pH sensor are connected to Esp32 and then forwarded to Firebase (Cloud Storage) using the internet network, then the data from each sensor will be displayed via the application from the farmer's android along with a warning if the water temperature, water current and water pH are below or exceed the specified limits. (Flores-Iwasaki et al., 2025; Sung et al., 2023; Sujiwa & Dianto, 2022; Za'bah & Mohamad, 2021)

## References

Al-Shareeda, M. A., Mohammed Ali, A., Hammoud, M. A., Kazem, Z. H. M., & Hussein, M.

A. (2025). Secure IoT-based real-time water level monitoring system using ESP32 for critical infrastructure. *Journal of Cyber Security Risk Audit*, 2025(2), 44–52. https://doi.org/10.63180/jcsra.thestap.2025.2.4

Alshami, A., Ali, E., Elsayed, M., Eltoukhy, A. E. E., & Zayed, T. (2024). IoT innovations in sustainable water and wastewater management and water quality monitoring: A comprehensive review of advancements, implications, and future directions. *IEEE Access*, 12, 58427–58453. https://doi.org/10.1109/ACCESS.2024.3392573

Anmi, F. H., et al. (2025). Implementation of Flutter and Firebase technologies in. 9(1), 246–259.

Ayeni, P. O., & Adesoba, O. C. (2025). IoT-based home control system using NodeMCU and Firebase. *Journal of Edge Computing*, 4(1), 17–34. https://doi.org/10.55056/jec.814

Badderol, M. H., & Abdullah, N. A. (2025). Intruder alert system with Firebase cloud for syndicate store and service. *Applied Information Technology and Computer Science*, 5(1), 13–19.

Baena-Navarro, R., Carriazo-Regino, Y., Torres-Hoyos, F., & Pinedo-López, J. (2025). Intelligent prediction and continuous monitoring of water quality in aquaculture: Integration of machine learning and Internet of Things for sustainable management. *Water*, 17(1). https://doi.org/10.3390/w17010082

Chavhan, N., et al. (2025). APAH: An autonomous IoT driven real-time monitoring system for industrial wastewater. *Digital Chemical Engineering*, 14, 100217. https://doi.org/10.1016/j.dche.2025.100217

Das, A. (2025). Water pollution and water quality assessment and application of criterion impact loss (CILOS), geographical information system (GIS), artificial neural network (ANN) and decision-learning technique in river water quality management. *Desalination and Water Treatment*, 321, 100969. https://doi.org/10.1016/j.dwt.2024.100969

Efendi, A., et al. (2025). IoT-based elderly health monitoring system using Firebase cloud computing. *Health Science Reports*, 8(3). https://doi.org/10.1002/hsr2.70498

El-Khozondar, H. J., et al. (2024). A smart energy monitoring system using ESP32 microcontroller. *e-Prime - Advances in Electrical Engineering, Electronics and Energy*, 9, 100666. https://doi.org/10.1016/j.prime.2024.100666

Ferrer-Cid, P., Barcelo-Ordinas, J. M., & Garcia-Vidal, J. (2025). A review of graph-powered data quality applications for IoT monitoring sensor networks. *Journal of Network and Computer Applications*, 236, 104116. https://doi.org/10.1016/j.jnca.2025.104116

Flores-Iwasaki, M., Guadalupe, G. A., Pachas-Caycho, M., Chapa-Gonza, S., Mori-Zabarburú, R. C., & Guerrero-Abad, J. C. (2025). Internet of Things (IoT) sensors for water quality monitoring in aquaculture systems: A systematic review and bibliometric analysis. *AgriEngineering*, 7(3). https://doi.org/10.3390/agriengineering7030078

Georgantas, I., Mitropoulos, S., Katsoulis, S., Chronis, I., & Christakis, I. (2025). Integrated low-cost water quality monitoring system based on LoRa network. *Electronics*, 14(5), 1–17. https://doi.org/10.3390/electronics14050857

He, W., Baig, M. J. A., & Iqbal, M. T. (2024). An open-source supervisory control and data acquisition architecture for photovoltaic system monitoring using ESP32, Banana Pi M4, and Node-RED. *Energies*, 17(10). https://doi.org/10.3390/en17102295

Jan, F., Min-Allah, N., & Düştegör, D. (2021). IoT-based smart water quality monitoring: Recent techniques, trends and challenges for domestic applications. *Water*, 13(13), 1–37. https://doi.org/10.3390/w13131729

Kalamaras, S. D., Tsitsimpikou, M. A., Tzenos, C. A., Lithourgidis, A. A., Pitsikoglou, D. S., & Kotsopoulos, T. A. (2025). A low-cost IoT system based on the ESP32 microcontroller for efficient monitoring of a pilot anaerobic biogas reactor. *Applied Sciences*, 15(1). https://doi.org/10.3390/app15010034

Kilawati, Y., Maimunah, Y., Amrillah, A. M., Dany, P., & Bhawiyuga, A. (2022). Characterization of water quality using IoT (Internet of Things), plankton and expression of virus-like particles in vannamei shrimp ponds of different constructions. 15(2), 912–926.

Kirchhof, J. C., Rumpe, B., Schmalzing, D., & Wortmann, A. (2022). MontiThings: Model-driven development and deployment of reliable IoT applications. *Journal of Systems and Software*, 183, 1–21. https://doi.org/10.1016/j.jss.2021.111087

Manoj, M., Kumar, V. D., Arif, M., Bulai, E. R., Bulai, P., & Geman, O. (2022). State of the art techniques for water quality monitoring systems for fish ponds using IoT and underwater sensors: A review. *Sensors*, 22(6). https://doi.org/10.3390/s22062088

Miller, M., Kisiel, A., Cembrowska-Lech, D., Durlik, I., & Miller, T. (2023). IoT in water quality monitoring—Are we really here? *Sensors*, 23(2), 1–12. https://doi.org/10.3390/s23020960

Mohd Jais, N. A., Abdullah, A. F., Mohd Kassim, M. S., Abd Karim, M. M., & Muhadi, N. A. (2024). Improved accuracy in IoT-based water quality monitoring for aquaculture tanks using low-cost sensors: Asian seabass fish farming. *Heliyon*, 10(8), e29022. https://doi.org/10.1016/j.heliyon.2024.e29022

Nagothu, S. K., Bindu Sri, P., Anitha, G., Vincent, S., & Kumar, O. P. (2025). Advancing aquaculture: Fuzzy logic-based water quality monitoring and maintenance system for precision aquaculture. *Aquaculture International*, 33(1), 1–21. https://doi.org/10.1007/s10499-024-01701-2

Natividad, A. N., Miranda, C., Valdoria, J. C., & Balubal, D. (2023). An IoT-based pH level monitoring mobile application on fishponds using pH sensor and waterproof temperature sensor. *Journal of Education and Teaching Trainers*, 14(3), 4. https://doi.org/10.47750/jett.2023.14.03.091

Ramadani, M. E., Raafi'u, B., Mursid, M., Ash-Shiddieqy, R. H., Zain, A. T., & Ladziimaa, A. F. (2021). Design and development of monitoring system on carp farming ponds as IoT-based water quality control. In *Proceedings of the 3rd International Conference on Research in Academic Community Services* (pp. 148–153). https://doi.org/10.1109/ICRACOS53680.2021.9701980

Sujiwa, A., & Dianto, R. R. (2022). Infusion monitoring system for patients based on the Internet of Things (IoT) with Android notification system. *BEST: Journal of Applied Electrical Science and Technology*, 4(2), 41–46. https://doi.org/10.36456/best.vol4.no2.6172

Sung, W. T., Isa, I. G. T., & Hsiao, S. J. (2023). An IoT-based aquaculture monitoring system using Firebase. *Computers, Materials & Continua*, 76(2), 2180–2200. https://doi.org/10.32604/cmc.2023.041022

Taiwo, A. A., et al. (2024). Internet of things weather monitoring system. *World Journal of Advanced Research and Reviews*, 22(2), 2099–2110. https://doi.org/10.30574/wjarr.2024.22.2.1647

Za'bah, N. F., & Mohamad, A. (2021). Mobile application monitoring system using Internet of Things (IoT) and Firebase. *Journal of Information Systems and Digital Technologies*, 3(1), 16–30. https://doi.org/10.31436/jisdt.v3i1.168