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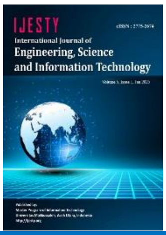

Application of the Internet of Things in Monitoring and Controlling Water Quality of Goldfish in Aquariums

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Abstract

Caring for ornamental fish in aquariums often presents significant challenges, primarily when maintenance relies on manual methods. Owners may face difficulties when they are unavailable to feed the fish or clean the aquarium, potentially compromising the health and well-being of the ornamental fish. Consistent water quality monitoring is critical to maintaining a stable and healthy environment for these aquatic creatures. To address these issues, this study developed an Internet of Things (IoT)-based system to monitor water conditions in real-time via an internet connection. By leveraging IoT technology, the system allows owners to access real-time data and remotely control aquarium parameters through a user-friendly interface, providing convenience and improved management. The system monitors essential water parameters, including temperature and pH levels, to sustain the fish's health and ensure the aquarium ecosystem's stability. Testing was conducted over two days, with data recorded at fifteen-minute intervals each day, and the results demonstrated that the system effectively monitored these parameters with sufficient accuracy. The collected data is presented in an intuitive table interface, making it easy for users to analyze trends and respond promptly to any irregularities. Additionally, the system features automatic actuator controls that allow necessary adjustments without requiring constant user involvement, significantly simplifying aquarium maintenance. The accompanying monitoring website further enhances usability by enabling users to check and manage water quality anywhere and anytime, providing flexibility and control. These features collectively ensure a more effective, efficient, and sustainable approach to ornamental fish care, ultimately improving aquarium management and fish well-being.

Keywords: *Internet of Things, Monitoring, Aquarium, Temperature, Actuator Control.*

1. Introduction

The rapid advancement of science and technology has significantly assisted and facilitated all human activities. Many technology applications and information systems, whether desktop, web, or mobile-based, are used by people to help with various tasks. These applications have become a part of daily activities, such as working, studying, or pursuing hobbies [1].
As the largest country in Southeast Asia, Indonesia has a strong economy and some of the world's richest biodiversity. The diversity of fish species in Indonesia is one of the outstanding biodiversity in the world. Fish have many benefits for humans, both as food and in their maintenance, and are an asset to be proud of. Ornamental fish is one of the most preferred fish species and is widely kept by the public because of its beautiful colour and low price. Freshwater ornamental fish is a type of fish that lives in freshwater and is kept not for consumption but to beautify the garden or living room. Its beautiful and diverse shapes and relatively easy maintenance make many people interested in caring for and maintaining it [2].
Among the many types of fish cultivated in Indonesia, chef carp is one type of ornamental fish that is very popular with ornamental fish hobbyists today for display in glass ponds or aquariums. Its popularity is due to the uniqueness of its attractive colour variations ranging from red, yellow, white, orange, black, and silver, which makes it more appealing to the body shape when compared to other ornamental fish [3].
Maintenance of ornamental fish at home is usually done using an aquarium. An aquarium is a transparent container or water-filled space decorated with animals and other aquatic plants. Because it saves space, it can also beautify the living room. Ornamental fish hobbyists

usually channel their artistic soul into the aquarium by providing sand, rocks, wood, and plants that will continue to be formed to resemble nature, also known as aquascape. In caring for ornamental fish in aquariums, several common problems often arise. Until now, many ornamental fish treatments are been done manually. This method is not entirely effective because the owner cannot always carry out the treatment. For example, when the owner is travelling away for a few days, there is no one to feed the fish and clean the aquarium; this can cause problems for the pet fish [4].

2. Literatur Review

2.1. Internet of Things (IoT)

The use of Internet of Things (IoT) technology with water temperature and pH sensors, controlled by a NodeMCU microcontroller that can be viewed or monitored remotely by the user using a laptop or smartphone. The Internet of Things (IoT) is also helpful in improving efficiency, convenience, and security by automatically connecting devices to exchange data. IoT also helps collect real-time data, save resources, and enable faster and more accurate decision-making. It can be applied in various sectors, such as smart homes, hobbies, agriculture, and industry [5].

2.2. Monitoring

Monitoring is the activity of regularly taking, collecting, and analyzing information about how a program or activity is running [6]. In addition, monitoring is also a process of collecting data that is carried out regularly and then evaluated.

2.3. Balinese Goldfish

Balinese Goldfish is a type of freshwater ornamental fish currently popular among aquarists. It has a very high economic value and is known for its distinctive appearance, short and upright body, and large and round head, a beautiful colour combination. This fish is relatively durable in various water environment conditions, but to maintain it well, proper care is needed, such as appropriate feeding, clean water, suitable temperature, and sufficient space in the aquarium [7].

2.4. Water Quality

According to Fazil (2017). Water is a natural resource needed as a source of energy for human, animal and plant life on earth, especially for fish survival [8]. If fish water quality decreases, it can cause problems such as lack of oxygen, excessive water turbidity, and unstable water pH, leading to fish death [4]. Problems that usually occur are caused by dirt, feed residue and the absence of a water filter. For this reason, it is necessary to monitor water quality so that fish are well maintained [9].

2.5. pH (Potential Of Hydrogen)

The pH value of water ranges from 0 to 14; a lower value indicates that the water is more acidic, and a higher value indicates that the water is more alkaline. pH is one of the ways to assess water quality. The ideal pH for Goldfish is between 6.5 and 8, but Goldfish can still survive with a pH of 8.5 [10].

2.6. Temperature

The suitable Temperatures for the growth of Goldfish ranges from 18˚C to 28˚C. In tropical regions like Indonesia, goldfish production tends to be higher due to warmer environmental temperatures ranging from 23˚C to 28˚C. Lower Temperatures can cause ornamental fish to become inactive and lose their appetite, while higher temperatures can reduce the oxygen levels in the water [11].

2.7. NodeMCU ESP8266

The NodeMCU ESP8266 module is an open-source WiFi module used as an additional device for microcontrollers such as Arduino and Raspberry Pi to connect directly to WiFi and create TCP/IP connections. This module requires around 3.3V of power and has three WiFi modes: Station, Access Point, and Both. It is also equipped with a processor, memory, and GPIO, with the number of pins depending on the type of ESP8266 used. Therefore, this module can operate independently without using any microcontroller because it already has the necessary components, like a microcontroller [12].

2.8. Sensor

A sensor is a device or instrument that converts mechanical, magnetic, thermal, light, and chemical quantities into voltage and electric current. They are often used for detection during measurement or control and respond to changes in the physical environment or specific conditions [13].

2.8.1. Sensor DS18B20

Various sensors measure temperature, depending on the object being monitored. The DS18B20 digital temperature sensor, a one-wire sensor, converts heat into voltage and operates as a chemical sensor by detecting substances and converting them into electrical signals. With a range of -55°C to 125°C and an accuracy of ±0.5°C within -10°C to 85°C, it provides 9 to 12-bit precision. The DS18B20 is placed in aquarium water to monitor and ensure accurate temperature readings [14].

2.8.1. Sensor pH-4502C

The pH sensor consists of a glass electrode with a sensitive glass bulb at its tip, a reference electrode and a chloride solution of known pH. It features a data acquisition module that converts the sensor's output into a voltage on an analogue pin. The module's characteristic indicates that higher acidity levels in water result in higher voltage readings [15].

2.8.2. Jumper Cable

A jumper cable is an electrical cable with connector pins at both ends to connect Internet of Things (IoT) components without soldering. The male connector is inserted into the female connector to establish the connection [16].

2.9. Website-Based Information System

In water quality monitoring and control, the obtained data is processed into an information and control system based on a website. Water quality data and sensor data are displayed on the website using the CodeIgniter framework and phpMyAdmin as the database management tool for execution.

2.9.1. CodeIgniter

One of the frameworks used in developing this final project is CodeIgniter. The author chose CodeIgniter because it eliminates the need to write code from scratch, making the development process faster and more efficient. According to Sallaby & Kanedi (2020), CodeIgniter is a PHP-based framework designed to assist web developers in creating or developing web-based applications [17].

·2.9.2. Php Myadmin

PhpMyAdmin is an open-source application that can be used for free to program and manage MySQL databases. It is built using PHP and supports various MySQL operations, including managing databases, tables, fields, relations, indexes, users, permissions, and more. It is important to note that PhpMyAdmin differs from MySQL itself. While PhpMyAdmin serves as a tool that simplifies the operation of MySQL databases, MySQL is the database system used for data storage [18][19].

·2.9.2. HTTP Request

An HTTP Request is a message sent by the client to the server to access resources on the internet using the HTTP protocol. It includes details such as the HTTP method, the requested URL, and headers with information like content type and cookies. After receiving the request, the server processes it and sends an HTTP Response containing the status code and requested data. This request and response process enables web communication, allowing users to interact with online services [20].

2. Literatur Review

3.1. Research Procedures

The steps taken by the author in this research are as follows:

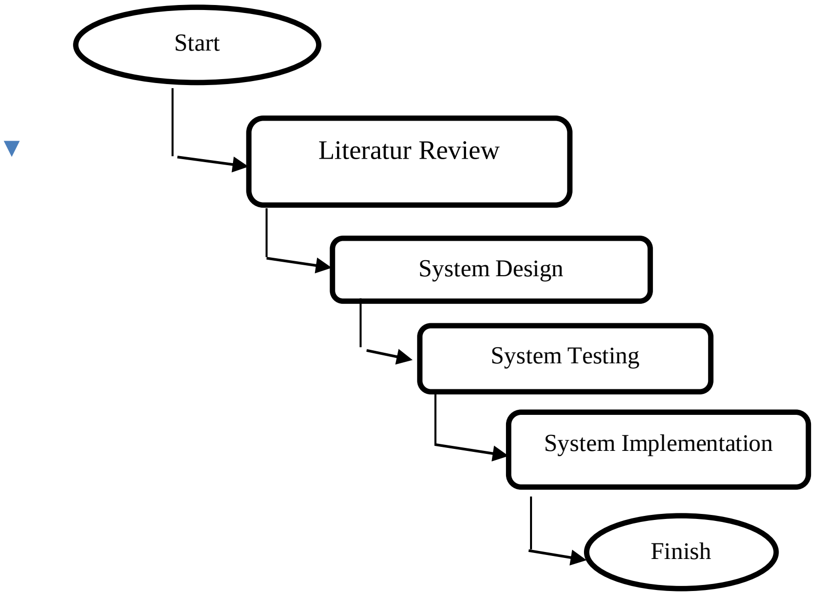

Fig 1. System Schema

3.1.1. System Design

The system is designed with components to monitor the temperature and pH of aquarium water. Key components include the aquarium, which houses the Goldfish, and sensors for measuring temperature and pH. The microcontroller used in this study is the NodeMCU ESP8266, which controls these sensors. When the sensors are submerged, they collect data and send it to the monitoring website via the NodeMCU. The NodeMCU processes the sensor data and transmits it to the website, which is accessible through a smartphone or laptop connected to the internet. Additionally, a breadboard connects the power source to the hardware, including the sensors. It facilitates data flow between the sensors and the NodeMCU, ensuring seamless system operation.

3.1.2. System Testing

After completing the design, the author conducted system testing. The author tested the microcontroller and other assembled devices to determine whether the functions operated according to the design. If they were, the system would be immediately implemented to monitor water quality, and if not, a review would be conducted.

3.1.3 System Implementation

System implementation is carried out by building a simple aquarium prototype with several sensors to measure water Temperature and pH. System implementation is the process of applying the designed system. There are two stages of implementation: software implementation and hardware implementation. Software implementation is done on the Arduino IDE and the website. The system application on the website aims to monitor temperature and pH anytime and anywhere the fish owner is, ensuring controlled fish maintenance. For hardware implementation, the device will be placed in the aquarium, where it monitors water temperature and pH, displayed on the monitoring website.

3.1.4 System Schema

A system schematic is necessary to facilitate programming and ensure no components are overlooked. Below is the schematic of the device and an illustrative depiction of the application of the Internet of Things (IoT) in monitoring the water quality of Goldfish in the aquarium.

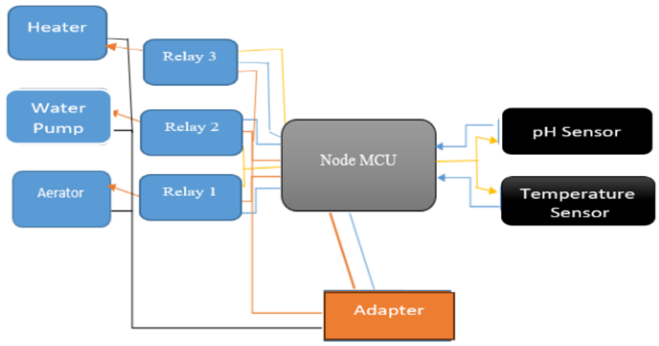

Fig 2. Tools Schema

The Node MCU receives data from the pH and Temperature sensors. Based on the data received, the Node MCU decides whether to activate or deactivate the aerator, heater, and water pump. Suppose the Node MCU decides to activate the devices. In that case, it sends an electrical signal to the corresponding relay (relay 1 for the aerator, relay 2 for the water pump, and relay 3 for the heater). The relay that receives the signal will close its circuit, allowing electrical current to flow to the device it controls. The relay isolates the control circuit (Node MCU) and the power circuit (aerator, water pump, and heater). This prevents voltage spikes or high currents from the mechanical devices that could damage the Node MCU.

The aerator, water pump, and heater will turn on. The aerator adds oxygen to the water, while the water pump circulates water in the system, and the heater warms the water if it is cold. When the water conditions meet or do not meet the desired settings, the Node MCU will send a signal to turn off the relay. The relay will open its circuit, cutting off the electrical flow to the aerator, water pump, and heater, which will then turn off.

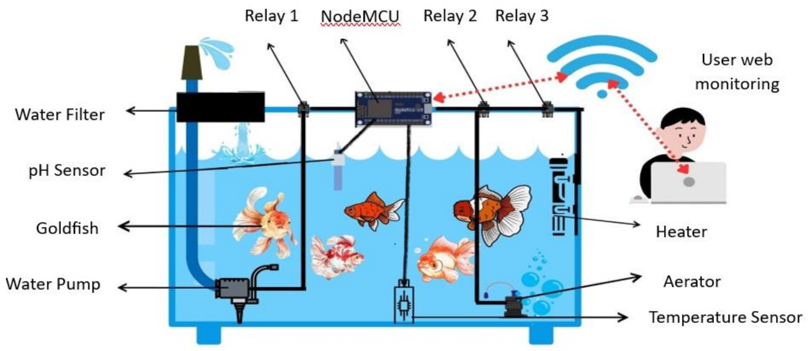

Fig 3. Illustration of water quality monitoring for chef carp

The image above illustrates an aquarium with pH and Temperature sensors to detect water quality. The data obtained from these sensors will be sent to the NodeMCU microcontroller for processing. The microcontroller will then decide based on the conditions for activating the aerator, water pump, or heater. The NodeMCU microcontroller sends the temperature and pH condition data to the monitoring website through a WiFi network. Additionally, this feature displays the temperature and pH conditions in graphs and numbers, allowing users to continuously monitor the water quality processed and stored by the system.

3.2.1. Overall System Flow Diagram

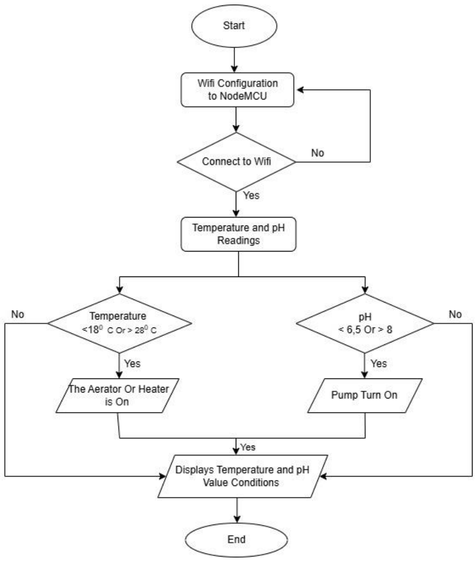

Fig 4. Flowchart of the Entire System

The system process begins with configuring the Node MCU to the access point (WiFi), so the Node MCU will connect to the IP address provided by the access point (WiFi) used. Then, the Node MCU will read sensor data. The Node MCU reads data from the DS18B20 temperature and pH sensors. After reading the sensor data, the next step is for the Node MCU to send the data to the monitoring website, which can be viewed on a smartphone or laptop connected to the internet.

4. Result and Discussion

This chapter will comprehensively explain and present the results of the system design and implementation that have been carried out, as well as the results of testing, which consist of several well-structured sections. The first section, which is the system design results, will provide detailed details about the design of the goldfish water quality monitoring and control system. This section will discuss the hardware and software used in this study, including the main components, technical specifications, and system design created to meet the research needs.

Next, the system testing section will present the results of various sensor tests and other features used in this research system. The tests include pH sensors, temperature sensors, data transmission to the server, and other additional features. The results of these tests will provide a more detailed picture of the accuracy, reliability, and consistency of sensor readings in monitoring water quality parameters that are important for Goldfish.

Throughout this chapter, the design, implementation, and testing processes will be explained in full and in detail, including drawing conclusions based on the research results. This analysis will include an evaluation of system performance and device connectivity capabilities, as well as the identification of weaknesses and shortcomings found during the testing process. Thus, this chapter aims to provide a comprehensive understanding of the successes and challenges faced in this research and assess whether the designed system can function as expected.

4.1. Results of Hardware Design

The hardware design in this research resulted in a monitoring and control system for the water quality of Goldfish. This was done by combining all interconnected components that worked well. The form of the combined result for the prototype device can be seen in the image below, where all the elements consist of an adapter, NodeMCU, pH sensor, temperature sensor, three relays, breadboard, water pump, heater, and aerator.

4.2. Software Design Result

The system developed in this research is designed to facilitate users in effectively monitoring and managing water conditions. The main focus of this system is to provide easy access for users to monitor critical parameters such as water pH and temperature in real-time. The system also displays the status of automatic control features that allow devices such as water pumps, aerators, or heaters to operate independently based on detected conditions.

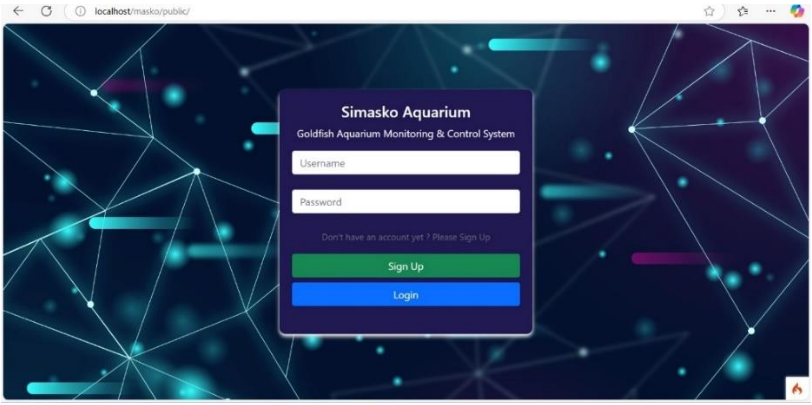

Fig 5. Login Page Display

"After a successful login, users will be directed to the dashboard, which is the main page of this system. The dashboard is designed to provide easy access and informative display for users. On this page, users can monitor various important information presented in real time, ensuring that the information received is always accurate and up-to-date, such as water pH conditions, water temperature, and the operational status of supporting devices like water pumps, aerators, and heaters. Additionally, it provides the five most recent data histories. Thus, caretakers can monitor changes in water quality periodically and detail data hourly to identify trends and patterns that may affect fish growth. Below is an image of the dashboard page."

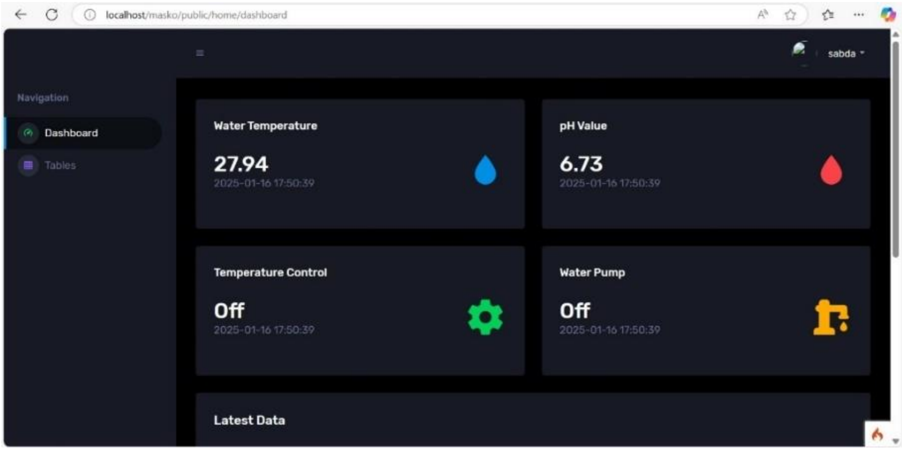

Fig 6. Dashboard Page View

"Next, the data table page is one of the essential components of this system. On this page, users can access summary report data on the pH and water Temperature conditions that have been previously monitored. The information on this page includes the results of measuring the water pH and Temperature values relevant to the goldfish farming process. This data is processed from continuous monitoring results, providing an overview of the water environment conditions over a certain period. The historical data can provide deeper insights into the patterns of pH and water Temperature fluctuations, allowing users to design more effective management strategies. This information is crucial for maintaining the sustainability and productivity of fish farming.

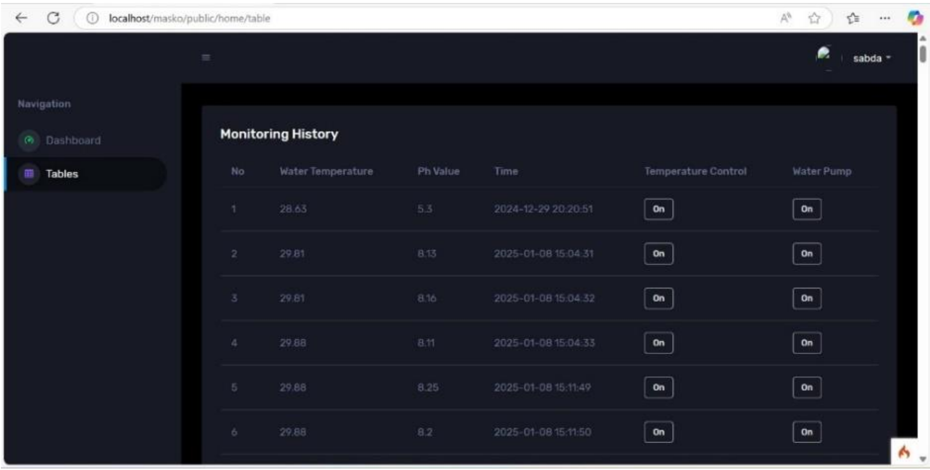

Fig 7. History Data Page

4.3. System Monitoring Test Results

In the system monitoring testing phase, the test results will be explained, covering the monitoring and control aspects of the system, including the sensors and other features used. This testing includes pH sensors, temperature sensors, relays, and data transmission to the website. The results of this testing provide an overview of the accuracy and reliability of the sensors in monitoring pH and Temperaturee parameters, which are crucial for the maintenance of Goldfish. The information obtained from this testing is essential to assess the system's ability to control and monitor water quality to remain optimal for goldfish growth.

4.3.1. pH Sensor Testing

Testing the pH sensor is essential in Goldfish's water quality monitoring and control system. Water samples with known pH values, namely pH 7 and pH 4, are required to calibrate the sensor. During calibration, the sensor will measure the voltage generated when placed in water with pH seven and pH 4. The calibration results will later be used as a reference in the program to calculate the pH value in subsequent measurements.

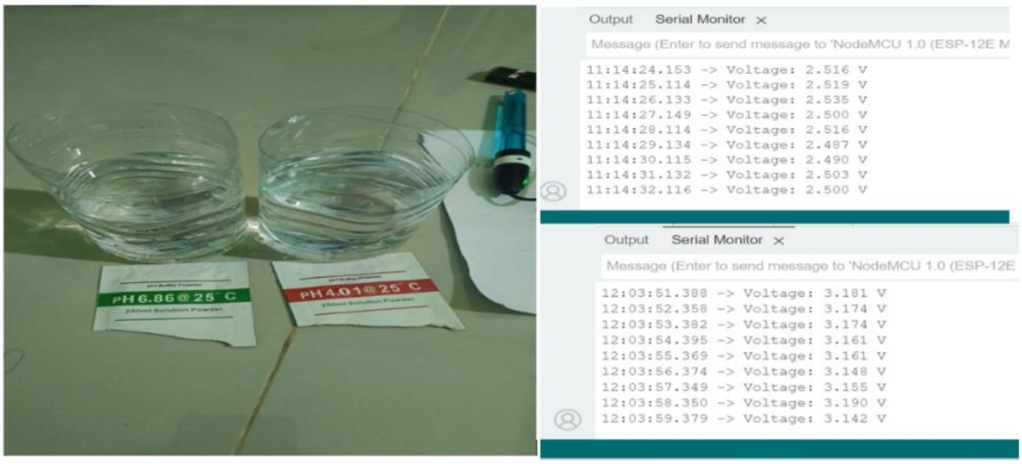

Fig 8. pH Sensor Calibration

The image above shows the results of the pH sensor calibration, where the sensor will take voltage data from the sensor immersed in pH four and pH seven solutions. This process allows system users to easily monitor the water pH value in real-time and ensure that the sensor functions accurately and reliably.

4.3.2. Temperature Sensor Testing

The DS18B20 Temperature sensor does not require a unique calibration process. This is because the data generated by this sensor is digital so it can be used directly without additional conversion. The data is also quickly processed through programs that utilize the built-in libraries provided for this sensor, making it practical and efficient for various Temperature measurement needs.

Fig 9. Temperature Sensor Testing

In the image above, the DS18B20 Temperaturee sensor is immersed in water to measure and test the Temperaturee. This testing aims to ensure that the sensor can provide accurate results according to the temperature changes occurring in the water. One of the main advantages of this sensor is its ability to provide temperature data with high accuracy and consistency.

4.3.3. Overal System Testing

Overall, system testing is an essential step in validating the successful implementation of the goldfish water quality monitoring and control system. The development of this system begins with the initial step of programming all IoT components, including sensors, relay modules, and microcontrollers, as the first step in system design. Next, this process continues by connecting several sensors, microcontrollers, and other control devices to create an integrated infrastructure. After this stage is completed, a series of tests are conducted according to the system's needs, with the aim of ensuring that all components function properly and the system operates as expected. This process involves monitoring, measuring, and analyzing test results to ensure the reliability and performance of the developed system. Below is an image of the overall system prototype.

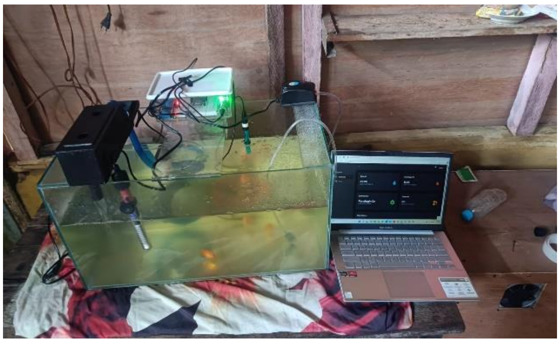

Fig 10. Overall System Device

4.4. System Test Result

This system testing is essential in successfully implementing the goldfish water quality monitoring system. The testing begins with installing sensors and actuators on a prototype aquarium containing Goldfish. Once everything is correctly installed, it is connected to a power source. The system will then detect the available internet network. Once connected, the system can be monitored in real-time on the web and smartphones.

During this system testing phase, the author monitored for two consecutive days. The data collected during the monitoring was recorded every fifteen minutes. This aims to provide deep insights into the system's ability to monitor water quality in real time over time. Below is a table of water quality test results in the goldfish aquarium for two days from January 8 to January 10, 2025:

Table 1. Overall System Testing Results for Two Days

No	Water Temperature	pH	Date	Temperature Control	Water Pump
1	29.88	8.16	1/8/2025 15:14	Cooler On	On
2	29.94	8.16	1/8/2025 15:29	Cooler On	On
3	30	8.22	1/8/2025 15:44	Cooler On	On
4	30.06	8.13	1/8/2025 16:00	Cooler On	On
5	30.06	8.22	1/8/2025 16:14	Cooler On	On
6	30.06	8.15	1/8/2025 16:29	Cooler On	On
7	30.06	8.2	1/8/2025 16:44	Cooler On	On
8	30.06	8.22	1/8/2025 17:00	Cooler On	On
9	30.06	8.16	1/8/2025 17:14	Cooler On	On
10	30	6.86	1/8/2025 17:29	Cooler On	Off
11	30	8.18	1/8/2025 17:44	Cooler On	On
12	29.94	8.09	1/8/2025 17:59	Cooler On	On
13	29.94	8.15	1/8/2025 18:15	Cooler On	On
14	29.88	8.16	1/8/2025 18:30	Cooler On	On
15	29.81	8.13	1/8/2025 18:44	Cooler On	On
16	29.75	8.29	1/8/2025 18:59	Cooler On	On
17	29.69	8.36	1/8/2025 19:15	Cooler On	On
18	29.63	8.29	1/8/2025 19:30	Cooler On	On
19	29.56	8.15	1/8/2025 19:44	Cooler On	On
20	29.44	8.22	1/8/2025 20:00	Cooler On	On
21	29.38	8.22	1/8/2025 20:14	Cooler On	On
22	29.31	8.32	1/8/2025 20:30	Cooler On	On
23	29.19	8.25	1/8/2025 20:44	Cooler On	On

24	29.13	8.24	1/8/2025 21:00	Cooler On	On
25	25.25	8.38	1/8/2025 21:15	Off	On
26	27.19	7.88	1/8/2025 21:30	Off	On
27	28.19	7.8	1/8/2025 21:45	Cooler On	Off
28	28.13	8.08	1/8/2025 22:00	Cooler On	On
29	28.06	7.8	1/8/2025 22:15	Cooler On	Off
30	28.06	7.97	1/8/2025 22:30	Cooler On	Off
31	28	7.99	1/8/2025 22:45	Off	Off
32	27.94	8.24	1/8/2025 23:00	Off	On
33	27.88	8.13	1/8/2025 23:15	Off	On
34	27.81	7.95	1/8/2025 23:29	Off	Off
35	27.75	8.09	1/8/2025 23:44	Off	On
36	27.69	8.16	1/8/2025 23:59	Off	On
37	27.63	7.99	1/9/2025 0:14	Off	Off
38	27.5	8.16	1/9/2025 0:29	Off	On
39	27.5	8.31	1/9/2025 0:44	Off	On
40	27.44	8.16	1/9/2025 0:59	Off	On
41	27.31	8.31	1/9/2025 1:14	Off	On
42	27.31	8.09	1/9/2025 1:29	Off	On
43	27.25	8.02	1/9/2025 1:44	Off	On
44	27.19	8.15	1/9/2025 1:59	Off	On
45	27.13	8.2	1/9/2025 2:14	Off	On
46	27.13	8.22	1/9/2025 2:29	Off	On
47	27.06	8.15	1/9/2025 2:44	Off	On
48	27	8.15	1/9/2025 2:59	Off	On
49	26.94	8.13	1/9/2025 3:14	Off	On
50	26.94	8.16	1/9/2025 3:29	Off	On
51	26.88	8.29	1/9/2025 3:44	Off	On
52	26.88	8.13	1/9/2025 3:59	Off	On
53	26.88	8.45	1/9/2025 4:14	Off	On
54	26.81	8.16	1/9/2025 4:29	Off	On
55	26.81	8.32	1/9/2025 4:44	Off	On
56	26.75	8.15	1/9/2025 4:59	Off	On
57	26.75	8.34	1/9/2025 5:14	Off	On
58	26.69	8.41	1/9/2025 5:29	Off	On
59	26.69	8.02	1/9/2025 5:44	Off	On
60	26.69	8.15	1/9/2025 6:00	Off	On
61	26.63	8.15	1/9/2025 6:15	Off	On
62	26.63	8.22	1/9/2025 6:30	Off	On
63	26.56	8.15	1/9/2025 6:45	Off	On
64	26.56	8.43	1/9/2025 7:00	Off	On
65	26.5	8.25	1/9/2025 7:15	Off	On
66	26.5	8.2	1/9/2025 7:30	Off	On
67	26.5	8.31	1/9/2025 7:45	Off	On
68	26.44	8.48	1/9/2025 7:59	Off	On
69	26.5	7.92	1/9/2025 8:14	Off	Off

70	26.5	8.02	1/9/2025 8:15	Off	On
71	26.5	8.04	1/9/2025 8:29	Off	On
72	26.5	8.09	1/9/2025 8:44	Off	On
73	26.56	8.05	1/9/2025 8:59	Off	On
74	26.63	8.09	1/9/2025 9:14	Off	On
75	26.75	8.14	1/9/2025 9:29	Off	On
74	26.63	8.09	1/9/2025 9:14	Off	On
75	26.75	8.14	1/9/2025 9:29	Off	On
76	26.88	8.09	1/9/2025 9:44	Off	On
77	27	7.92	1/9/2025 9:59	Off	Off
78	27.06	8.17	1/9/2025 10:15	Off	On
79	27.19	8.05	1/9/2025 10:30	Off	On
80	27.25	8.07	1/9/2025 10:44	Off	On
81	27.38	8.02	1/9/2025 11:00	Off	On
82	27.5	8.02	1/9/2025 11:14	Off	On
83	27.5	8.02	1/9/2025 11:30	Off	On
84	27.5	8.02	1/9/2025 11:45	Off	On
85	27.5	8.02	1/9/2025 12:00	Off	On
86	27.5	8.02	1/9/2025 12:15	Off	On
87	27.5	8.02	1/9/2025 12:30	Off	On
88	27.5	8.02	1/9/2025 12:45	Off	On
89	27.5	8.02	1/9/2025 13:00	Off	On
90	27.65	8.02	1/9/2025 13:15	Off	On
91	27.75	8.02	1/9/2025 13:30	Off	On
92	27.75	8.02	1/9/2025 13:45	Off	On
93	27.81	8.02	1/9/2025 14:00	Off	On
94	27.96	8.02	1/9/2025 14:15	Off	On
95	28.5	8.02	1/9/2025 14:30	Cooler On	On
96	28.35	8.02	1/9/2025 14:45	Cooler On	On
97	28.45	8.02	1/9/2025 14:59	Cooler On	On
98	27.88	7.69	1/9/2025 15:00	Off	Off
99	27.88	7.77	1/9/2025 15:14	Off	Off
100	27.94	7.82	1/9/2025 15:29	Off	Off
101	29.76	7.74	1/9/2025 15:44	Cooler On	Off
102	29	7.74	1/9/2025 16:00	Cooler On	Off
103	28.88	7.77	1/9/2025 16:14	Cooler On	Off
104	29	7.82	1/9/2025 16:30	Cooler On	Off
105	29.06	7.87	1/9/2025 16:45	Cooler On	Off
106	29	7.64	1/9/2025 17:00	Cooler On	Off
107	29	7.58	1/9/2025 17:15	Cooler On	Off
108	28.94	7.84	1/9/2025 17:29	Cooler On	Off
109	27.94	7.64	1/9/2025 17:44	Off	Off
110	29.81	7.76	1/9/2025 17:59	Cooler On	Off
111	27.88	3.19	1/9/2025 18:14	Off	On
112	27.94	3.94	1/9/2025 18:30	Off	On
113	27.94	3.19	1/9/2025 18:45	Off	On

114	28.88	5.97	1/9/2025 19:00	Cooler On	On
112	27.94	3.94	1/9/2025 18:30	Off	On
113	27.94	3.19	1/9/2025 18:45	Off	On
114	28.88	5.97	1/9/2025 19:00	Cooler On	On
115	27.88	6.9	1/9/2025 19:15	Off	On
116	28.38	7.61	1/9/2025 19:30	Cooler On	Off
117	27.31	7.76	1/9/2025 19:45	Off	Off
118	27.25	8.22	1/9/2025 19:59	Off	On
119	28.25	3.19	1/9/2025 20:14	Cooler On	On
120	28.25	3.19	1/9/2025 20:29	Cooler On	On
121	27.25	8.56	1/9/2025 20:45	Off	On
122	27.25	3.19	1/9/2025 21:00	Off	On
123	27.19	3.19	1/9/2025 21:14	Off	On
124	28.25	8.07	1/9/2025 21:30	Cooler On	On
125	28.19	9.87	1/9/2025 21:44	Cooler On	On
126	28.19	5.5	1/9/2025 21:59	Cooler On	On
127	27.56	7.51	1/9/2025 22:14	Off	Off
128	27.13	3.19	1/9/2025 22:29	Off	On
129	27.13	6.38	1/9/2025 22:44	Off	On
130	28	8.4	1/9/2025 22:59	Off	On
131	28	8.79	1/9/2025 23:15	Off	On
132	28	5.48	1/9/2025 23:29	Off	On
133	27.94	7.86	1/9/2025 23:44	Off	Off
134	27.94	8.97	1/9/2025 23:59	Off	On
135	27.88	3.19	1/10/2025 0:14	Off	On
136	28.88	5.79	1/10/2025 0:29	Cooler On	On
137	27.81	3.19	1/10/2025 0:44	Off	On
138	27.75	3.19	1/10/2025 0:59	Off	On
139	27.69	3.71	1/10/2025 1:15	Off	On
140	27.63	3.19	1/10/2025 1:30	Off	On

The table above shows that the system data works well when programmed on Arduino. The results of the water monitoring system test for goldfish show that at a Temperature of 29.88°C, the aerator will turn on (Cooler On), and at a water pH of 8.16, the water pump will turn on (On), thus providing an indication that the system is working as expected.

4.5. Discussion

The results met expectations based on the goldfish water quality monitoring and control system testing in the aquarium over two days at fifteen-minute intervals. During the monitoring phase, the system could monitor temperature and pH parameters. The test results showed that the sensors used in the system could detect water Temperature and pH with accurate responses. The system also periodically collected sensor data and displayed water quality data on the record table interface, allowing for effective monitoring. With this system, actuator control can be performed without user involvement. This monitoring website will also enable users to access and monitor the system from anywhere.

5. Conclusion

Based on the research conducted by the author, from design implementation to testing of the 'Application of Internet Of Things (IoT) in Monitoring and Controlling Goldfish Water Quality in Aquariums,' the following conclusions can be drawn:

1. In this study, the water monitoring system test results for Goldfish showed that at a water Temperature of more than 28°C and a pH of 8.00, the system automatically activates the control and pump. Thus, the NodeMCU will perform this function automatically according to the received data.
2. On the website, sensor data and water quality are successfully displayed in real time. Additionally, the system can also automatically control actuators according to changes in water quality conditions.

References

[1] Immanuel Balvin K.,1,, F. D. (2023). Perancangan dan Implementasi Sistem Pakan Otomatis dan Monitoring tds Pada Akuarium Ikan Hias Berbasis iot. 02, 154–169.

[2] Kharisma, R S. T. (2020). Rancang Bangun Alat Monitoring Dan Penanganan Kualitas Ait Pada Akuarium Ikan Hias Berbasis Internet Of Things (IOT). Jurnal Teknik Elektro Dan Komputer TRIAC, 7(2), 69–74. https://doi.org/10.21107/triac.v7i2.8148

[3] Afandi, a., Jalil, w., Studi, p., Perairan, b., Perikanan, f., & Kelautan, i. (2023). Pertumbuhan dan Kelangsungan Hidup Ikan Mas Koki (Carassius Auratus) pada Sumber Mata Air Berbeda di Ruang Semi Outdoor Growth and Survival Rates of Goldfish (Carassius Auratus) with Different Spring Water Sources in Semi Outdoor Space. Jurnal Akuakultur Rawa Indonesia Afandi dan Jalil, 11(1), 74–86.

[4] Kadir, S. F. (2019). Mobile Iot (Internet of Things) Untuk Pemantauan Kualitas Air Habitat Ikan Hias Pada Akuarium Menggunakan Metode Logika. Jurnal Mahasiswa Teknik Informatika, 3(1), 298–305.

[5] Nunsina, Fatimah Zuhra, Z. Y. (2024). Sosialisasi Peningkatan Kualitas Produktivitas Panen Udang Melalui Pengontrolan Kadar air Berbasis iot di Desa Kuala Ceurape. 7(1), 57–64.

[6] Yunizar zara1, N. (2023). Sistem Monitoring Revass (Revanue Assurance) Pelanggan Pasang Baru di Pt. Pln Ulp Krueng Geukuh Lhokseumawe Berbasis Web. Karakteristik Marshall Campuran AC-BC Menggunakan Ethylene Vinyl Acetate Sebagai Asphalt Modifier, 4(1), 891–902.

[7] Moh.Fahmi, LilikIndayani; MuhammadYani. (2024). Analisis Kualitas Produk, Persepsi Harga dan Kepercayaan Konsumen Terhadap Keputusan Pembelian Ikan Mas Koki Melalui Instagram. Jurnal Ilmiah MEA (Manajemen, Ekonomi, Dan Akuntansi), 8(3), 852–867. https://doi.org/https://doi.org/10.31955/mea.v8i3.4547

[8] Fazil M, Adhar S, Ezraneti R, "Efektivitas penggunaan ijuk, jerami padi dan ampas tebu sebagai filter air pada pemeliharaan ikan mas koki (Carassius auratus)". Aquatic Science Journal, 4:1 (April, 2017): 37-43. https://doi.org/10.29103/aa.v4i1.322

[9] Kadir, S. F. (2019). Mobile Iot (Internet of Things) Untuk Pemantauan Kualitas Air Habitat Ikan Hias Pada Akuarium Menggunakan Metode Logika. Jurnal Mahasiswa Teknik Informatika, 3(1), 298–305.

[10] Satriawan, M. R., Priyandoko, G., & Setiawidayat, S. (2023). Monitoring pH Dan Suhu Air Pada Budidaya Ikan Mas Koki Berbasis IoT. Jambura Journal of Electrical and Electronics Engineering, 5(1), 12–17. https://doi.org/10.37905/jjeee.v5i1.16083

[11] Lestari, D., Yuniarti, E., & Dinda Sari, Y. (2024). Sistem Monitoring Kualitas Air dan Pakan Otomatis Pada Akuarium Ikan Mas Koki Terintegrasi IoT. BEES: Bulletin of Electrical and Electronics Engineering, 4(3), 103–111. https://doi.org/10.47065/bees.v4i3.4624

[12] Kharisma, R S. T. (2020). Rancang Bangun Alat Monitoring Dan Penanganan Kualitas Ait Pada Akuarium Ikan Hias Berbasis Internet Of Things (IOT). Jurnal Teknik Elektro Dan Komputer TRIAC, 7(2), 69–74. https://doi.org/10.21107/triac.v7i2.8148

[13] Amin, M., Harahap, R., & Pelawi, Z. (2023). Rancang Bangun Sistem Kendali Dan Monitoring Pengolahan Air Limbah Berbasis PLC. 8(2), 43–48.

[14] M. A. Askar, E. Susanto, and A. S. Wibowo, "Sistem Pengendalian Pakan dan Monitoring Kualitas Air Akuarium Otomatis," e-Proceeding Eng., vol. 9, no. 2, pp. 273–280, 2022.

[15] A. Pradypta, L. Anifah, N. Kholis, and F. Baskoro, "Rancang Bangun Sistem Monitoring pH Dan Kontrol Suhu Pada Media Pemeliharaan ikan Hias Air Tawar Afrianzah Pradypta Lilik Anifah , Nur Kholis , Farid Baskoro," J. Tek. Elektro, vol. 11, no. 2, pp. 270–277, 2022.

[16] Tri Sulistyorini, Nelly Sofi, and Erma Sova, "Pemanfaatan Nodemcu Esp8266 Berbasis Android (Blynk) Sebagai Alat Alat Mematikan Dan Menghidupkan Lampu," J. Ilm. Tek., vol. 1, no. 3, pp. 40–53, 2022, doi: 10.56127/juit.v1i3.334.

[17] A. F. Sallaby and I. Kanedi, "Perancangan Sistem Informasi Jadwal Dokter Menggunakan Framework Codeigniter," J. Media Infotama, vol. 16, no. 1, pp. 48–53, 2020, doi: 10.37676/jmi.v16i1.1121.

[18] R. E. Standsyah and I. E. Restu, "Implementasi phpMyAdmin pada Rancangan Sistem Pengelolaan barang," J. UJMC, vol. 3, no. 2, pp. 38–44, 2017.

[19] A. Guion, K. Burton, H. Hodgkins, and D. Morris, "Implementation Of An Interactive Database Interface Utilizing HTML, PHP, JavaScript, and MySQL In Support Of Water Quality Assessments In The Northeastern North Carolina Pasquotank Watershed," AGU Fall Meet., no. 1, pp. 1–16, 2015, [Online]. Available: http://nia.ecsu.edu/ur/1415/teams/db/2015_mmt_Report_v_150421.pdf

[20] Muthiatur Rohmah. (2024. Februari 23). Memahami HTTP Request Beserta Kegunaannya. dibimbing. https://dibimbing.id/blog/detail/memahami-http-Request-beserta kegunaanya#:~:text=HTTP Request adalah permintaan yang dikirim oleh klien,mengakses sumber daya di internet melalui protokol HTTP.