Jurnal Teknologi Informasi dan Pendidikan
Volume 17, No. 2, September 2024
https://doi.org/10.24036/jtip.v17i2.824

P.ISSN: 2086 – 4981
E.ISSN: 2620 – 6390
tip.ppj.unp.ac.id

Real-time Fishpond Water Temperature Monitoring with Internet of Things (IoT) Technology

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Article Information

Article history:

No. 824
Rec. December 28, 2023
Rev. April 01, 2024
Acc. April 01, 2024
Pub. April 17, 2024
Page. 315 – 328

Keywords:

- *Temperature*
- *Sensor*
- *Internet of Things*
- *Monitoring*
- *Water Quality*

ABSTRACT

The quality of pond water is an important factor in ensuring the health and sustainability of the organisms within it. Internet of Things (IoT) technology has enabled the development of sophisticated and effective monitoring systems to monitor water quality in real-time. One important parameter that needs to be monitored is the temperature of the pond water, as unstable temperatures can harm aquatic organisms. To obtain good quality and disease-free fish at normal times, the optimal temperature for catfish fry is around 28˚C - 30˚C. Manual monitoring or using thermometer measuring instruments is still very traditional and limited to the ability of supervisors to carry out continuous monitoring and may cause delays in detecting significant temperature changes. This research aims to analyze the monitoring system of pool water quality based on temperature by utilizing IoT technology. The proposed system uses a DS18B20 temperature sensor that is wirelessly connected to the IoT network. The temperature data collected in real time will be uploaded to Firebase for storage and further analysis. Through the development of this IoT-based pond water quality monitoring system, it is expected to increase efficiency and reliability in monitoring pond water quality. From the monitoring conducted for approximately 24 hours, the temperature in the fishpond is 28°-30°. After analyzing with direct monitoring, the good temperature is at night at 18.00-00.00 WIB. In conjunction with a standard thermometer, resulted in an average temperature sensor error rate of less than 5%, highlighting the reliability of the IoT technology in real-time environmental monitoring.

How to Cite:

Muslimin, S., et al. (2024). Real-time Fishpond Water Temperature Monitoring with Internet of Things (IoT) Technology. Jurnal Teknologi Informasi Dan Pendidikan, 17(2), 315-328. https://doi.org/10.24036/jtip.v17i2.824

1. INTRODUCTION

Growing awareness of the importance of monitoring and maintaining pond water quality. Ponds are used for various activities such as swimming, fish farming, and irrigation. therefore, maintaining optimal pond water quality is essential for health and productivity [1] . Pond water temperature is one of the most significant water quality parameters. Drastic changes in temperature can have a negative impact on the living organisms in it. For example, water that is too hot can reduce dissolved oxygen levels in the water, causing stress to fish or other aquatic organisms. Conversely, temperatures that are too low can affect the metabolism and activity of organisms. [2], [3]. Observation is a routine activity involving the gathering of data and assessing advancements in relation to program goals. The scrutiny of changes places emphasis on procedures and results. Continuous monitoring yields data on the status and emerging patterns through consistent measurement and evaluation. Typically undertaken for a distinct purpose, monitoring entails scrutinizing the course of an entity or appraising circumstances and advancements leading to a desired outcome. [4]

Traditionally, checking the condition of pool water is done routinely by only paying attention to the color of the water, the smell, and checking the conditions around the pool whether there are trees or branches that cover the pool, so that air is difficult to enter, or the sun cannot shine on the pool, causing unstable temperatures. Manual monitoring or using traditional measuring instruments is limited to the supervisor's ability to monitor continuously and can cause delays in detecting significant temperature changes. This traditional method still lacks accuracy and time efficiency. Therefore, an automation system is needed in this case to address the accuracy of checking and feeding routines. By utilizing a microcontroller system connected to a temperature sensor, monitoring and controlling water conditions and feeding according to the needs of catfish development age can be done automatically, checking pond condition data, and feeding schedules can be monitored properly [5].

Water quality is one of the most important factors affecting the survival of cultured fish. Some parameters are a must of attention to develop one of them development in catfish is temperature. In this case if the temperature in the pond is high, the catfish will be stressed, and if the temperature is too low it can affect the organism in binding oxygen thus inhibiting growth. This is the beginning of the emergence of disease and causes death in fish [6] .Catfish seedling cultivation requires simple supervision and maintenance, as it requires a pond with good air quality. The primary concern for farmers is the quality of water, as it directly influences the attainment of high-quality and disease-resistant fish during regular conditions. Maintaining the ideal temperature for catfish seedlings, which falls within the range of 28˚C to 30˚C, is crucial for optimal results. [7]. In addition to temperature, there are also factors that can affect the quality of pond water, namely turbidity. Turbidity is a factor that measures the clarity of water, including the color of water or air that cannot be reached

P.ISSN: 2086 – 4981
E.ISSN: 2620 – 6390
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by incoming sunlight. Things that cause turbidity of pond water include the presence of dissolved substances such as plankton and food waste that settles in the water. Very turbid water quality will cause the light that enters the water to be more scattered than forwarded to the water, even though catfish seedlings really need sunlight for growth [8].

In fish farming, the timing of fish feeding is very important; fish need regular and continuous feed. Feeding is a component in fish farming that is useful for growth, so feeding is fundamental in fish farming. Overfeeding can increase production costs and reduce water quality. Fish farmers often must perform several activities at the same time, which can lead to errors in fish feeding. This results in a decrease in fish quality. From the above problems, a system is needed that can provide feed, especially fish feed, automatically according to the right schedule and dosage. The objective of this research is to develop and execute a system for automatically feeding fish utilizing IoT (Internet of Things) technology [9], [10], [11]. The Internet of Things (IoT) involves linking communication devices, such as smartphones, the internet, TV, sensors, and actuators, to the internet. This enables the interconnection of smart devices, creating opportunities for innovative communication methods. The utilization of IoT technology can be one of the supports for the efficiency of remote temperature monitoring and checking systems [12]. The system works according to a predetermined schedule and provides feed according to a predetermined dose. The hardware in this system can be controlled anytime and from anywhere via a smartphone so that fish farmers do not need to worry anymore when they have other activities or when they leave the house [13], [14].

Based on the case study and literature facts in the background, special research was conducted by the author. In addition, it can also help catfish seed cultivators to get healthy, disease-free, quality, and delicious catfish for consumption. Where the control system can control water temperature against fishpond water quality using Fuzzy calculations. As well as real-time temperature control. And activate the heater as a water warmer so that the temperature is well maintained.

2. METHOD

2.1. Use Case Diagram

Block diagram is one of the most important parts in designing a system. From the block diagram, the working principle of the whole circuit can be known. The block diagram of the circuit that has been arranged as well as possible will produce a system that can function as the working principle of the design of a system that is made [15], [16].

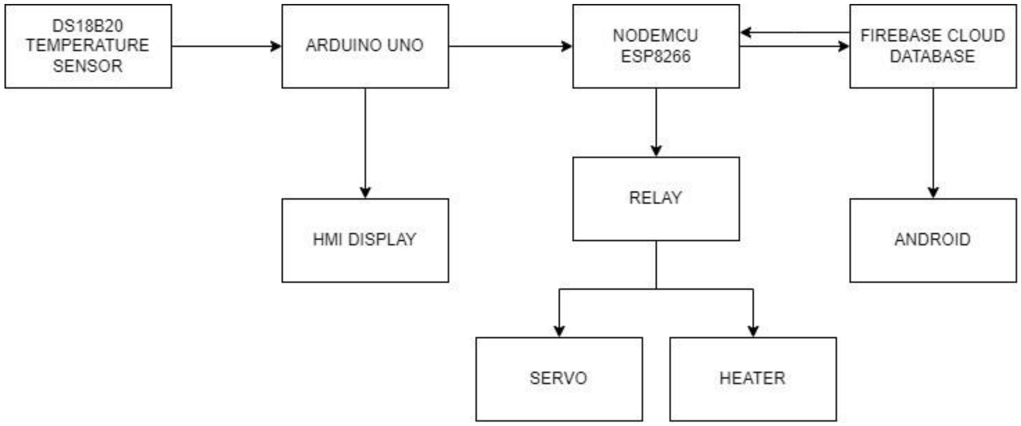

Figure 1. System Design Diagram

The system planning diagram depicted in Figure 1 comprises three primary components: input, process, and output design. Within the input segment, there is a temperature sensor, while the process section features an Arduino. An Arduino is an open-source electronic circuit board equipped with a central element, specifically a microcontroller chip [17]. Arduino Mega2560 microcontroller and NodeMCU ESP8266 functions as a microcontroller enhancement so that it can connect directly with Wi-Fi and make connections. Furthermore, data from the DS18B20 temperature sensor will be sent from ESP8266 to firebase data for Real Time as a data storage medium. And in the output section there is a servo and heater. In this system, monitoring uses LCD (HMI). Where, after detection is carried out by the sensor, the results of the sensor detection will be sent to the microcontroller. Then, the microcontroller will send the detection results to the LCD, where the LCD will display numerical characters as temperature information [18].

2.2. Flowchart

The workings of a tool can be seen from the flowchart or flow chart of the tool process from start to finish. To facilitate reading, the thing to do in the design is to make a flowchart [19], [20]. Flowchart Figure 2 below to get the value of the temperature of the Monitoring System on Pool Water Quality Based on Temperature Based on Internet of Things.

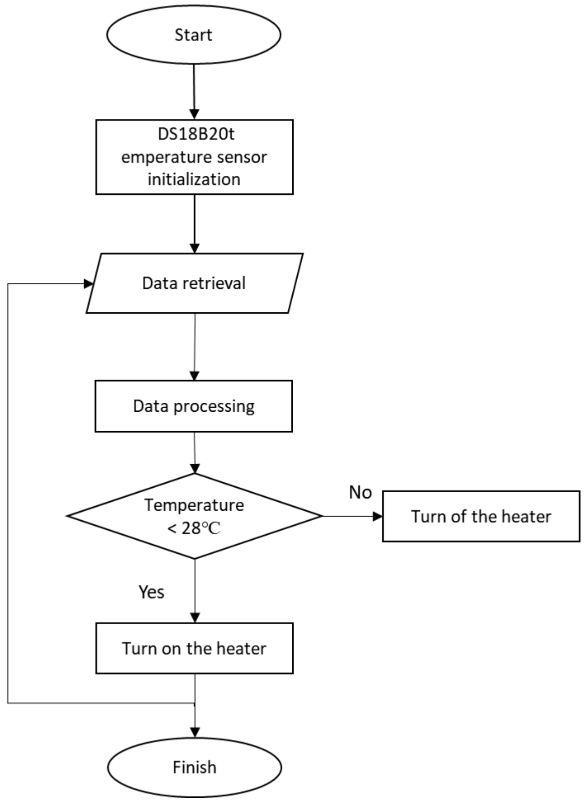

Figure 2. Flowchart

The Monitoring System on Pool Water Quality utilizes the Internet of Things (IoT) technology to ensure optimal water conditions. The system begins by initializing the temperature sensor, which is a crucial component for monitoring the pool's thermal state. Once initialized, the sensor actively reads and records the water's temperature data.

The core logic of the system evaluates the sensor's data to determine if the water temperature falls below a predefined threshold, indicating a low temperature. If such a condition is detected, the system triggers the heater to activate, thereby raising the water temperature to a more suitable level.

The system continues to monitor the temperature sensor readings diligently. As long as the temperature remains low, the heater stays on. Once the sensor indicates that the temperature has risen sufficiently and is no longer low, the system deactivates the heater [21], [22]. This cycle ensures that the pool water maintains a consistent and comfortable temperature for users. The system begins its operation by initializing the temperature sensor, a critical step to ensure accurate readings. Once the sensor is active, it continuously monitors the water temperature, relaying the data for analysis.

The system is programmed with a specific temperature setting at 28˚C to 30˚C — which is considered ideal for pool water. Should the sensor detect a temperature below this threshold, it triggers the heater to turn on, gently warming the water until the desired temperature is reached. Conversely, if the sensor readings show that the water temperature has achieved or surpassed 30˚C, the system responds by turning off the heater, thereby maintaining a consistent and comfortable water temperature. This automated process not only provides a pleasant swimming experience but also optimizes energy usage, ensuring the heater operates only when necessary.

2.3. Mechanical Design

Before being realized into physical form, a tool design is first carried out to facilitate the manufacture of the product / machine. The following is the construction form of an automatic fish feeder.

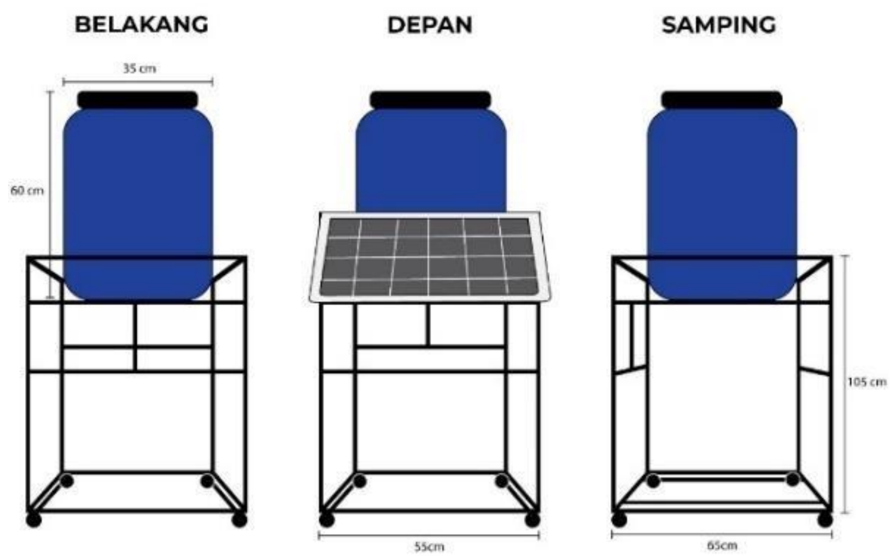

Figure 3. Mechanical Design

2.4. Electrical Design

Figure 4 to Figure 6 display the wiring of the estimated temperature monitoring analysis circuit. Arduino Mega2560 as a microcontroller and NodeMCU ESP8266 which is used as an additional device for the microcontroller to connect directly with Wi-Fi and make connections. The input section has a temperature sensor and in the output section there is a servo and heater. Finally, all data both measured and processed by Arduino Mega and ESP8266 will be displayed on the HMI display.

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E.ISSN: 2620 – 6390
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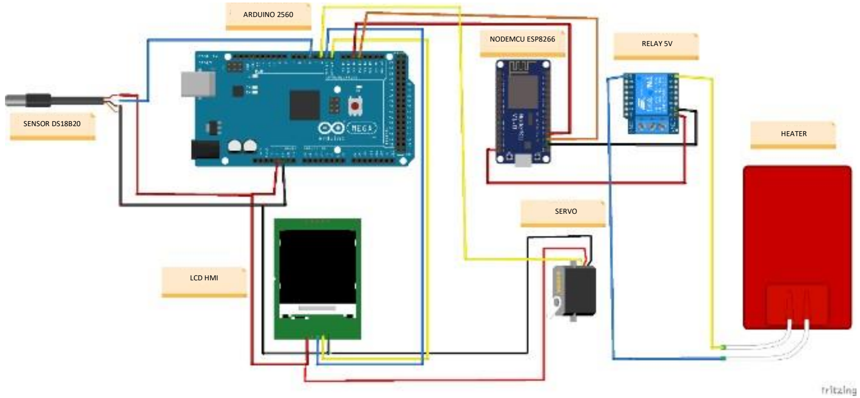

Figure 4. Circuit Diagram

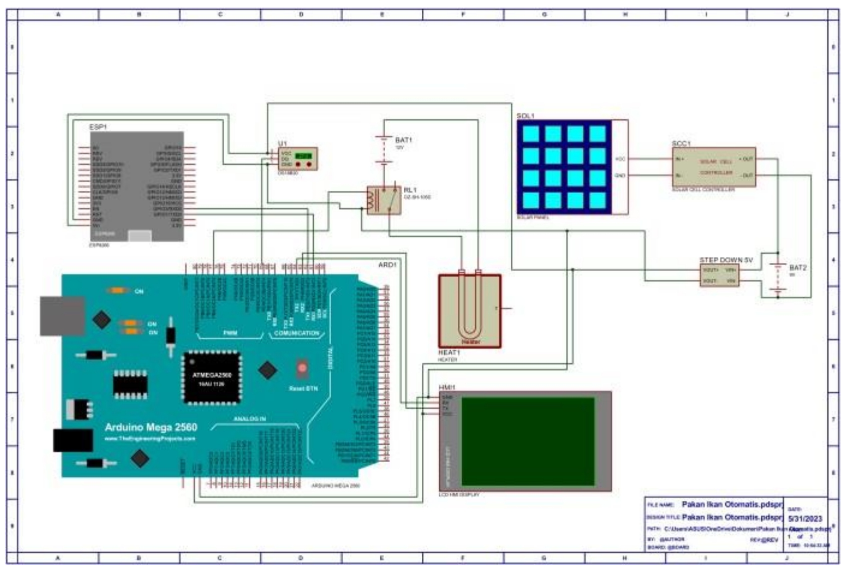

Figure 5. Schematic Diagram

The Arduino mega2560 design is interfaced with ESP82, so that the Arduino mega2560 can connect to Wi-Fi because ESP 8266 is used as a Wi-Fi module. Pin TR3 Arduino mega2560 is connected to pin RX ESP 8266, pin RX3 is connected to pin TX on ESP 8266. Moreover, the Arduino Mega 2560's Vcc pin is linked to the Vcc of the ESP8266, while the GND pin of the Arduino Mega 2560 is connected to its own GND pin.

The design of the Arduino Mega2560 with a DS18B20 temperature sensor function as a measuring device for the temperature of the fishpond water during the monitoring process. In this setup, the DS18B20 temperature sensor's data pin is linked to the Digital 2 (D2) pin on the Arduino Mega2560. Simultaneously, the sensor's VCC pin is attached to the 5V pin on the Arduino Mega2560, and the temperature sensor's ground pin is connected to the ground pin on the Arduino Mega.

For Mg995 Servo Design this motor is designed for closed loop control where the motor will move following the PWM angle or speed command given. Where the servo motor is used to open the fish feed automatically. In this setup, the data pin of the Mg995 Servo is linked to the Digital 3 (D3) pin on the Arduino Mega2560. Simultaneously, the Vcc pin of the sensor is connected to the 5V pin on the Arduino Mega2560, and the ground pin of the temperature sensor is attached to the ground pin of the Arduino Mega.

In the temperature controller LCD circuit using one LCD type LCD HMI (Human Machine Interface) where this LCD operating voltage is 5V, with 100% brightness. The temperature sensor reading value is presented on the LCD screen. The LCD HMI port is linked to the Arduino Mega2560's TX pin, with the RX connected to another pin on the Arduino Mega2560. Additionally, the SDA and SCL pins of the four LCDs are interconnected in sequence. The Vcc pin is attached to the Arduino Mega2560's 5v, and the ground pin is linked to the Arduino Mega2560's ground pin.

Arduino Mega2560 design with a heater in a fishpond during the warming process of fishpond water. In this circuit using one heater because the heater has AC voltage, a 5V relay is needed as a voltage connector and disconnector. The relay
has several positive relay pins connected to the 5V Arduino mega2560 pin, the negative relay pin is connected to the GND pin on the Arduino mega2560, and the first relay data pin is connected to digital pin 9 (D9) Arduino mega2560. To connect the relay pin to the heater using the Normally Close (NC) pin and the feed pin is directly connected to the Solar Panel voltage.

2.5. Software Design

Software design is used to form an IoT device that plays a role in carrying out the monitoring function of the sensor temperature reading. The platform tested in this design is a device based on the Android Operating System due to the ease and flexibility in designing the system as a form of Open-Source function. The design is done using IDE (Integrated Development Environment) which is Android application developer software. The design of the monitoring application is described in the following stages.

1. Determine the components that will be displayed in the application. This component is in the form of monitoring information data such as temperature state, time, and date of measurement.
2. Creation of application device access accounts. The purpose of creating an account is to limit access to the device for data security on the server and keep the server from overloading.
3. connect or connect the Android studio application to Firebase so that real-time data, namely temperature sensor data, date and time can appear in the Android studio application...

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E.ISSN: 2620 – 6390
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Jurnal Teknologi Informasi dan Pendidikan
Volume 17, No. 2, September 2024
https://doi.org/10.24036/jtip.v17i2.824

Create a simple layout of the application display to give a basic idea of how the finished application will be programmed.

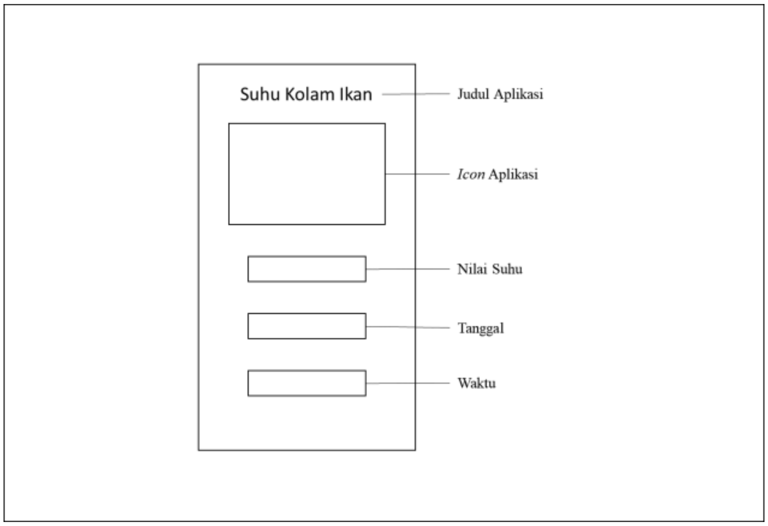

Figure 6. Layout Design

Connect the Android Studio program script that has been done to the intended Android device. So that it becomes an application that is ready to be used to monitor pool temperature measurements using data captured by the DS18B20 temperature sensor with the final display results as follows.

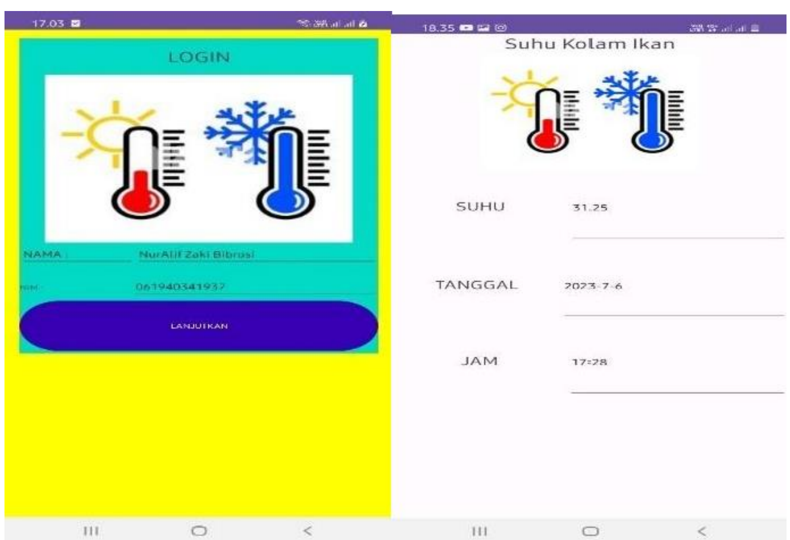

Figure 7. Android Application Display

3. RESULTS AND DISCUSSION

This segment elucidates the outcomes of the study while simultaneously providing an in-depth analysis. Findings may be depicted through figures, graphs, tables, or other visual aids to enhance reader comprehension [23], [24]. The analysis can be organized into various sub-sections for a more detailed exploration.

Monitoring the pool water temperature along with testing the DS18B20 Sensor and Thermometer. Monitoring for 24 hours, measurements are taken once an hour. Testing is carried out for approximately 24 hours (WIB), in order to determine the value of the temperature sensor tool with a Thermometer. The temperature sensor is connected to the microcontroller port. Testing is done with different times. In the morning until at night, when entering the temperature sensor and thermometer wait 1 minute to get stable results. Because the temperature sensor and thermometer need a delay to measure the temperature around the pool in order to get the desired value. There is a graph of the DS18B20 sensor and thermometer measurements can be seen in Figure 8.

Table 1. Results of the coba test fish choleam temperature

No.	Hour (WIB)	Temperature (°)	
		Thermometer	**DS18B20 Sensor**
1	00.00-01.00	30	29,3
2	01.00-02.00	29,8	28,2
3	02.00-03.00	29,6	28,1
4	03.00-04.00	29,3	28
5	04.00-05.00	28,6	27,8
6	05.00-06.00	27,8	27,4
7	06.00-07.00	29,1	28,2
8	07.00-08.00	29,7	28,4
9	08.00-09.00	30	28,9
10	09.00-10.00	30,1	29,1
11	10.00-11.00	30,2	29,6
12	11.00-12.00	31	30,1
13	12.00-13.00	31,5	30,8
14	13.00-14.00	31,9	31,3
15	14.00-15.00	32	31,7
16	15.00-16.00	32	31,5
17	16.00-17.00	32	31,3
18	17.00-18.00	31,5	31,1
19	18.00-19.00	31	30,7
20	19.00-20.00	31	30,7
21	20.00-21.00	30,8	30
22	21.00-22.00	30,2	29,9
23	22.00-23.00	30,1	29,6
24	23.00-00.00	30	29,4

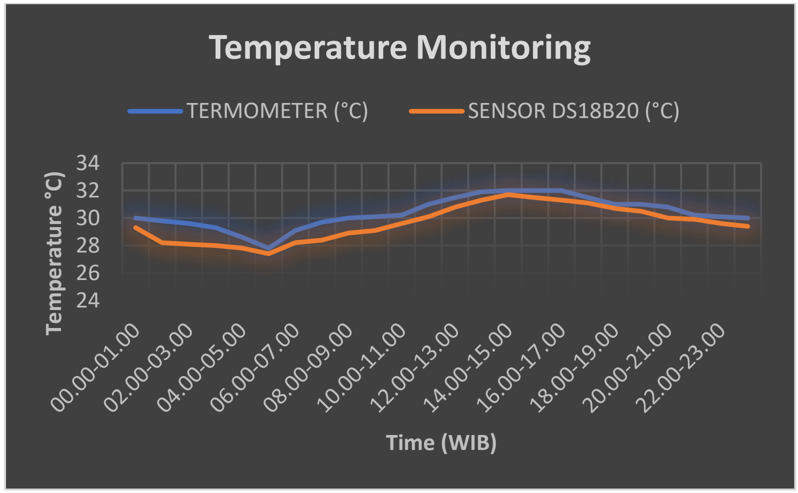

Figure 8. Graph of DS18B20 sensor test results against thermometer

There are temperature conditions in the fish pond environment where, the temperature conditions around the fish pond are also very influential on the temperature of the pond water. We can see in table II Test Results of Temperature Conditions in the Pond environment.

Table 2. Test results of ambient temperature conditions

Temperatue Condition	Temperature Sensor	Thermometer	*Error*
Raining	25,6°	25°	2,400%
Noon	27,4°	27°	1,481%
Evening	33,9°	32,5°	4,307%
Night	28,3°	28°	1,071 %
	Error Average		9,256%

It is then necessary to calculate the percentage error as well as the average error value.

$$Error = \frac{Temoerature\ Sensor\ Value - Thermometer\ Value}{Thermometer\ Value} \times 100\% \quad (1)$$

3.1. Cold Temperature (Rain)

$$Error = \frac{25{,}6 - 25}{25} \times 100\% = 2{,}400\% \quad (2)$$

We can see that the temperature conditions when it rains the temperature drops dramatically around 25.6 ° in measurements using the DS18B20 temperature sensor, and in measurements using a thermometer around 25 °. And has a percentage error of 2.400%.

3.2. Morning Temperature

$$Error = \frac{27{,}4 - 27}{27} \times 100\% = 1{,}481\% \quad (3)$$

Temperature conditions in the morning the temperature drops around 27.4 C° in measurements using the DS18B20 temperature sensor, and in measurements using a thermometer around 27 °C. And has a percentage error of 1.481%.

3.3. Afternoon Temperature

$$Error = \frac{33{,}6 - 32{,}5}{32{,}5} \times 100\% = 4{,}071\% \quad (4)$$

Temperature conditions in the afternoon the temperature is higher around 33.9 °C in measurements using the DS18B20 temperature sensor, and in measurements using a thermometer around 32.5 °. And has a percentage error of 4.307%.

3.4. Night Temperature

$$Error = \frac{28{,}3 - 28}{28} \times 100\% = 1{,}071\% \quad (5)$$

Temperature conditions at night the temperature is stable around 28.3 ° ° in measurements using a DS18B20 temperature sensor, and in measurements using a thermometer around 28 °. And has a percentage error of 1.071%. And below is the process of calculating the average error based on the data above.

$$Error\ Average\ = \frac{£\,error}{£\,trial} = \frac{9{,}259}{3} = 3{,}086\% \quad (6)$$

So, based on the comparison of water temperature data using the DS18B20 temperature sensor and Thermometer, the average error value is 3.086%. Visualization of the temperature sensor trial can be seen in the graph below with the blue line showing the measurement results using a thermometer and the orange line showing the measurement results using the DS18B20 temperature sensor [25].

4. CONCLUSION

Based on the test and measurement results, the following conclusions can be drawn:

1. In this water temperature control tool in fish ponds using DS18B20 sensors and thermometers, these sensors and thermometers have a percentage level, namely: average percentage of temperature sensor error 3,086%.

P.ISSN: 2086 – 4981
E.ISSN: 2620 – 6390
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2. The temperature control device has worked properly with the main components including the temperature sensor and heater.
3. From monitoring conducted for approximately 24 hours, the best temperature in the fish pond is 28°-30°, the best temperature percentage is at night at 18.00-00.00 WIB.

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P.ISSN: 2086 – 4981
E.ISSN: 2620 – 6390
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