Design of a Koi Fish Quarantine Aquarium Water Quality Control Application Using Method Forward Chaining at The Kediri District Koi Nusantara Auction

Azam Muzakhim Imammuddin[1], Sri Wahyuni Dali[2], Abirawa Agung Laksana[3]

[1,2,3] Digital Telecommunication Network Study Program, Department of Electrical Engineering, State Polytechnic of Malang, 65141, Indonesia.

[1] azam.muzakhim@polinema.ac.id , [2] sri.wahyuni@polinema.ac.id , [3] 2041160039@student.polinema.ac.id

Abstract— **The quarantine process for koi fish at the Lelang Koi Nusantara event is still carried out manually, which increases the risk to fish health, particularly when water quality is not consistently monitored. As a result, koi fish may experience stress or mortality due to undetected changes in environmental conditions. This study aims to design and develop an automatic Internet of Things (IoT)–based control and monitoring system to improve the effectiveness of the quarantine process. The proposed system can detect key water quality parameters, including temperature, pH, ammonia concentration, water level, and turbidity in koi quarantine aquariums. Several sensors are employed, namely the DS18B20 temperature sensor, pH 4502 sensor, MQ-135 ammonia sensor, HC-SR04 water level sensor, and SEN0189 turbidity sensor, with measurement accuracies of ±0.6 °C for temperature, ±0.12 for pH, ±0.26 for turbidity, and ±0.2 for ammonia. Monitoring results are displayed through a web-based application integrated with MySQL and Firebase databases, allowing users to access real-time data and remotely observe water conditions. A forward chaining method is implemented to determine appropriate control actions, such as activating the heater, adding salt, or draining the water. System testing indicates that the proposed solution responds accurately to changes in water quality and supports better fish health management during quarantine.**

Keywords—Ammonia Sensor, Forward Chaining, pH Sensor, Real-Time Monitoring, Temperature Sensor, Turbidity Sensor, Water Quality Control

I. INTRODUCTION

The first reason to start a koi fish business is because of economics or profit. The price of koi fish is one of the most expensive ornamental fish [1]. The price can reach millions of rupiah for fish with beautiful patterns, because the market for koi fish is very large, especially because of the large number of koi lovers in Indonesia [2]. In fish farming, temperature is a very important factor to pay attention to [3]. This water temperature is very important because it will affect the activity of the fish while they are being kept [4]. Temperatures that are too high cause fish to breathe more quickly, which increases oxygen demand, and excrete waste more quickly, which results in a significant decrease in water quality [5]. The ideal water temperature for fish during transportation is around 25–30 degrees Celsius [6]. Fish resistance will decrease due to higher or lower temperatures [7]. Water pH also affects the growth of koi fish. The ideal pH for fish weight growth is 7-8, and the best pH for fish color is 4-5 [8]. High water turbidity can prevent light from entering the quarantine aquarium, reducing light intensity [9]. As a result, it can affect the way koi fish identify, find food, and interact with their environment [10]. Koi fish can experience stress when the water is cloudy [11]. Fish's immune system can be weakened by stress, making them more susceptible to disease [12].In previous research conducted by Andhika Bayu Pratama Imam Much Ibnu Subroto and Andi Riansyah in their journal entitled "Water Quality Monitoring and Control System in Koi Fish Ponds Based on Internet of Thing (IoT)" research was conducted for a Koi Fish Based Monitoring and Control System Internet of Things This can carry out the functions of data retrieval, decision making, sending data to cloud and running the actuator [12]. Apart from that, water quality has been well controlled in determining optimal water quality decisions and control [13].

This condition is the background for planning this research, by creating a tool for controlling and monitoring water quality in the form of water temperature, pH levels, ammonia levels, and water turbidity in the filtration system, which later this tool can detect the above parameters in real-time via the user's device so that it can be monitored and controlled remotely. This tool will issue output in the form of handling actions in fish quarantine aquariums that experience water quality problems which can affect the health and quality of koi fish [14]. The action provided by this tool is in the form of activating the heater to stabilize the water temperature. If the pH exceeds the specified limit, this tool will be controlled by a servo motor to pour salt so that the water pH becomes stable. This tool also has an MQ-135 sensor to detect ammonia levels in the water. quarantine aquarium and automatic draining of the quarantine aquarium will be carried out using an ultrasonic sensor to measure the water change limit that will be replaced with new water, while monitoring water quality in the filtration system using a turbidity sensor by emitting light on the sensor, to monitor water turbidity in quarantine aquarium filtration. So that the koi fish quarantine aquarium can be controlled and monitored properly [15].

II. METHOD

A. Types of research

This type of research takes the form of creating/developing tools and web applications that can help Nusantara Koi Auction business owners in Kediri to control the water quality of koi fish quarantine aquariums, with control of water quality based on Internet of Things so that the equipment can be controlled remotely to reduce losses in this business due to death of koi fish. This research will design an application that can take action if water quality (temperature, pH level, ammonia level and water turbidity) is in poor condition. The results of this tool and application will be implemented and used in the Auction Koi Nusantara fish quarantine aquarium. This tool will be integrated using the method forward chaining. Forward chaining ensuring that the tool automatically responds and controls water quality conditions according to predetermined rules to prevent koi fish death and maintain ideal environmental conditions.

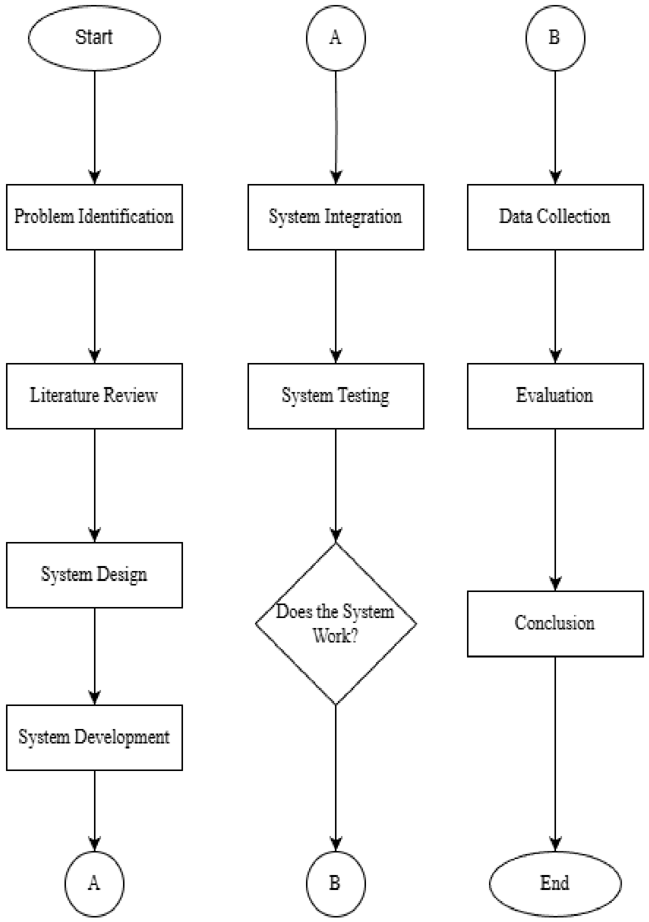

Figure 1. Flow diagram of research stages

Fig. 1 explains the research stages that will be carried out. Research starts from problem identification, namely making observations and identifying the problems found. After finding a problem, the research continues with literature study to look for references and sources in solving the problem. In the next stage, the design and manufacture of the tool will be carried out by implementing it wiring that has been planned, writing programming code, compiling the code with the IDE, and saving the code to the microcontroller and assembling the device. After the tool has been created, the next step is tool integration, namely connecting the water quality control measurement tool with the system so that they can work together and exchange information. Next, the tool testing includes sensor sensitivity in monitoring the quality of the koi fish aquarium.

The next stage is designing the design and application by determining the question parameters and determining the output or results of the method forward chaining to produce output in the form of actions that must be taken to drain and monitor aquarium water quality. After the application has been created, testing will be carried out to see the strength and accuracy of the device. After all tests are completed, the next stage is data collection in the form of success in monitoring water quality and also success in making decisions via a web based application that can be controlled remotely. Next, periodic evaluations are carried out to ensure that the tool continues to meet user needs and that its performance is optimal. The final stage is drawing conclusions based on the analytical data that has been collected during the research.

B. Schematic Network Planning

Schematic network planning that will be used by the system is as follows.

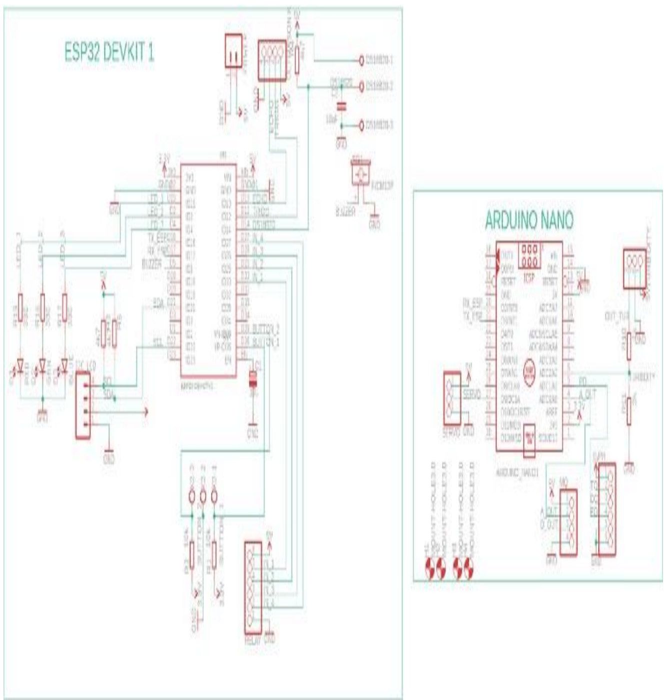

Figure 2. Schematic Network Planning

Fig. 2 shows wiring system diagram. Pin usage is shown in table 1 and Table 2 below.

TABLE I
ESP32 PIN USAGE

Pin ESP32	Component	Component Pins	Information
22	LCD 16x2	SDA	Serial Data
21	LCD 16x2	SCL	Serial Clock
5	Buzzzer	V+	Input Voltage
4	LED 1	Resistor 330	Pin input resistor
2	LED 2	Resistor 330	Pin input resistor
15	LED 3	Resistor 330	Pin input resistor
16	TX_ESP	ESP32	Communication Series
17	RX_ESP	ESP32	Communication Series
13	ECHO	HC-SR04	Input HC-SR04
12	TRIGGER	HC-SR04	Input HC-SR04
14	DS18B20	OUTPUT DS18B20	OUTPUT DS18B20
27	INI	RELAY	Input RELAY
26	IN2	RELAY	Input RELAY
25	IN3	RELAY	Input RELAY
33	IN4	RELAY	Input RELAY
39	BUTTON 2	Push Button 2	Kaki input Button
36	BUTTON 1	Push Button 1	Kaki input Button

TABLE II
USING ARDUINO NANO

Pin Arduino Nano	Component	Component Pins	Information
Serial Data	Serial Data	Serial Data	Serial Data
Serial Clock	Serial Clock	Serial Clock	Serial Clock
Input Voltage	Input Voltage	Input Voltage	Input Voltage
Pin input resistor	Pin input resistor	Pin input resistor	Pin input resistor

III. RESULTS AND DISCUSSION

A. *Place and Time of Implementation*

This research was carried out at Auction Koi Nusantara Regency, Kediri on July 20-July 23 2024.

B. *Research result*

This section presents the results of tool testing to control the water quality of koi fish quarantine aquariums and the results of the web application using the method Forward Chaining to determine the action taken according to the water conditions in the aquarium.

1) Tool implementation

The following are the results of a koi fish quarantine aquarium water quality control tool. Fig. 3 shows a top view of the tool in accordance with the designed design. The tool is designed for an aquarium that has dimensions of 60.4 cm wide and 30 cm high. These dimensions were chosen to ensure sufficient space for the placement of the various sensors and electronic components required.

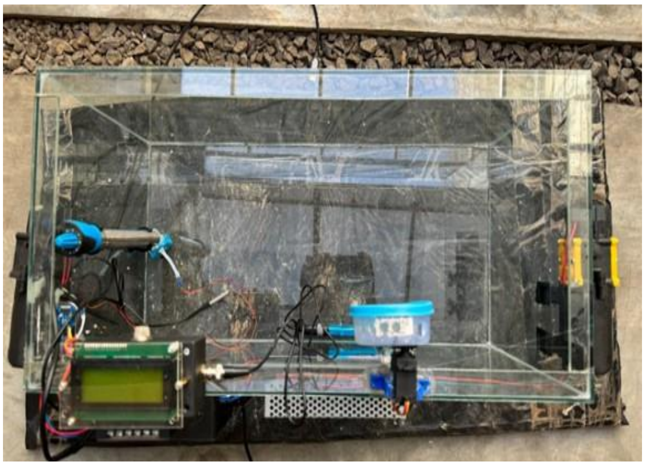

Figure 3. Tools (Top View)

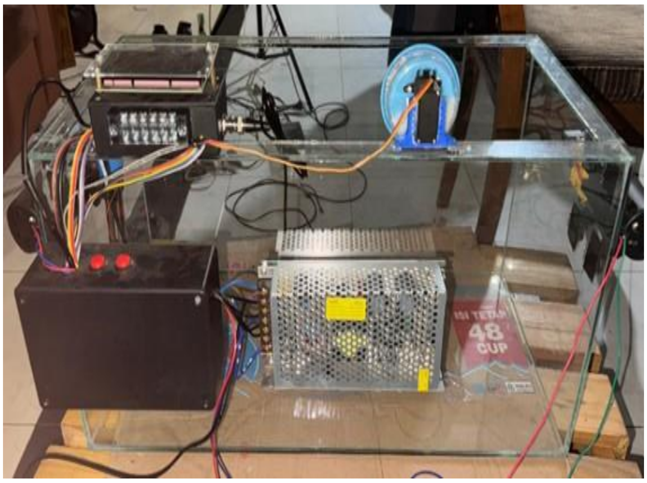

Figure 4. Tools (Front View)

Fig. 4 shows the front view of the aquarium. The heater component and DS18B20 sensor are placed on the far left side of the aquarium. The DS18B20 sensor is responsible for measuring water temperature in real-time. When the water temperature drops below the desired limit, the heater will be activated to increase the temperature until it reaches normal temperature. This sensor is installed in the specific aquarium behind the component box located on the front side of the aquarium.

The MQ-135 sensor is used to detect ammonia levels in water. High ammonia levels can harm fish, so this sensor is very important for maintaining water quality, while the turbidity sensor is placed parallel to the DS18B20 sensor on the left side of the aquarium. Turbidity sensors measure water turbidity which reflects the level of cleanliness of the water. If the water is too cloudy, the system will activate the drain pump to replace the water, and a pH sensor is placed in the aquarium to measure the acidity level of the water. If the water pH exceeds the desired limit, the servo motor will be activated to add salt automatically to balance the pH.

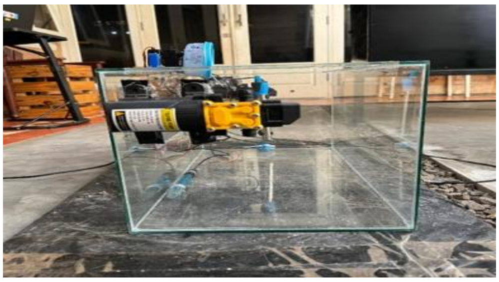

Figure 5. Side View Tool (Water Pump)

Fig. 5 shows the visible view of the tool side (water pump) namely a draining and filling pump that has been integrated with an ultrasonic sensor. The microcontroller used is an Arduino Nano and ESP32 which is located in the component box and functions as the main microcontroller which collects data from the installed sensors. Arduino Nano collects data from pH, MQ-135, and turbidity sensors, then sends the data to the ESP32 for further processing. The ESP32 collects data from the DS18B20 and ultrasonic sensors, and controls output components such as relays, buzzers, LCDs and servos. Meanwhile, the function of the relay is to activate the heater, filling pump and drain pump. Meanwhile, the function of the buzzer is to provide sound notifications.

2) Web implementation

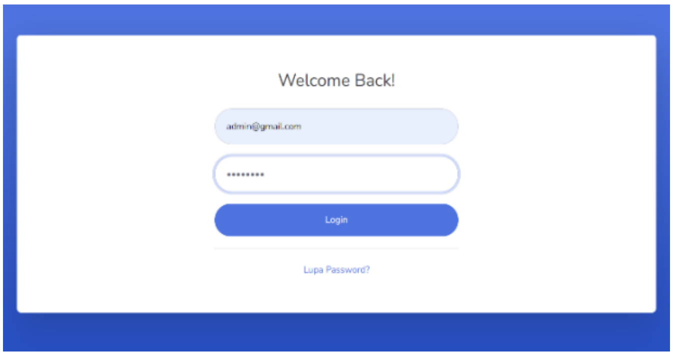

Figure 6. Login page

Fig. 6 shows the login page, on this login page the owner must enter his email and password, after that the system will verify the data so he can move on to the next page.

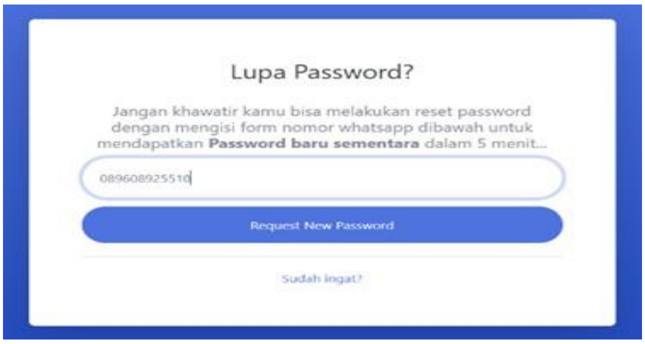

Figure 7. Forgot Password page

Fig. 7 shows the page when the owner presses the forget password button, this page is used to reset the password, the system will send an OTP code via WhatsApp.

Figure 8. Display of messages sent to WhatsApp

Fig. 8 shows the WhatsApp message sent containing the OTP code. This code is entered on the login page as a password.

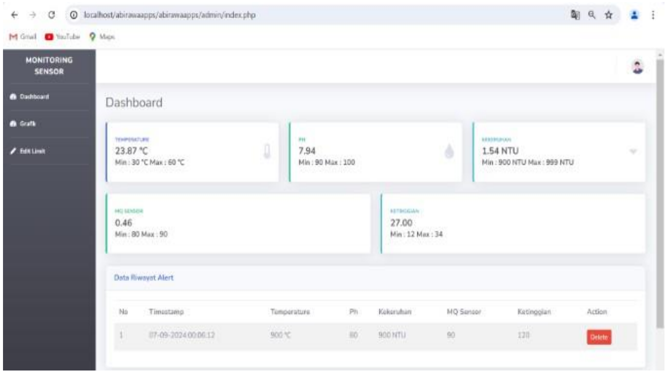

Figure 9. Dashboard page

Fig. 9 shows the main dashboard page displaying a summary of status information from sensor measurement values in the aquarium, namely temperature, pH, ammonia levels and water turbidity.

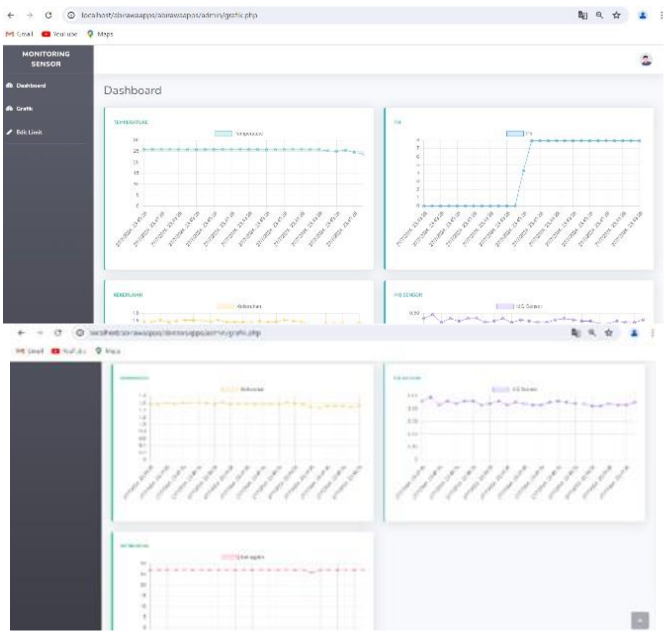

Figure 10. Sensor Graphics Page

Fig. 10 displays a graphic dashboard that presents water quality monitoring data in graphical form. Users must fill in several health question parameters so that the data can be processed to obtain lifestyle results.

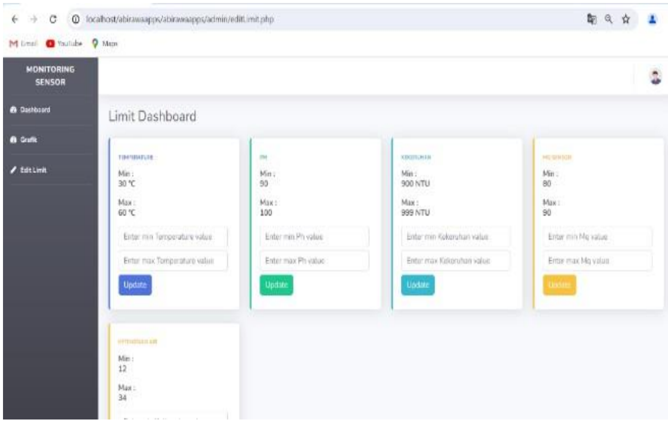

Figure 11. Edit Set page

Fig. 11 shows the edit set limit dashboard used to set later quality parameter limits which change the limit value of each parameter, namely temperature, pH, ammonia levels and water turbidity.

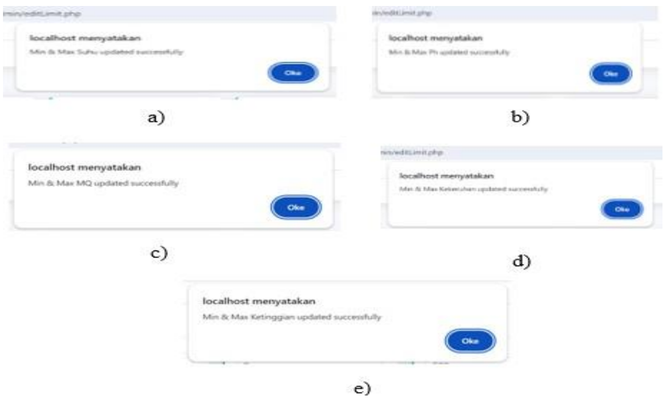

Figure 12. Edit Limit Sensor Sukses (a), (b), (c), (d), (e)

Fig. 12 shows that the et limit editing of each water quality parameter was successful.

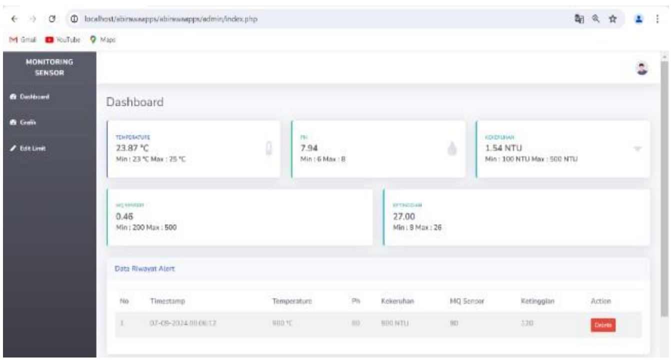

Figure 13. Dashboard display after Edit Limit

Fig. 13 shows the dashboard display after the owner successfully edits the limit.

3) MySQL database implementation

Figure 14. Database MySQL

Fig. 14 shows a table in a database in MySQL, this database is used for user management and authentication, such as storing user data, managing logins, and sending OTP codes for security verification.

4) Database implementation Firebase

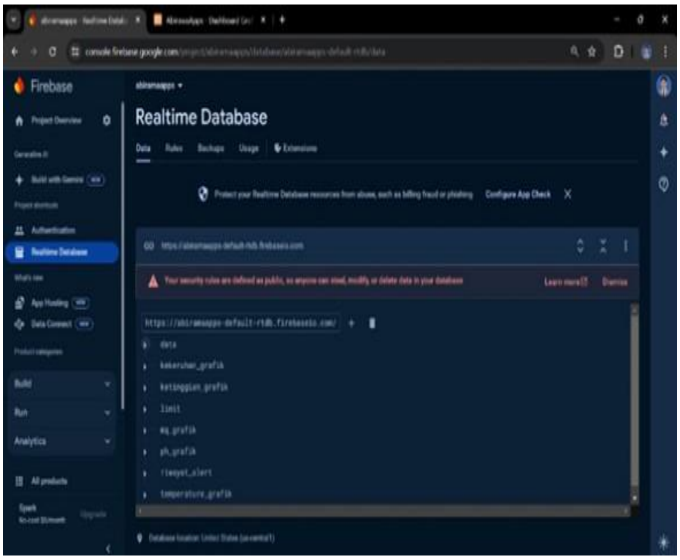

Figure 15. Database Firebase

Fig. 15 is Firebase Realtime Database used for monitoring sensor data real-time, storage of historical data required for analysis and decision making, as well as for displaying data in graphical form on dashboard web. This system supports communication and data storage for remote monitoring and control of aquariums via access point. This access point connects the ESP32 with a database to send sensor data in real-time. So users can monitor aquarium conditions remotely via the internet.

C. Tool Test Results

This test is carried out to measure the accuracy of the tool. This measurement was carried out by monitoring the progress of the tool for 4 days in an aquarium filled with koi fish for quarantine to get the following results.:

1) Temperature Test Results in Aquariums

TABLE III
TESTING OF TEMPERATURE MEASUREMENT RESULTS

No	Tgl Input	Original Temperature	Tool Temperature	Category	Error
1	20/07/24	21.7	21.1	Cold water temperature	0.03%
2	21/07/24	25.4	24.8	Normal water temperature	0.02%
3	22/07/24	19.9	19.3	Cold water temperature	0.03%
4	23/07/24	26.3	25.6	The water temperature is stable	0.03%

Table 3 shows test results to ensure that the aquarium water quality monitoring system works accurately, the water temperature was tested using the DS18B20 sensor for 4 days. There are small differences between the two tools, with errors ranging from 2.36% to 3.01%. Despite the differences, the resulting temperature categories remain consistent, classifying water temperatures as cold, normal, or stable.

2) Results of pH Testing in Aquariums

TABLE IV
TESTING PH MEASUREMENT RESULTS

No	Tgl Input	Original pH	pH Tools	Category	Error
1	20/07/24	6.36	6.4	Water conditions are normal	0.006%
2	21/07/24	4.28	4.33	Acidic water conditions	0.011%
3	22/07/24	6.87	6.75	Water conditions are normal	0.017%
3	23/07/24	7.94	7.81	Waterconditions are normal	0.016%

Table 4 displays the results To ensure that the aquarium water quality monitoring system works accurately, the pH of the water is tested using a pH 4502 sensor for 4 days. Although there are slight differences with errors between 0.63% to 1.75%, the results for the water condition category remain consistent, indicating that these two tools are reliable for monitoring water pH

3) Turbidity Test Results in Aquariums

TABLE V
TURBIDITY RESULTS TESTING

No	Tgl Input	Voltage	Water Conditions
1	20/07/24	1.26	Clean water conditions
2	21/07/24	1.52	Clean water conditions
3	22/07/24	1.64	Clean water conditions
4	23/07/24	0.87	Water conditions are murky

Table 5 displays the results testing to ensure the system works, testing the water quality using a turbidity sensor for 4 days. A higher voltage indicates clean water conditions, while a lower voltage indicates cloudy water. Ammonia Test Results in Aquariums.

4) Ammonia Test Results in Aquariums

TABLE VI
AMMONIA RESULTS TESTING

No	Tgl Input	Voltage	Water Conditions
1	20/07/24	0.6	Amonia up to normal
2	21/07/24	0.8	Amonia up to normal
3	22/07/24	1.3	Amonia up to normal
4	23/07/24	1.4	High ammonia levels

Table 6 shows test results to ensure the aquarium water quality monitoring system is working accurately. A lower voltage (0.6 to 1.3) indicates normal ammonia levels, while a higher voltage (1.4) indicates high ammonia levels. This confirms that voltage measurements can be used to effectively monitor ammonia levels in water.

5) Results of Ultrasonic Testing in Aquariums

TABLE VII
ULTRASONIC RESULTS TESTING

No	Tgl Input	Original water level	Tool water level (ultrasonic)	Error
1	20/07/24	24 cm	24 cm	0%
2	21/07/24	24 cm	24 cm	0%
3	22/07/24	8 cm	8 cm	0%
4	23/07/24	24 cm	24 cm	0%

Table 7 displays the test results to ensure the aquarium water quality monitoring system works accurately which was carried out for 4 days. Test results show that each measurement is consistent with the results recorded on the meter. All data shows an error of 0%, meaning there is no difference between the ultrasonic sensor and meter measurements. This shows that the ultrasonic sensor worked accurately in detecting water levels during the test period.

D. Forward Chaining Prediction Test Results

his test was carried out to evaluate the performance of the method Forward Chaining implemented in the aquarium water quality monitoring system, a series of tests were carried out. This test aims to provide accurate actions based on data obtained from sensors. Following are the test results Forward Chaining in this research:

1) Forward Chaining Test Results on Temperature Sensor (DS18B20)

TABLE VIII
TESTING FORWARD CHAINING ON TEMPERATURE SENSOR

No	Tgl Input	Tool Temperature (DS18B20)	Action/Output	Success/Fail Status
1	20/07/24	21.1	The heater is on	Succeed
2	21/07/24	24.8	Stable condition	Succeed
3	22/07/24	19.3	The heater is on	Succeed
4	23/07/24	25.6	Stable condition	Succeed

Table 8 shows that the water quality monitoring system functions well. On 07/20/24 and 07/22/24, when the water temperature was detected as low (21.1°C and 19.3°C), the system successfully activated the heater to increase the temperature, with successful action status. On 07/21/24 and 07/23/24, when the temperature was within the stable range (24.8°C and 25.6°C), the system managed to maintain a stable temperature condition without requiring changes, with the action status also successful.

2) Forward Chaining Test Results on pH Sensor(pH 4502)

TABLE IX
TESTING FORWARD CHAINING ON THE PH SENSOR

No	Tgl Input	pH Tool (pH4502)	Action/Output	Success/Fail Status
1	20/07/24	6.4	Stable condition	Succeed
2	21/07/24	4.33	Stable condition	Succeed
3	22/07/24	6.75	Salt pouring	Succeed
4	23/07/24	7.81	Stable condition	Succeed

Table 9 shows that the system successfully managed water pH: at stable pH values (6.4; 4.33; and 7.81), the system succeeded in maintaining a stable condition. At a pH indicating acidic conditions (4.33), the system successfully carried out salt pouring to adjust the pH, with all actions recorded as successful.

3) Forward Chaining Test Results on Turbidity Sensors

TABLE X
TESTING FORWARD CHAINING ON TURBIDITY

No	Tgl Input	Water Conditions	Action/Output	Success/Fail Status
1	20/07/24	Clean water conditions	Stable	Succeed
2	21/07/24	Clean water conditions	Stable	Succeed
3	22/07/24	Clean water conditions	Stable	Succeed
4	23/07/24	Clean water conditions	Draining and Filling	Succeed

Table 10 shows that the system is successful in managing water conditions: in clean water conditions, the system is successful in maintaining stability. On 07/23/24, when the water conditions were cloudy, the system succeeded in draining and filling to restore the water conditions. All actions were recorded as successful.

4) Forward Chaining Test Results on Ammonia Sensor (MQ-135)

TABLE XI
TESTING FORWARD CHAINING ON THE AMMONIA SENSOR

No	Tgl Input	Water Conditions	Action/Output	Success/Fail Status
1	20/07/24	Ammonia conditions are normal	Stable	Succeed
2	21/07/24	Ammonia conditions are normal	Stable	Succeed
3	22/07/24	Ammonia conditions are normal	Stable	Succeed
4	23/07/24	High ammonia conditions	Send WA Drain and Fill Notification	Succeed

Table 11 shows an overview of how the system gradually evaluates the information obtained from the ammonia sensor Journal of Telecommunication Network (Journal of Telecommunication Networks) and produces output in the form of recommendations or actions that will be produced. The system succeeded in managing ammonia levels, at normal ammonia levels, the system succeeded in maintaining stable conditions and was successful.

5) Ultrasonic Forward Chaining Test Results

TABLE XII
TESTING FORWARD CHAINING ON TURBIDITY

No	Tgl Input	Tool water level (ultrasonic)	Process	Success/Fail Status
1	20/07/24	24 cm	Stable	Succeed
2	21/07/24	24 cm	Stable	Succeed
3	22/07/24	8 cm	Stable	Succeed
4	23/07/24	24 cm	Drain	Succeed

Table 12 shows that the system successfully managed the water level: at a height of 21 cm, the system succeeded in maintaining stability. On 07/23/24, when the water level dropped to 8 cm, the system successfully drained, and then after the level returned to 21 cm, the system successfully filled.

6) Functional Results of System Testing

TABLE XIII
FUNCTIONAL RESULTS OF SYSTEM TESTING

No	Testing	Description	Expected Results	Tool Results	Status OK/ Failed
1	Temperature Measurement	The Temperature sensor measures the water temperature in the aquarium.	The water temperature sensor can be measured, sent to the microcontroller, namely ESP32,and displayed on the LCD screen.	The temperatue sensor can measure water temperature and the measurement results are then displayed on the 12C LCD via the ESP 32 microcontrller.	OK
2	pH measurement	The pH sensor measures the acidity level of water.	The pH sensor will measure the acidity level of the water.The results of these measurements will be sent to the Arduino Nano and displayed onthe LCD	The pH sensor can measure water acidity and the measurement results are displayed on the 12C LCD.	OK
3	Ammonia Measurement	The MQ-135 sensor detects ammonia levels in water.	Information from the ammonia sensor will be sent to the Arduino Nano and will be displayed on the LCD	Ammonia levels can be read and displayed on the LCD	OK
4	Turbidity Measurement	Turbidity Sensor users measure water turbidity	The turbidity measurement results are sentto the Arduino nano and displayed on the LCD	The splash screen displays correctly and the system redirects the user to the page login.	OK
5	Water Filling	Fill the water when the water is cloudy.	The ultrasonic sensor measures the water heightwhen filling, the measured water height, the filling process stops automatically at the specified limit.	The system successfully filled theaquarium according to the measured height	OK
6	Water Draining	Carry out water management when the water is cloudy.	The ultrasonic sensor measures the water level when draining,the draining process stops according to the specified limit.	The system successfully drains the aquarium according to the measured height	OK
7	Heater	The heater is active when The temperature is	The heater turns on when the water temperature is	The heater successfully turns on and off	OK

No	Testing	Description	Expected Results	Tool Results	Status OK/ Failed
		below normal limits.	below normal limits and the heater turns off automatically when the temperature is normal	according to temperature conditions	
8	Servo	The servo performs the salt pouring.	The active servo adds salt when the pH is outside normal limits.	The servo is active and the water pH returns to normal limits	OK
9	Page Login	Web displays pages login,on page login this willdisplay the email as well password which must be entered by the aquarium owner.	The system will display the page login from the web, contains email and password koi fish quarantine aquarium owner.	The system successfully displays the page login	OK
10	Forgotten Page password	The web displays the forgotten page password when the owner presses the'forget&a pos; button password"	The system displays a page to reset the password, the owner enters the WA number and then the system will send a WA OTP code so the owner can do it login.	The OTP code was successfully sent by the system via the WA number that was listed.	OK
11	Main Dashboard Page	The web displays a Dashboard page which contains information from each sensor.	The system displays the main dashboard page and displays system information and alert.	The system successfully displays the dashboard page and displays information from the sensors on the dashboard page.	OK
12	Graphics Page	The web displays information on the progress of sensor measurements via graphic displays.	The system displays graphic information for each sensor with the same measurement results as the LCD.	The system successfully displays graphic images on each sensor and successfully displays the same information as on the LCD.	OK
13	Edit Set Limit page	Web displays setting normal limit parameters (temperature, pH, ammonia, turbidity)	The system displays and resets when the owner sets the limit set for each sensor	The system has successfully edited the limit as specified.	OK

Table 13 is a table of tool system functionality and applications that summarizes various main features and system performance in the context of monitoring and managing water quality.

E. Discussion

1) Discussion of Results and Tool Testing

This tool is made from an aquarium that has dimensions of 60.4 cm wide and 30 cm high. These dimensions were chosen to ensure sufficient space for the placement of the various sensors and electronic components required. When looking at the front of the aquarium, the heater component and DS18B20 sensor are placed on the far left side of the aquarium. The DS18B20 sensor is responsible for measuring water temperature in real-time. The MQ-135 sensor is used to detect ammonia levels in water. The turbidity sensor measures the turbidity of the water which reflects the level of cleanliness of the water. When the components are seen from the side, namely the drain and fill pump integrated with an ultrasonic sensor, this sensor is used to measure the water level in the aquarium.

Microcontroller The Arduino Nano and ESP32 used are located in the component box to function as the main microcontroller which collects data from the installed sensors. Arduino Nano collects data from pH, MQ-135, and turbidity sensors, then sends the data to the ESP32 for further processing. The ESP32 collects data from the DS18B20 and ultrasonic sensors, and controls components output such as relays, buzzers, LCDs, and servos. Meanwhile, the function of the relay is to activate the heater, filling pump and drain pump. Meanwhile, the function of the buzzer is to provide sound notifications.

2) Discussion of Results and Web Testing

On the login page, the owner must enter his email and password, then the system will verify the data so he can move on to the next page. When the owner presses the forget password button, the system will send an OTP code via WhatsApp. After getting the OTP code, the code is entered on the login page as a password.

The main dashboard page displays a summary of status information from sensor measurement values in the aquarium, namely temperature, pH, ammonia levels and water turbidity. Then there is a graphic dashboard that presents water quality monitoring data in graphical form. Users must fill in several health question parameters so that the data can be processed to obtain lifestyle results.

Next, the edit set limit dashboard is used to set water quality parameter limits which change the limit values for each parameter, namely temperature, pH, ammonia levels and water turbidity.

MySQL database is used for user management and authentication, such as storing user data, managing logins, and sending OTP codes for security verification. Firebase Realtime Database is used for real-time monitoring of sensor data, storing historical data needed for analysis and decision making, and for displaying data in graphical form on web dashboards. This system supports communication and data storage for monitoring and controlling the aquarium remotely via an access point.

This access point connects the ESP32 with a database to send sensor data in real-time. So users can monitor aquarium conditions remotely via the internet.

3) Discussion on Implementing the Forward Chaining Method

Implementation of the method forward chaining for determining facts and making decisions at the Nusantara Koi Auction quarantine aquarium involves the use of sensor data to determine the actions needed to maintain water quality. Temperature sensor testing (DS18B20), forward chaining decide to turn on the heater when the water temperature is low and maintain stable conditions when the temperature is normal. The test results show that the system successfully turns on the heater at low temperatures (21.1°C and 19.3°C) and maintains stable conditions at normal temperatures (24.8°C and 25.6°C).

Testing the pH sensor using the pH 4502 sensor forward chaining determine stable action for pH within the normal range and pour salt if the pH is too high. In testing, the system succeeded in maintaining stable conditions at pH 6.4 and 4.33, and carried out salt pouring at pH 6.75 and 7.81.

Turbidity sensor testing shows that forward chaining Deciding that when conditions are stable, the aquarium will remain in the same condition, whereas when the water is indicated to be cloudy, we will take action to drain and fill the water in the koi fish quarantine aquarium.

Ammonia sensor (MQ-135) uses forward chaining to determine stable conditions at normal ammonia levels and send WhatsApp notifications as well as drain and fill when ammonia levels are high. Ultrasonic sensor testing determines to maintain stable conditions at normal water levels and drain or fill when necessary.

IV. CONCLUSION

Based on research entitled "Implementation of Lifestyle Determination in Obesity Sufferers Using the Internet of Things (IoT) Based Forward Chaining Method", it can be concluded that the water quality control device for the Auction Koi Nusantara quarantine aquarium was successfully designed using various sensors, including the DS18B20 sensor for temperature monitoring , pH 4502 sensor to measure pH levels, MQ-135 sensor to detect ammonia levels, and turbidity sensor to measure water turbidity. The accuracy of these sensors varies, with temperature sensors having an accuracy of ±0.6°C, pH sensors ±0.12, turbidity sensors ±0.26, and ammonia sensors ±0.2. Additionally, the ultrasonic sensor shows no difference in water level measurements. This research also includes a web-based application that has been designed to make it easier for Nusantara Koi Auction owners to monitor the health of koi fish remotely. This application utilizes a MySQL database to store users' WhatsApp numbers and Firebase to store real-time sensor data. Users can log in, receive an OTP code via WhatsApp for security, access the main dashboard, view graphs of historical water quality parameters,

REFERENCES

[1] D. H. Sulaksono and A. M. Suryo, “Automatic monitoring and control system for koi fish cultivation with temperature and pH parameters based on internet of things,” *Journal of Aquaculture Engineering and Technology*, 2020.

[2] R. Fakhriza, B. Rahmat, and S. Astuti, “Design and implementation of water quality monitoring and controlling tools in koi pond,” *International Journal of Electrical and Computer Engineering*, 2019.

[3] C. A. Kurniawan et al., “Design of an automatic monitoring and control system for IoT-based koi fish cultivation,” *Journal of Physics: Conference Series*, vol. 6, 2023.

[4] T. H. Rochadiani, W. Widjaja, H. Santoso, Y. Natasya, D. N. Ariqoh, and R. A. S. Rahayu, “Application of IoT for monitoring the water quality of fish farmers’ pond,” *Journal of Community Service and Technology*, vol. 5, 2022.

[5] Prawira, “Koi fish disease diagnosis expert system using classic probability methods with android-based forward chaining inference machine,” *Journal of Information Systems and Artificial Intelligence*, vol. 2, no. 1, 2018.

[6] N. Rochyani, “Analysis of water environment and pond characteristics in supporting fish cultivation,” *Jurnal Ilmu Perikanan dan Biologi Perairan*, vol. 13, no. 1, 2018.

[7] M. A. Nugroho and M. Rivai, “Ammonia level control and monitoring system for fish cultivation implemented on Raspberry Pi,” *Journal of Information Technology and Intelligent Systems*, vol. 7, no. 2, pp. 374–379, 2019.

[8] J. Karangan, B. Sugeng, and S. Sulardi, “Water acidity test using a pH sensor,” *Jurnal Keteknikan*, vol. 2, no. 1, pp. 65–70, 2019.

[9] F. Chuzaini, “Internet of things based water quality monitoring using temperature, pH, and total dissolved solids sensors,” *International Journal of Smart Systems*, 2022.

[10] M. Z. Zain, “Internet of things based aquascape maintenance automation system,” *Journal of Automation and Control Systems*, 2021.

[11] K. Sari, R. Hidayat, and D. Purnomo, “Real time water quality monitoring system for freshwater fish cultivation based on internet of things,” *International Journal of Engineering Research and Technology*, 2020.

[12] Y. Adityas, M. Ahmad, M. Khamim, K. Sofi, and S. R. Riady, “Water quality monitoring system with parameters of pH, temperature, turbidity, and salinity based on internet of things,” *Jurnal Informatika dan Sains*, vol. 4, no. 2, pp. 138–144, 2021.

[13] K. L. Tsai, L. W. Chen, L. J. Yang, H. J. Shiu, and H. W. Chen, “IoT based smart aquaculture system with automatic aerating and water quality monitoring,” *Journal of Internet Technology*, vol. 23, no. 1, pp. 177–185, 2022.

[14] W. Al Mutairi and K. M. Al Aubidy, “IoT based smart monitoring and management system for fish farming,” *Bulletin of Electrical Engineering and Informatics*, vol. 12, no. 3, pp. 1435–1446, 2023.

[15] G. Macaulay, F. Warren Myers, L. T. Barrett, F. Oppedal, M. Fore, and T. Dempster, “Tag use to monitor fish behaviour in aquaculture: a review of benefits, problems, and solutions,” *Aquaculture*, 2021.