Water Quality Control System and Automatic Feeding Based on The Internet of Things for GoldFish

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Abstract

Water quality affects fish survival and growth. Research on water quality management of aquaculture ponds can improve fish growth. Physical parameters of water quality, such as temperature, acidity, total dissolved solids and turbidity, affect fish growth. Feeding is also important, as fish require adequate feed intake. Improper use of feed can affect water quality indicators. Automatic water quality control and feeding systems have been developed with wireless technology and sensors of various functions. Data sent to mobile devices allows administrators to monitor air quality in fish farms. The creation of an automatic water metering device controlled through a smartphone was also carried out. This research aims to create an automatic water quality stabilization and feeding system for good fish growth.

Keywords: Automatic feeder; Control systems; Internet of things; Water quality

1. Introduction

The survival and growth of fish is influenced by water quality. Good quality will serve as a medium for various kinds of fish well. Aquaculture pond water quality management can be a solution to increase fish growth, with the physical parameters of water quality, namely temperature (C), degree of acidity (pH), amount of dissolved solids (PPM) and turbidity (NTU) [1]. Apart from water quality, feed is the next factor, each fish will also consume enough feed according to its needs. If you give too little feed then fish growth will not be optimal, whereas if you give too much feed it will affect water quality indicators such as the degree of acidity (pH), Total Dissolved Solids (PPM) and Turbidity (NTU) produced by unused feed residues. Eaten by fish or excess fish excretions, both urine and feces, this can cause mass fish deaths if this problem is not handled quickly and appropriatel [2]. So, a system is needed that can regulate the stability of water quality and feeders automatically based on the optimal needs of the fish.

The development of an air quality control and automatic feeding system has been carried out. In this research written by [3] it is explained that this research uses wireless technology transmission with various sensors to transmit temperature, pH value, dissolved oxygen, air height, and expectations. live sensors in the fish farm to the server. Integrated data transmitted to mobile devices via the Internet of Things, allows administrators to aggregate air quality in fish farms via mobile devices [4]. Because current pH sensors cannot be submerged in liquid for long periods of time for measurement, human resources and time are required to bring the instrument to each fish farm for testing at designated times. Therefore, a robotic arm was developed to complete automatic measuring and maintenance actions. We designed this arm with a programmable logic controller, a single chip combined with a wireless transmission module, and an embedded system

Based on the problems above, in this final project a control tool is designed that consistently stabilizes pond water quality indicators with water quality control technology to monitor and stabilize water quality combined with automatic feeding equipment in accordance with the fish's living environment. This system uses an ESP8266 microcontroller as a component. system controller and will be controlled and monitored via smartphone. This research aims to stabilize water quality and be equipped with an automatic feeder so that fish grow well.

This research aims to create a water quality stabilization system by controlling the accuracy of temperature (C), degree of acidity (pH), amount, of dissolved solids (PPM) and turbidity (NTU) as water quality parameters and combined with an automatic feeding device and integrated via smartphone. so that it can be controlled and monitored easily.

2. Method

In this chapter, the final project research methodology will be discussed which includes the stages in completing the final project as a whole process. The completion of this final project is depicted in a flow diagram as shown in the image below:

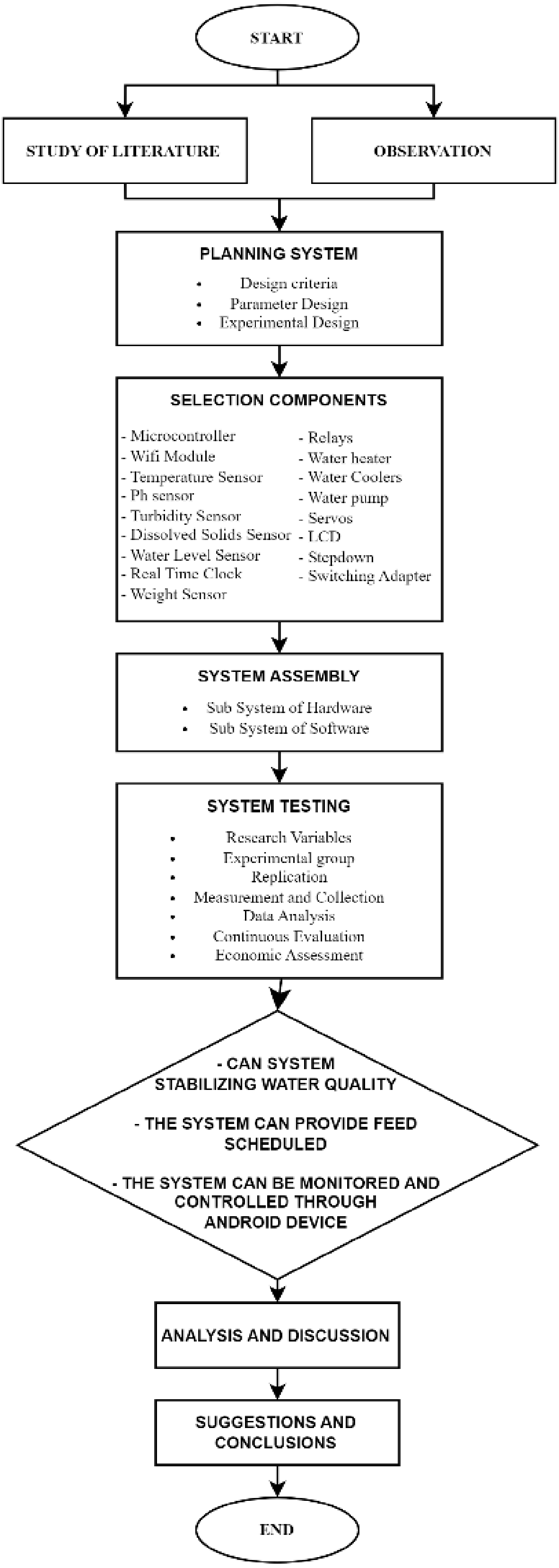


Figure 1. Research flowchart.

2.1. Observes

Field observations are carried out to collect data and obtain an overview of the problems that occur in the field to ensure that the proposed system design is in accordance with the objectives to be achieved and is developed to solve the problems. Researchers explained the problem through interviews conducted in October 2023 with a group of ornamental fish traders and observers at the Gunungsari Ornamental Fish Center, Surabaya.

2.2. Literature Study

The literature study in research methodology for Water Quality Control Systems and Automatic Feed Systems based on the Internet of Things aims to gather an in-depth understanding of the conceptual framework, current technology, measurement methodology, and previous research findings that are relevant to the research topic.

2.3. Planning

At this research stage, planning is used to refer to the plan or strategy used to collect data and answer research questions by preparing a system design that details the structure and function of the system to be built. The aim of this design is to ensure that the research or project can be carried out in a systematic way. This research involved 3 design elaborations. Namely Criteria Design, Parameter Design, Experimental Design.

2.3.1. Parameter Design

a) Functional Requirements

Functional Requirements Are needs that must be met and processes that can be carried out by the system. The system functionality requirements in this research are explained in the following table:

Table 1. System fuction requirements.

	Feature	Functional
CONTROL SYSTEM	1. Water quality indicators	a) Normal Water Temperature / neither hot nor cold
		b) Degree of Acidity Water is neutral / neither acidic nor alkaline
		c) The water turbidity level is clear / not dirty
		d) Dissolved solids Clean / uncontaminated water
	2. The system can maintain water quality	a) The system can heat up if the water temperature is cold
		b) The system can cool the water if the water temperature is warm
		c) The system can replace water if the water is acidic/alkaline, the water is cloudy, and/or the water is contaminated
	3. The system can provide feed	d) with an intensity of 2 times a day with an adjusted amount of feed
INTERNET OF THINGS	1. The system can be monitored	a) via mobile phone
	2. The System Can be operated automatically or manually and change the set point	a) to adjust fish needs which are controlled/set via smartphone application

b) Non-Functional Requirements

Non-functional requirements are requirements that focus on behavior and functional limitations of the system. In this research, non-functional requirements consist of hardware requirements and software requirements

(1) Hardware Requirements
(2) Software Requirements

c) System Scope

(1) *Object: Goldfish*
(2) *Container/place: Aquarium*

d) Internet of Things connectivity

(1) Network Used: LAN/PAN
(2) LAN/PAN Protocol Used: Wi-Fi

e) Software Developer and Data Integration

(1) Data Storage Platform: Cloud Firebase.
(2) Programming Sketch Platform used: Arduino IDE
(3) Circuit Sketch Platform Used: Fritzing
(4) 3D Design and CAD Modeling Platform Used: Autodesk Inventor

f) Energy Availability

- Resources Used: PLN

2.3.2. Criteria Design

a) Water Quality Criteria

(1) Parameters to be Measured
- Water temperature level in Celsius (°C)
- Water Acidity Level pH in units of degrees of acidity
- Level of Turbidity Clarity in Nephelometric Turbidity Units (NTU)
- Dissolved Solids in Parts Per Million (PPM) units

(2) Acceptable Range
- Temperature: Ideal Range 24°C-28°C (normal)
  Upper Limit : 24°C (Cold temperature)
  Lower Limit : 28°C (Warm Temperature)
- pH: Ideal Range 6.5 – 8.5 (neutral)
  Upper Limit : 6.5 (Acid)
  Lower Limit : 8.5 (Base)
- Turbidity: Ideal Range < 15 NTU
  Upper Limit : 0 NTU (Clear)
  Lower Limit : 15 NTU (turbid/dirty)
- Dissolved Solids: Ideal Range < 350 PPM
  Upper Limit : 0 PPM (Net)
  Lower Limit : 350 PPM (Contaminated)

b) Feeding Criteria

(1) Frequency and Feeding Schedule
- Frequency of feeding twice a day: Morning and evening
  Morning : 08.00
  Afternoon : 16.00

(2) Amount of Feed
The amount of feed depends on the size and number of fish. Which is set via the platform device user interface

c) Data communication

IoT (Internet of Things) architecture involves a number of components and layers that work together to connect devices, collect data, and provide services. The following is the general sequence of IoT architecture layers from device to cloud control System

2.3.3. Experimental Design

Experimental design is a systematic plan or strategy used to organize the implementation of experimental research. The goal is to ensure that research results are reliable, valid, and provide useful information about the cause-and-effect relationships between the variables studied. A good experimental design allows the researcher to isolate the effect of the independent variable on the dependent variable as best as possible.

Some of the main components of experimental design in this research include:

a) Research Variables
b) Experimental group
c) Replication
d) Measurement and Collection
e) Data Analysis
f) Continuous Evaluation
g) Economic Assessment

2.4. Component Selection

The selection of components in the research methodology for Water Quality Control Systems and Automatic Feeding Systems based on the Internet of Things is very important, taking into account the specific characteristics of each component in supporting the function and research objectives.

2.5. Assembly

The system design in research on Water Quality Control Systems and Automatic Feeding Systems based on the Internet of Things includes a comprehensive process to develop an integrated and efficient infrastructure, which allows accurate data collection, continuous monitoring, and precise control of water quality and automatic feeding. This involves harmonious integration of hardware and software, as well as thorough testing to ensure optimal performance. System design is divided into two, namely hardware design and software system design.

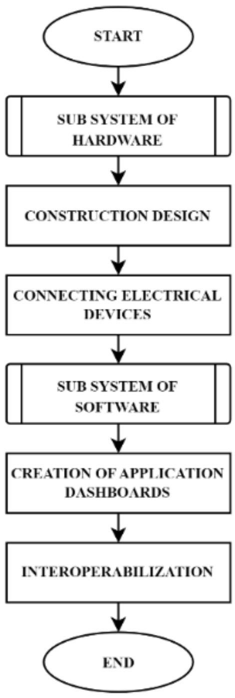


Figure 2. System planning (*flowchart*).

2.5.1. Sub Hardware

a) Construction Design

(1) Casing
(2) Feed Tank
(3) Assembly Device

b) Electrical Device Networking

The design of electrical devices for Water Quality Control Systems and IoT-based Automatic Feed Systems involves optimizing their configuration and arrangement to support efficient operation. This includes considering individual power needs and prioritizing energy efficiency to seamlessly integrate IoT technology into aquatic environments.

2.5.2. Sub Software

a) Programming

The system programming design for Water Quality Control Systems and Automatic Feed Systems based on the Internet of Things focuses on creating advanced algorithms for precise control and monitoring. It employs a modular approach for flexibility and scalability, integrating various sensors and hardware. Utilizing cutting-edge technology in programming and data communications, the design aims to produce a reliable and adaptive system. This enables researchers to optimize system operation effectively, supporting aquatic environment sustainability through IoT.

b) Creating user interface application dashboards

The user interface application dashboard for Water Quality Control Systems and Automatic Feed Systems IoT research aims to facilitate easy monitoring and management. It presents real-time sensor data, water quality analysis, and feed system status intuitively. With responsive features and critical parameter notifications, it empowers users to maintain aquatic environments and fish welfare effectively, enabling immediate action through IoT technology.

2.6. System Testing

After completing the electrical system design and IoT system design, the next step is to carry out the tests described in the next point

Figure 3. System testing (flowchart).

2.6.1. Determination of Test Variables

Research variables are attributes or characteristics that can vary in a study. These variables are factors that are researched or observed to see the relationship, differences, or influence between them in a particular research context. In scientific research, variables can be divided into two main types: independent variables and dependent variables. In this research the variables were divided into 3, namely independent variables, Dependent variables and Control variables. The following are the variables for this research:

Table 2. Test variables.

Variables	Factor
Dependent	- Component Type - Frequency and Amount of feed - Automation in Water control - Automation in Feeding
Independent	- Fish Survival and Growth - Source and quality of water used
Control	- Sensor Accuracy - Actuator efficiency and effectiveness - Monitoring Dashboard

2.6.2. Determination of Test Groups

In this research, the testing group was divided into 2, namely the aquarium that used the system was called the Experimental Group and the aquarium that did not use the system was called the Control group. The following is the distribution of testing group treatments:

Table 3. Testing Group

Experimental Group	Control Group
Aquariums that use IoT-based automatic water and feed quality control systems.	Aquariums that Use Conventional systems
Water quality measurement and control is regulated based on parameters measured by IoT sensors.	Measuring water quality is only through calculation and sight alone
Feeding is regulated and can be controlled stably through an automatic feeding system	Frequency of feeding is done in a time-disciplined manner (depending on the fish owner) and the amount of feed is based on calculation (1 table spoon)

2.6.3. Replication

Replication is repeating an experiment as many times as possible to increase the validity and reliability of the results. In this research, replication is carried out through test scenarios. The following are test scenarios Measurement and Data Collection

Table 4. Replication.

Test To	Testing Scenario	Method	Expected Results
1	Lowering Temperature	Ice water	The water heating system can increase the temperature until it returns to the set point
2	Raising Temperature	Warm water	The water-cooling system can reduce the temperature until it returns to the set point
3	Lowers pH	Vinegar	The Water Replacement System can normalize pH until it returns to set point
4	Raises pH	Baking soda	The Water Replacement System can normalize pH until it returns to set point
5	Muddy the Water	Milk	The Water Replacement System can normalize clarity until it returns to set point
6	TDS is within safe limits	Detergent Water	The Water Replacement System Can Normalize Dissolved Solids until they Return to set point

2.6.4. Measurement And Data Collection

a) Sensor Accuracy

Sensor testing aims to determine the accuracy of the sensor in measuring parameters of the aquarium water media. Sensor testing is carried out by comparing the sensor measurement data with what is read/measured using a comparison measuring instrument. The data taken aims to determine the magnitude of the difference between a dimension and the standard size[4].

Table 5. Sensor testing aspects.

Testing Aspect	Method	Objective	Expected Result
Temp. Parameter Reading	calibrate the readings from the Temperature Sensor with the Thermometer	determine the accuracy of temperature sensor indicator readings in retrieving data	Accuracy >90%
pH Parameter Reading	calibrate the reading results from the pH Sensor with the pH Meter	determine the accuracy of the pH sensor indicator readings in collecting data	Accuracy >90%
Turbidity Parameter Reading	calibrate the reading results from the Turbidity Sensor with the Turbidity Meter	determine the accuracy of the turbidity sensor indicator readings in collecting data	Accuracy >90%
TDS Parameter Reading	calibrate the reading results from the TDS Sensor with the TDS Meter	determine the accuracy of temperature sensor indicator readings in retrieving data	Accuracy >90%

Water Level Reading	Calibrate the readings from the water level sensor with a Ruler through the aquarium[5]	Know the accuracy of the water level during the water replacement process	Accuracy >90%
Feed Weight Reading	Calibrate the readings from the weight sensor with a digital scale through feed output	Know the accuracy of the weight of feed given	Accuracy >90%
Time Reading	Calibrate the reading results from the RTC with the clock via smartphone	Knowing the accuracy of feeding times with	The time difference does not exceed 10 seconds

Sensor accuracy is calculated using the following formula:

$$Accuracy\ Value = 1 - \frac{calibrator\ read - sensor\ read}{calibrator\ read} \times 100\% \quad (1)$$

b) *Mechanical Device Performance*

(1) *Water Replacement Effectiveness Ratio*

Collecting pump effectiveness data in this research aims to determine pump speed in terms of flow rate/water discharge for the water replacement control system process. Calculation of water discharge is calculated using the following formula:

$$D = \frac{V}{W} \quad (2)$$

Where:
- D = Discharge (litres/hour)
- V = Volume (litres)
- W = Time (Hours)

(2) *Water Heating and Cooling Effectiveness Ratio*

Data collection n the effectiveness of water heating and cooling in this study aims to determine the speed of the water heater and water cooler for the aquarium water heating and cooling control system process.

$$Effectiveness = \frac{Temperature\ Change}{Sec} \quad (3)$$

(3) *Feed thrower Effectiveness Ratio*

Collecting data on the effectiveness of water heating and cooling in this study aims to determine the servo speed for the fish feeding control system process in the aquarium.

$$Effectiveness = \frac{grams}{Sec} \quad (4)$$

c) *Influence of the System on Survival and Growth of Fish*

These parameters include absolute weight growth, specific growth rate, and survival. needed as a benchmark for whether the tool system achieves the desired quality, namely that it can influence the survival and growth of fish.

(1) *Survival Rate*

Fish survival is calculated using the formula according to [5] as follows:

$$SR = \frac{Nt}{No} \quad (5)$$

Where:
- SR = Survival Rate (%)
- Nt = Number of fish alive during the study (tail)
- No = Number of fish at the start of the study (tails)

(2) Absolute weight growth

Absolute weight growth was measured using digital scales. Absolute growth is calculated using the [5] formula as follows:

$$W = Wt - Wo \tag{6}$$

Where:
- W = Average absolute weight growth of fish (g)
- Wt. = Average weight at the end of the study (g)
- W0 = Average weight at the start of the study (g)

(3) Daily growth rate

Daily growth rate or also known as Specific Growth Rate is the percentage of fish growth per day. Specific daily observations of fish were carried out at the beginning and end of the research to determine the results of fish growth. Fish weighing is done by taking all the fish from the total number of live fish. Specific Growth Rate is calculated using the formula of [6] as follows:

$$SGR = \frac{LnWt - LnWo}{t} x\ 100\% \tag{7}$$

Where:
- SGR = Daily growth rate (%/day)
- Ln = Natural logarithm.
- Wt. = Average weight of fish at time t (g)
- W0 = initial weight of fish (g)
- t = observation time (Day)

2.6.5. Data Analysis

Data analysis of water quality control and IoT-based feeding systems involves extracting, processing, and interpreting sensor data to understand water conditions and feeding management. Statistical methods and machine learning identify patterns and anomalies, enhancing system performance and reliability through necessary adjustments and improvements.

2.7. Decision Making

As stated in the flowchart, there are 3 factors that are parameters for success, namely:

1. The system can automate water and feed control
2. Effective & efficient component selection
3. The system can be controlled and monitored via an Android device

3. Results and Discussion

This chapter discusses the testing and analysis of the system for water quality control and automatic feeding that was planned in the previous chapter. The image below shows water quality control and automatic feeding designed to carry out research on this final project. Testing and analysis in this chapter is divided into various stages, by discussing sub-sections of the overall system design accompanied by tables and figures that support system testing and analysis.

Figure 4. Smart aquaculture

The goal of the research on Water Quality Control Systems and Automatic Feeding Systems based on the Internet of Things is to enhance aquatic environment management and fish feeding efficiency using advanced technology. Leveraging IoT solutions, the system aims to monitor and regulate key water quality parameters like pH, temperature, and dissolved oxygen, while optimizing feed delivery to sustain fish health and growth. Additionally, it aims to boost productivity, decrease waste, and conserve resources by making data-driven decisions in real-time, ultimately striving to establish an optimal environment for fish growth and ensure ecosystem sustainability.

3.1 Definition of System Goals

The goal of the research on Water Quality Control Systems and Automatic Feeding Systems based on the Internet of Things is to enhance aquatic environment management and fish feeding efficiency using advanced technology. Leveraging IoT solutions, the system aims to monitor and regulate key water quality parameters like pH, temperature, and dissolved oxygen, while optimizing feed delivery to sustain fish health and growth. Additionally, it aims to boost productivity, decrease waste, and conserve resources by making data-driven decisions in real-time, ultimately striving to establish an optimal environment for fish growth and ensure ecosystem sustainability.

3.2 Planning System

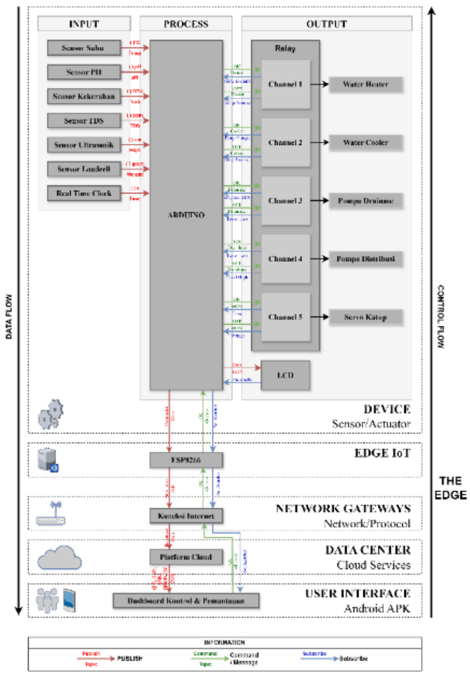


Figure 5. System block diagram.

1) *Data communication*

In the picture above is the IoT architecture of the system created. The IoT architecture consists of 5 stages, namely Sensors / Actuators, EDGE IoT, Network Gateways, Data Center and User Interface. Sensors / Actuators include Arduino Mega Pro 2563, ESP8266, Analog pH Sensor, Turbidity Sensor, TDS Sensor, Ultrasonic Sensor, Real time clock, Loadcell, Relay, Aquarium Heater, Aquarium Cooler, Water Pump, Servo, LCD, step down and power supply, in EDGE IoT there is ESP 8266, Network Gateways there is Wi-Fi, in the Data Center it uses the Firebase platform and in the user interface it uses an application device on an Android cellphone. The following is the workflow of the IoT architecture:

Table 6. Functional architecture of IoT.

	Functionality
Data Flow	- The ESP8266 can provide access point services for sensor devices via the Arduino Mega Pro 2560 - Sensor devices via the Arduino Mega Pro 2560 can be connected to the Arduino access point so that data exchange occurs - The ESP8266 can send Temperature, pH, Turbidity and Dissolved Solids data to Firebase

	- Firebase can receive Temperature, pH, Turbidity and Dissolved Solids data from the ESP8266 - Firebase can send Temperature, pH, Turbidity and Dissolved Solids data to the Monitoring Application - The Monitoring application can receive Temperature, pH, Turbidity and Dissolved Solids data from Firebase - The Monitoring Application can display Temperature, pH, Turbidity and Dissolved Solids data sent by the Sensor Device
Control Flow	- The Monitoring application can send settings/changes to set point data for Temperature, pH, Turbidity and Dissolved Solids to Firebase - Firebase can receive data settings/changes for Set Point Temperature, pH, Turbidity and Dissolved Solids and feed weight from the Monitoring Application - Firebase can send Set Point data settings/changes to the ESP8266 - ESP8266 can receive Set Point data settings/changes from Firebase - ESP8266 can send Set Point data settings/changes to Arduino - Arduino can receive Set Point data settings/changes from the ESP8266 - The device can work via Arduino Mega Pro 2560 commands

2) *Temperature Control Sub System*

In the Temperature Control Subsystem, the functional requirements that must be met and which can be carried out by the system are as follows in the following table:

Table 7**.** Temperature control system functionality.

Device	**Functional**
Sensors	- Temperature Sensor devices can send Water Temperature data to the Microcontroller
Microcontroller	- The microcontroller can receive Water Temperature data from the Sensor Device so that data processing can occur - Microcontroller Can send work signals/commands to the actuator
Actuator	- The actuator can receive signals/work orders from the microcontroller so that water temperature control can occur

After explaining it in the system functionality table, the author divides it into 3 blocks in the block diagram, namely the Input block for data reception, the Process block for data processing, and the Output block for actuator work. The block diagram of this sub system is explained in the following figure:

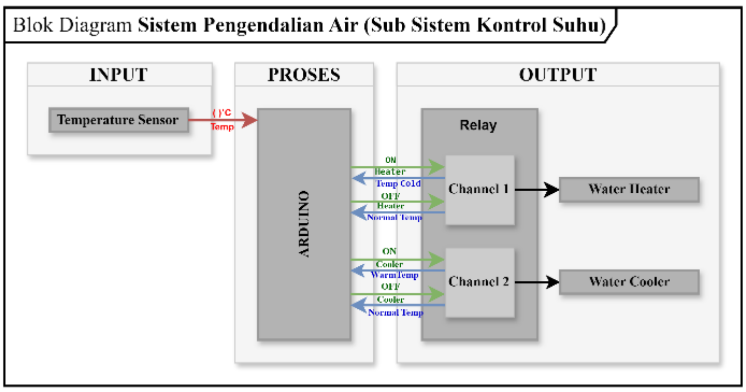


Figure 6. Block diagram of temperature control sub system.

The following is an explanation of the Temperature Control Sub System Block diagram:

- Input Block:

The Temperature Sensor functions as a sensor that can detect the temperature conditions of the water that will be processed by the Arduino Atmega for controlling the Temperature Control System water.

- Process Block:

When the Arduino Atmega receives data from the Temperature Sensor. Arduino will initialize the temperature data as follows:

- The water temperature is 24 ˚C - 28 ˚C then the water condition is normal
- water temperature <24˚C then the water conditions are cold
- water temperature >28˚C means the water is warm

After the initialization process, the Arduino provides a working signal to turn on/off the actuator as follows:

- Normal water conditions mean the water heater is off, the water cooler is off
- When the water is cold, the water heater is on, the water cooler is off
- When the water is warm, the water heater is on, the water cooler is off

- Output Block:

The process of receiving signals for actuator work is carried out by Relay. The relay in the temperature control system is divided into 2 channels, namely relay channel 1 to turn on and turn off the water heater and relay channel 2 to turn on and turn off the water cooler.

After explaining through block diagrams, the working functionality of the device, the author creates a system operation workflow to explain how this temperature control system works. The following is the operation diagram in the image below.

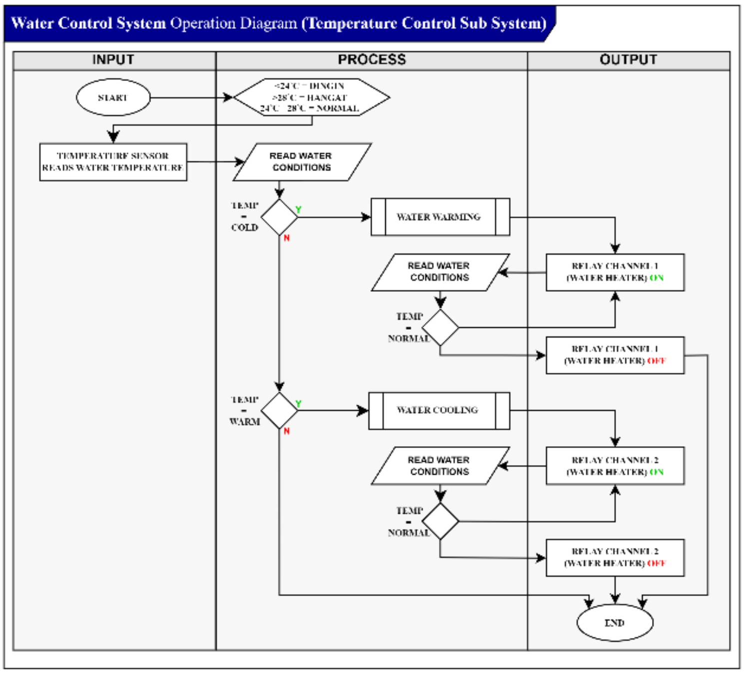


Figure 7. Temperature control system operation diagram.

3) *Water Replacement Sub System*

In the water replacement control sub system, the functional requirements that must be met and which can be carried out by the system are as follows in the following table:

Table 8. Water change system functionality

Device	Functionality
Sensors	- The PH Sensor device can send data on the Degree of Acidity of Water to the Microcontroller - The Turbidity Sensor device can send water turbidity data to the microcontroller

	- The TDS Sensor device can send Water Dissolved Solids data to the Microcontroller
Microcontroller	- The microcontroller can receive data on the Degree of Acidity, Turbidity and Dissolved Solids from the Sensor Device so that data processing can occur - Microcontroller Can send work signals/commands to the actuator
Actuator	- The actuator can receive signals/work orders from the Microcontroller so that control for water replacement can occur

After explaining it in the system functionality table, the author divides it into 3 blocks in the block diagram, namely the Input block for data reception, the Process block for data processing, and the Output block for actuator work. The block diagram of this sub system is explained in the following figure:

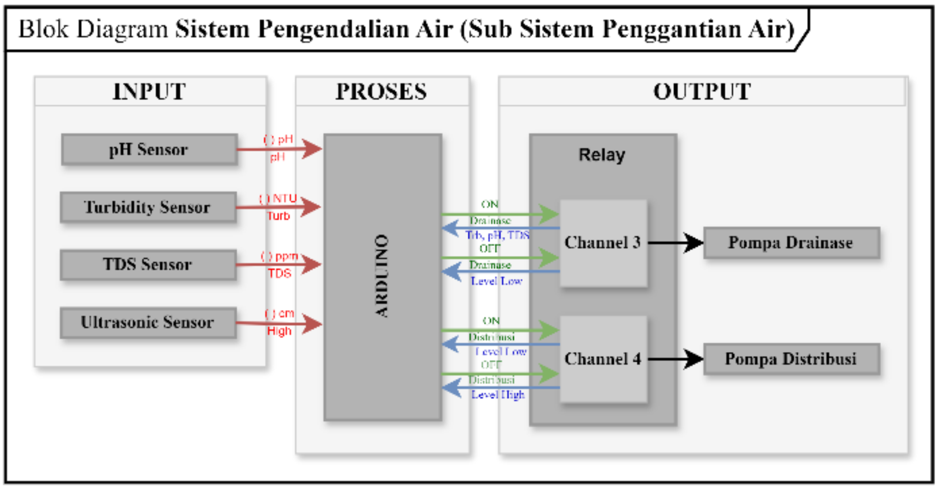


Figure 8. Block diagram of water change sub system.

The following is an explanation of the Temperature Control Sub System Block diagram:

- Input Block:

The sensor device functions as a data reader to detect the condition of the water that will be processed by the Arduino Atmega for water control in the Water Replacement Control System. The following are the sensor devices that work in the Water Change Control System:
- PH sensor to read the acidity of the water
- Turbidity sensor to read water turbidity conditions
- TDS sensor to read the condition of dissolved solids in water
- Ultrasonic sensor to read water level

- Process Block:

When the Arduino Atmega receives data from the sensor device. Arduino will initialize the data as follows:
- The pH of the water is 6.5 – 8.5, so the water condition is Neutral
- Water pH <6.5 means the water condition is acidic
- Water pH >8.5 means the water condition is alkaline
- Water turbidity < 15 NTU means the water is clear
- Water turbidity > 15 NTU means the water condition is cloudy
- Dissolved solids in the water mean the water is clean
- Dissolved Solids in the water means the water is contaminated
- The water level is 5 cm, so the water conditions are poor
- The water height is 25 cm, so the water is filled

After the initialization process, the Arduino provides a working signal to turn on/off the actuator as follows:
- The water condition is neutral then the water change cycle is off
- Water conditions are acidic, so the water change cycle is on
- Water conditions are alkaline then the water change cycle is on
- If the water is clear, then the water change cycle is off
- Water conditions are cloudy then the water change cycle is on
- The water condition is clean then the water change cycle is off
- If the water is contaminated, then the water change cycle is on

In the water change cycle process, there are work processes following the work process of the water change cycle Drainage pump turns on → water level 5 cm → drainage pump turns off and distribution pump turns on → water level 25 cm → distribution pump turns off

- Output Block:

The process of receiving signals for actuator work is carried out by Relay. The relay in the water replacement control system is divided into 2 channels, namely relay channel 3 to turn on and turn off the Drainage pump and relay channel 4 to turn on and turn off the Distribution Pump.

After explaining through block diagrams, the working functionality of the device, the author creates a system operation workflow to explain how this temperature control system works, here is the operation diagram in the following image:

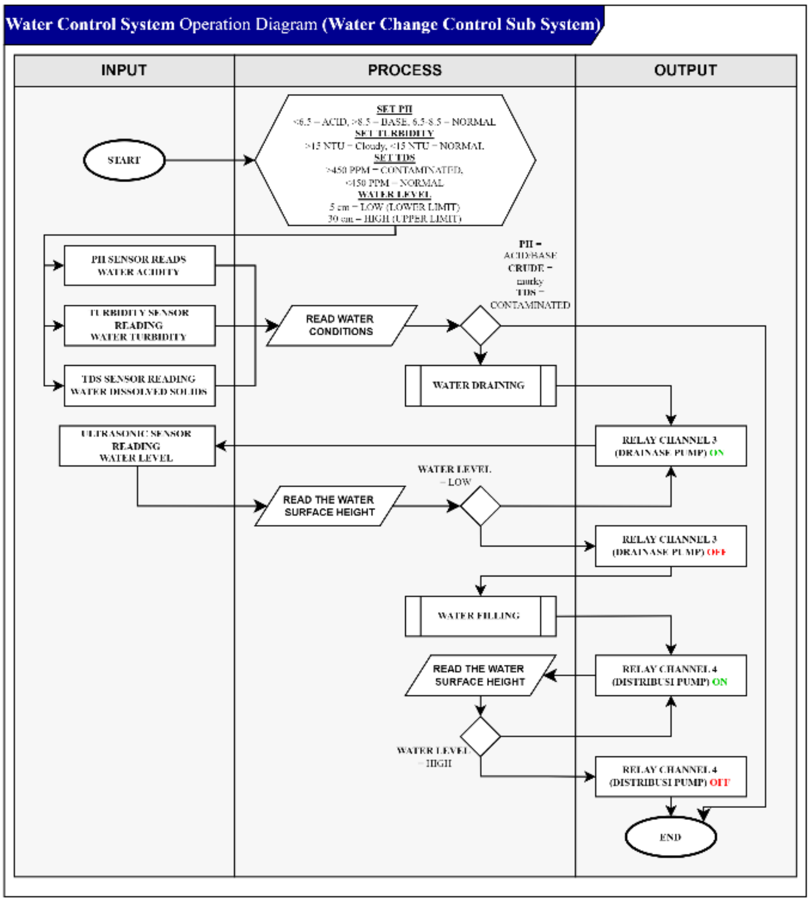


Figure 9. Water change control system operation diagram.

4) *Feeding Sub System*

In the Feeding Control Subsystem, the functional requirements that must be met and which can be carried out by the system are as follows in the following table:

Table 9. Feeding system functionality.

Device	Functionality
Sensors	- RTC devices can send Time data to the Microcontroller

	- The Loadcell Sensor device can send feed weight data to the Microcontroller
Microcontroller	- The microcontroller can receive feed time and weight data from the Sensor Device so that data processing can occur - Microcontroller Can send work signals/commands to the actuator
Actuator	- The actuator can receive signals/work orders from the Microcontroller so that control for water replacement can occur

After explaining it in the system functionality table, the author divides it into 3 blocks in the block diagram, namely the Input block for data reception, the Process block for data processing, and the Output block for actuator work. The block diagram of this sub system is explained in the following figure:

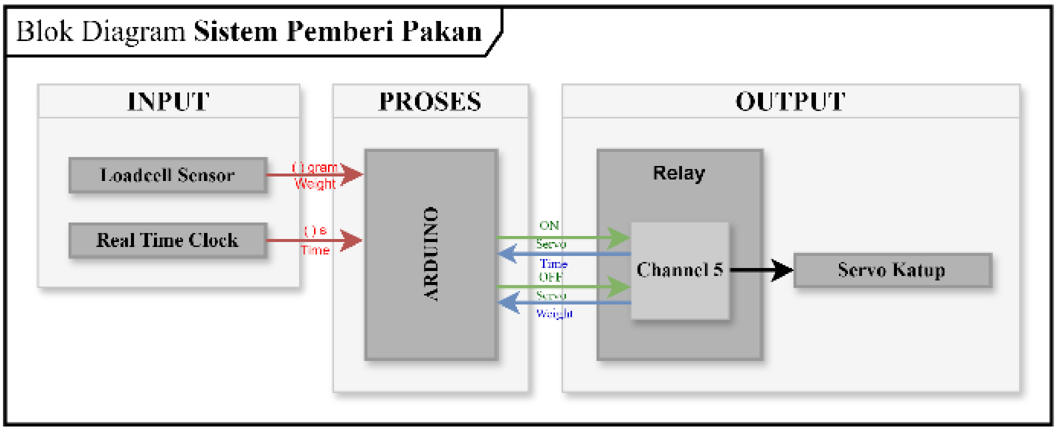


Figure 10. Block diagram of feeding control system.

The following is an explanation of the Feed Control System Block diagram:

- Input Block:

The sensor device functions as a data reader to detect the feeding schedule and weight which will be processed by the Arduino Atmega for the feeding control system. The following are sensor devices that work in the feeding control system:
- RTC to read time
- Loadcell sensor to read feed weight Process Block

- Process Block:

When the Arduino Atmega receives data from the sensor device. Arduino will initialize the data as follows:
- 08.00 & 16.00 Feeding Time
- Hours other than 08.00 & 16.00 are not feeding times

After the initialization process, the Arduino provides a working signal to turn on/off the actuator as follows:
- When feeding, the feed servo turns on
- It's not feed time then the servo dies

In the water change cycle process, there are work processes following the work process of the water change cycle Servo on → Feed set weight → Servo off

- Output Block:

The process of receiving signals for actuator work is carried out by Relay. The relay in the feeding control system is relay channel 5 to turn on and turn off the servo. The author creates a system operation workflow to explain how this temperature control system works. The following is the operation diagram in the image below.

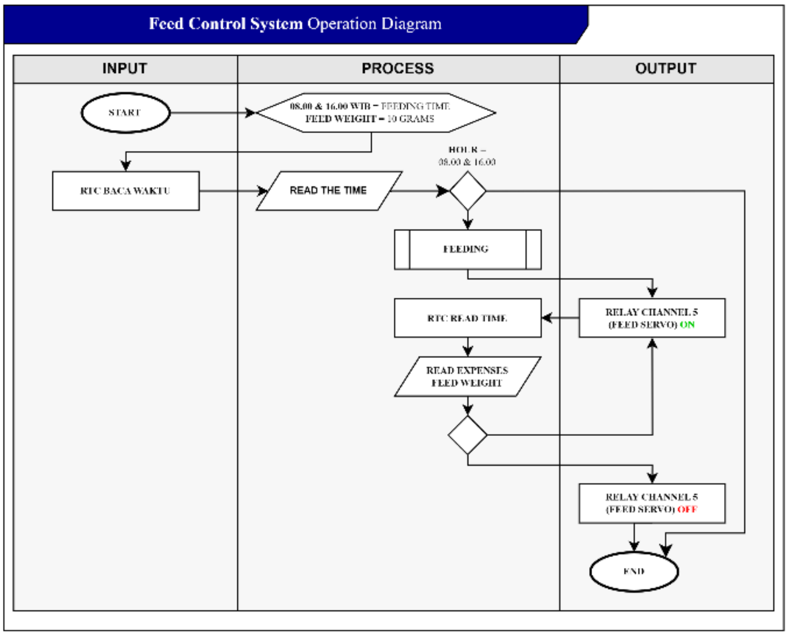


Figure 11. Feeding control system operation diagram.

3.3 Component Selection

Table 10. Realization of components used.

Need	Components		Description	Need	Components		Description
Microc ontroller		**Mega** Pro 2560 Arduino	Used as the control center for the entire series of modules	Relay		**Modul Relay 5V** TS0010D SunFounder	Sends/breaks electrical currents to mechanical system networks
Modul Wifi		**ESP8266** D1 Mini Wemos	Connecting the system with the IoT network	LCD		**I2C 20x4** DFR0154 DFRobot	Raising Water Temperature
Sensor Suhu		***Temperature Sensor*** DS18B20 DFRobot	Receive temperature values on water quality	Water Heater		***Aquarium Heater*** AA HT 304 STA Recent	Lowering Water Temperature
Sensor pH		***Analog* PH *Sensor*** Sen0161 DFRobot	Receive the value of the degree of acidity on water quality	Water Cooler		***Aquarium Thermoelectric Cooler Water Chiller*** TBVECHI	drain and fill water

Sensor Kekeruhan		***Analog Turbidity Sensor*** Sen0189 DFRobot	Receive Turbidity Value on water quality
Sensor Padatan		***Analog* TDS *Sensor*** Sen0244 DFRobot	Receive Dissolved Solids Value on water quality
Sensor Ketinggian Air		***Ultrasonic Sensor*** HC-sr04 Universal-Solder	Water level meter / monitor
Real Time Clock		***Real Time Clock*** DS3231 SparkFun Eletronics	Accurate time reading from memory
Sensor Bobot		***Load Cell*** Amp HX711 SparkFun Eletronics	Receive feed weight value
Pompa DC		**Pompa Air Brushless DC 12V** ZYW890 Taffware	pumping water
Servo		**Motorservo** MG995 Tower Pro	Displays measured and process values
Stepdown		**Modul Step Down** LM2596 Kuongshun Electronic	Voltage reducer to 5v
AC/DC Converter		**Switching Power Supply** ALRS12V10AT Analog Technologies	Voltage reducer

3.4 System Assembly

From the selected components, the next steps are assembled. the purpose of assembling components according to [7] so that these components can function according to the instructions created by the author.[7] The electrical circuit or better known as the Wiring Diagram of the water control and automatic feeding device can be seen in the picture above.

The implementation stage is the realization stage of the design stage. The implementation of the tool is shown in Figure 6. Explain that the electronic circuit and programming software have been integrated with the design of the flowchart. Implementation for the component of the tool along with the sensor made a container/ casing in the form of an acrylic cube with a size of 17 x 13 x 10 cm^3. Casing a series of tools placed on the cover of the water media.

1) Sub Hardware

a. Electric device circulation

The assembly process for the water quality control and automatic feed systems in IoT research involves carefully merging electrical components like sensors, actuators, and controllers. Each component is installed and connected according to technical specifications, ensuring seamless integration between hardware and software for subsequent testing and implementation. The following is a wiring of the electrical device:

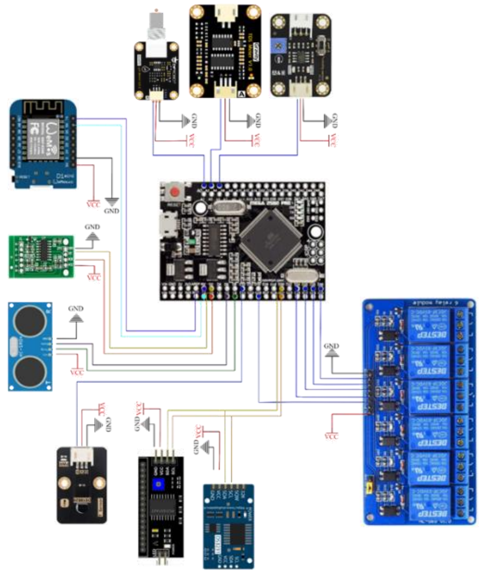


Figure 12. Electric device wiring.

The PIN configuration of each device show on table 11.

Table 11. Pin configuration.

Esp8266	Arduino
GND	GND
VCC	5V
RX	TX 1
TX	RX 1

HC–sr04	Arduino
GND	GND
VCC	5V
TRIG	PIN 7
ECHO	PIN 9

DS3231	Arduino
GND	GND
VCC	5V
SDA	PIN 20
SCL	PIN 21

HX-711	Arduino
GND	GND
VCC	5V
DT	PIN 3
SCK	PIN 2

DFR0154	Arduino
GND	GND
VCC	5V
SDA	PIN 20
SCL	PIN 21

DS1820	Arduino
GND	GND
VCC	5V
DATA	PIN 10

Sen0189	Arduino
GND	GND
VCC	5V
OUT	PIN A4

Sen0244	Arduino
GND	GND
VCC	5V
OUT	PIN A6

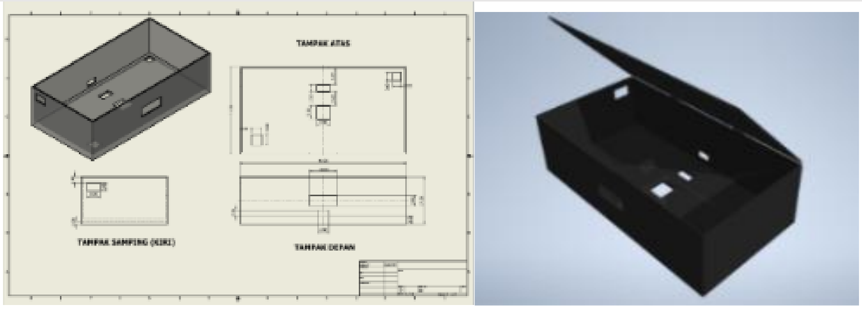
Sen0161	Arduino
GND	GND
VCC	5V
SIGNAL	PIN A0

TS0010D	Arduino
GND	GND
VCC	5V
IN 1	24
IN 2	26
IN 3	28
IN 4	30
IN 5	15
IN 6	17

a) System construction assembly

(1) Making a casing

Making or assembly of casing/cover tools in research on water quality control systems and automatic feed systems based on internet of things is an important stage in the development of the system, which involves the design and construction of physical containers to protect and accommodate electronic and mechanical components installed in it. This process considers factors such as resistance to environmental elements, mechanical reliability, and accessibility for routine maintenance and monitoring. The casing/cover design must allow easy installations, sufficient air circulation to prevent heat buildup, and protection of water, dust, and humidity and maintain the safety and integrity of electronic devices in it.



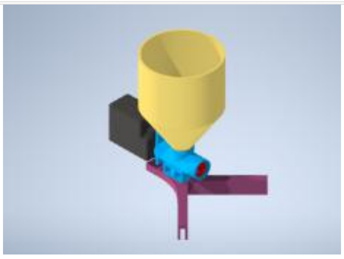
(a) Design planning

(b) Implementation

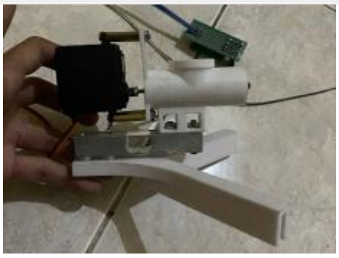
Figure 13. Casing.

(2) Making feed tanks

The manufacture or assembly of a tub/feeding container in research on water quality control systems and automatic feed systems based on internet of things involves a careful and detailed process to create containers that can manage and distribute feed accurately and efficiently. This includes designs that consider the capacity, flow, and stability of the container, as well as the integration of automatic mechanisms that will regulate the time and amount of feed released according to fish needs and environmental conditions. During the manufacture or assembly, factors such as construction materials that are waterproof and corrosion resistant, ease of maintenance, and availability of accessibility for feed refilling must be considered carefully.



(a) Design planning

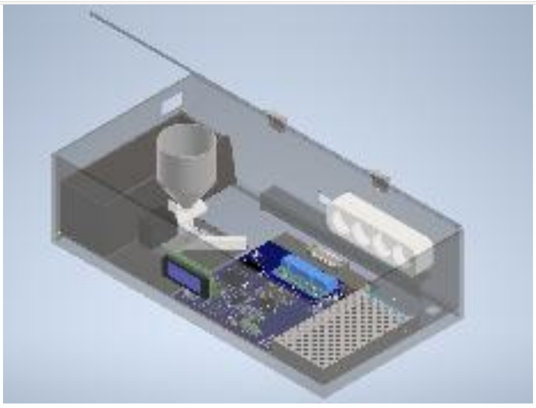


(b) Implementation

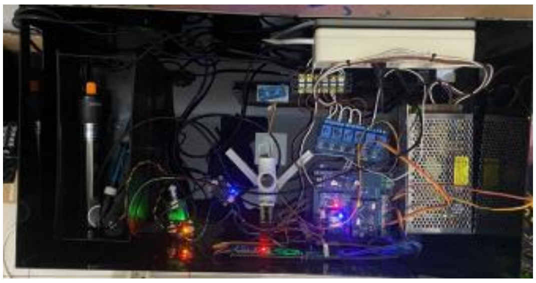
Figure 14. Feed tanks.

(3) Assembly of the whole device

The overall assembly of component devices in the penetration of water quality control systems and automatic feed systems based on Internet of Things involves a combination of all hardware elements that have been designed and selected beforehand. This includes the installation of water quality sensors, actuators for controlling feed, microcontroller, communication module, as well as all other supporting components into one integrated unit. During the assembly process, each component is installed with predetermined technical specifications, while ensuring the right connection. The result is a system that is ready to be tested and implemented in the research environment, which is able to collect data in real-time about water quality and regulate feeding automatically, supports research objectives in optimizing water quality control and feed systems for fish populations through Internet of Things technology.



(a) Design planning



(b) Implementation

Figure 15. Assembly device.

1) Sub Software

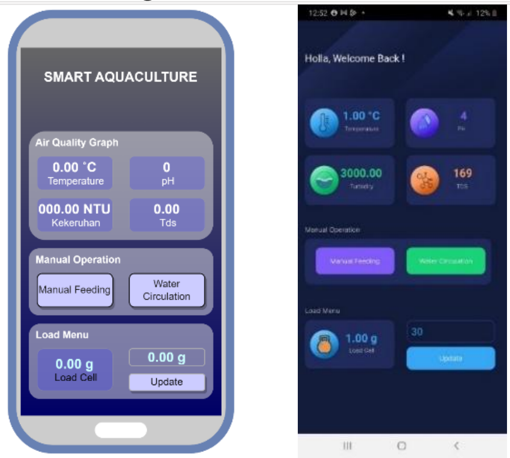
Design and assembly of software in research systems of water quality and automatic feed systems based on internet of things involving a systematic development process that includes modeling, programming, testing, and integration of various software components needed to regulate, control, and monitor the operations of the two systems automatically. This includes the development of the right control algorithm, an intuitive user interface, and integration with the IoT communication platform to facilitate efficient data exchange between hardware and software. Through the design and assembly of careful software sub-software, this research will create a solid foundation for overall system operation, ensuring optimal performance in controlling water quality and automatic feeding with the help of the Internet of Things.

a) Programming

System programming in research into Water Quality Control Systems and Automatic Feeding Systems based on the Internet of Things involves developing complex code to manage interactions between sensors, actuators and other IoT devices.

b) Making of interface applications

Creating a monitoring dashboard application in research on Water Quality Control Systems and Automatic Feeding Systems based on the Internet of Things aims to present critical information about aquatic environmental conditions and feeding status in real-time in a visual display that is intuitive and easy to understand. The app will enable researchers and managers to monitor key parameters such as pH, temperature, dissolved oxygen, as well as feeding patterns and feed consumption by fish directly from their mobile devices or computers. With a responsive interface and comprehensive monitoring features, this dashboard application will be an invaluable tool in supporting fast and informed decision making, ensuring optimal water quality and efficiency in automatic feeding, as well as accelerating research progress in water quality control and systems automatic feed via the Internet of Things.



(a) Design planning (b) Implementation

Figure 16. Application interface display.

3.4 System Testing

1) Determination of Test Variables

Research variables are attributes or characteristics that can vary in a study. These variables are factors that are researched or observed to see the relationship, differences, or influence between them in a particular research context. In scientific research, variables can be divided into two main types: independent variables and dependent variables. In this research the variables were divided into 3, namely independent variables, Dependent variables and Control variables. The following are the variables for this research:

1) Determination of Test Groups

(a) Experimental Group Aquarium

(b) Control Group Aquarium

Figure 17. Test group.

2) Replication

Replication is repeating an experiment as many times as possible to increase the validity and reliability of the results. In this research, replication is carried out through test scenarios. The following are test scenarios Measurement and Data Collection

Table 12. Replication.

Test To-	Testing Scenario	Method	Expected Results
1	Lowering Temperature	Ice water	The water heating system can increase the temperature until it returns to the set point
2	Raising Temperature	Warm water	The water-cooling system can reduce the temperature until it returns to the set point
3	Lowers pH	Vinegar	The Water Replacement System can normalize pH until it returns to set point
4	Raises pH	Baking soda	The Water Replacement System can normalize pH until it returns to set point
5	Muddy the Water	Milk	The Water Replacement System can normalize clarity until it returns to set point

6	TDS is within safe limits	Detergent Water	The Water Replacement System Can Normalize Dissolved Solids until they Return to set point

3) Measurement and Data Collection

a) Sensor Performance Test Results

Sensor testing aims to determine the accuracy of the sensor in measuring parameters of the aquarium water media. Sensor testing is carried out by comparing the sensor measurement data with what is read/measured using a comparison measuring instrument. The data taken aims to determine the magnitude of the difference between a dimension and the standard size.

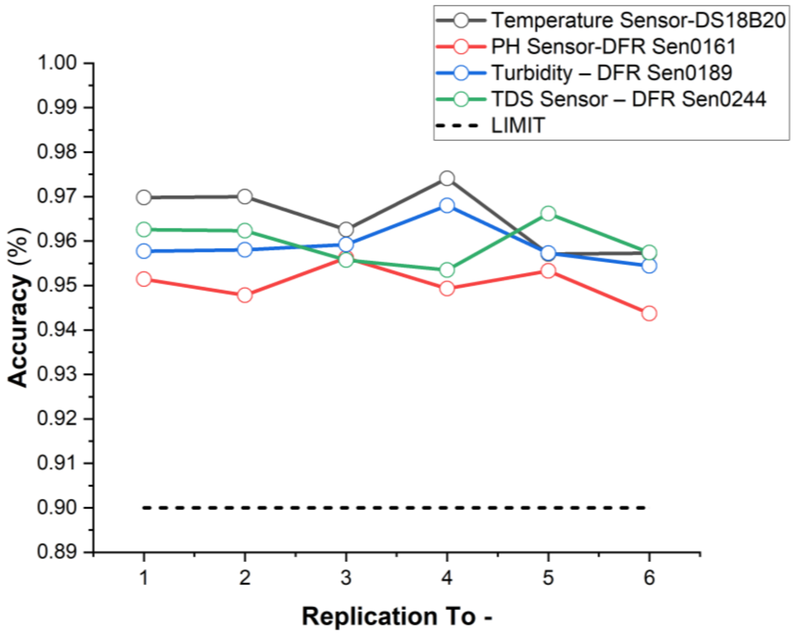


Figure 18. Sensor performance test results.

(1) Temperature Sensor-DS18B20 Test Results

The testing of the DS18B20 Temperature Sensor is aimed at figure 1 which aims to determine the ability of the DS18B20 Temperature Sensor to measure parameters in the form of water temperature in the aquarium. Testing the performance of the tool is carried out over time by comparing the temperature measured using a thermometer with data from temperature measurements using the DS18B20 Temperature Sensor. The following are the results of the DS18B20 Temperature Sensor test in the table 13.

Table 13. Accuracy test results of temperature sensor - on water quality readings.

Test To-	Water Condition	DS18B20 (°C)	Thermo Meter (°C)	Accuracy (%)
1	Cold water	24.7	25.5	96.98%
2	Warm water	28.2	27.3	97.00%
3	Acid Water	27.3	26.5	96.26%
4	Alkaline Water	27.9	26.9	97.41%
5	Murky Water	26.6	27.8	95.71%

6	Poisonous Water	26.0	27.2	95.73%
AVERAGE				96.43%

(2) PH Sensor-DFR Sen0161 Test Results

Testing of the PH Sensor DFR Sen0161 aims to determine the ability of the PH Sensor DFR Sen0161 in measuring parameters in the form of acidity levels in the aquarium. Equipment performance testing is carried out over time by comparing the turbidity measured using a pH meter with data from turbidity measurements using the DFR Sen0161 PH Sensor. The following are the test results for the PH Sensor DFR Sen0161 in the table below.

Table 14. Accuracy test results of ph sensor-dfr sen0161 on water quality readings.

Test To -	**Water Condition**	**Dfr Sen0161 (Ph)**	**Ph Meter (Ph)**	**Accu Racy (%)**
1	Cold water	7.0	7.4	95.14%
2	Warm water	8.1	7.7	94.78%
3	Acid Water	6.4	6.2	95.62%
4	Alkaline Water	8.6	9.1	94.93%
5	Murky Water	7.8	7.5	95.33%
6	Poisonous Water	7.7	8.2	94.37%
AVERAGE				95.23%

(3) Turbidity – DFR Sen0189 Test Result

The testing of the DFR Sen0189 Turbidity Sensor aims to determine the capability of the DFR Sen0189 Turbidity Sensor in measuring parameters in the form of water turbidity in the aquarium. Equipment performance testing is carried out over time by comparing the turbidity measured using a Turbidity Meter with data from turbidity measurements using the DFR Sen0189 Turbidity Sensor. The following are the test results for the DFR Sen0189 Turbidity Sensor in the table below.

Table 15. Accuracy test results of turbidity sensor – dfr sen0189 on water quality readings.

Test To -	**Water Condition**	**Dfr Sen0189**	**Turbidity Meter** (Ph)	**Accu Racy** (%)
1	Cold water	13.8	13.3	95.77%
2	Warm water	13.7	14.3	95.80%
3	Acid Water	13.5	13.0	95.92%
4	Alkaline Water	12.9	12.5	96.80%
5	Murky Water	15.7	16.4	95.73%
6	Poisonous Water	13.2	13.8	95.44%
AVERAGE				95.85%

(4) TDS Sensor – DFR Sen0244 Test Result

Testing of the TDS Sensor DFR Sen0244 aims to determine the ability of the TDS Sensor DFR Sen0244 in measuring parameters in the form of Dissolved Solids in the water in the aquarium. Equipment performance testing is carried out over time by comparing the turbidity measured using a TDS Meter with data from turbidity measurements using the TDS Sensor DFR Sen0244.

The following are the TDS Sensor DFR Sen0244 test results in the table below

Table 16. Accuracy test results of tds sensor – dfr sen0244 on water quality readings.

Test To -	**Water Condition**	**Dfr Sen0244** (Ppm)	**Tds Meter** (Ppm)	**Accuracy** (%)
1	Cold water	416	401	96.26%
2	Warm water	408	424	96.23%
3	Acid Water	410	429	95.57%
4	Alkaline Water	428	409	95.35%
5	Murky Water	457	473	96.62%
6	Poisonous Water	465	446	95.74%
AVERAGE				95.80%

(5) Ultrasonic HC-Sr04 Test Results

Water level readings are carried out by the DFR Sen0368 Capacitive Water Level Sensor. Therefore, it is necessary to test the water level sensor to determine the accuracy of the sensor performance shown in the table below

Table 17. Accuracy test results of the hc-sr04 ultrasonic sensor on water level measurement.

Test To -	**Upper Limit**			**Lower Limit**		
	HC-Sr04 (Cm)	**Ruler** (Cm)	**Accuracy** (%)	**HC-Sr04** (Cm)	**Ruler** (Cm)	**Accuracy** (%)
3	5	5	100%	25	24.9	99.6%
4	5	5.1	98%	25	25	100.0%
5	5	5	100%	25	25	100.0%
6	5	5	100%	25	24.8	99.2%
AVG			**99.3%**			**99.8%**

(6) Loadcell - HX711 Test Results

Table 18. Accuracy test results of loadcell sensor on feed weight measurement.

Test To -	**Load Cell** (Gram)	**Digital Scales** (Gram)	**Accuracy** (%)
7	15.0	15.3	98.04%
8	15.0	15.2	98.68%
9	20.0	20.2	99.01%
10	20.0	20.3	98.52%
11	25.0	25.2	99.21%
12	25.0	25.3	98.81%
	Average		**98.71%**

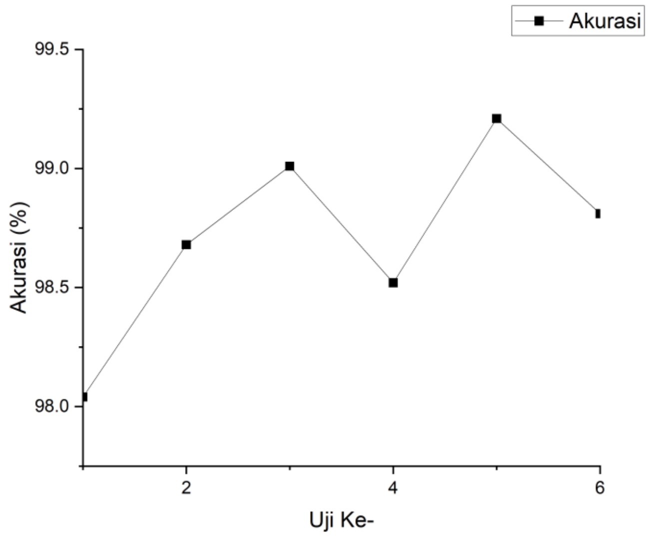


Figure 19. Ogive Loadcell Sensor Accuracy Test

(7) Real Time Clock - DS3231 Test Results

Table 19. Accuracy test results of real time clock sensor - ds3231 on a set feed time.

Test To -	Set Time	Servo Is On	Diff
7	07:00:00	07:00:04	00:00:04
8	16:00:00	16:00:03	00:00:03
9	07:00:00	07:00:05	00:00:05
10	16:00:00	16:00:04	00:00:04
11	07:00:00	07:00:03	00:00:03
12	16:00:00	16:00:04	00:00:04
	AVERAGE		00:00:04

b) Mechanical Device Performance

(1) Water Replacement Effectiveness Ratio

Table 20. Water discharge test results on the water replacement system.

Test To -	Time Required To Change The Water			
	Drainage Pump	**Distri-Bution Pump**	**Total Time**	**Debit** (l/s)
3	149	171	320	0.099
4	150	175	322	0.099
5	151	173	324	0.098
6	149	176	325	0.098
AVG	**148,62 s**	**175,12 s**	**323,75 s**	**0.098 l/s**

(2) Test the water heater for water heating

Table 21. Test results of water heater

Test To -	Initial Parameter (°C)	Parameter When System Is Off (°C)	Time Required (S)	Temp Changes (°C/S)
1	24.7	25.2	35	0.0143

(3) Test the water cooler for water cooling

Table 21**.** Test results of water cooler

Test To -	Initial Parameter (°C)	Parameter When System Is Off (°C)	Time Required (S)	Temp Changes (°C/S)
1	24.7	25.2	35	0.0143

(4) Influence of the System on Survival and Growth of Fish

These parameters include absolute weight growth, specific growth rate, and survival. needed as a benchmark for whether the tool system achieves the desired quality, namely that it can influence the survival and growth of goldfish.

Table 22. Comparison of fish that use the system and do not use the system

Week To -	Experimental Group	Control Group
1	Fish move normally, all fish are alive	All fish are alive, fish move normally
2	Fish move normally, all fish are alive	All fish are alive, fish move normally
3	Fish move normally, all fish are alive	All fish are alive, fish move normally
4	Fish move normally, all fish are alive	The fish are silent, occasionally taking oxygen to the surface. All fish are alive
5	Fish move normally, all fish are alive	Some fish began to weaken and move on the bottom, all fish were alive
6	Fish move normally, all fish are alive	The first-time death occurred, 1 fish died
7	Fish move normally, all fish are alive	Pale colored fish
8	Fish move normally all fish are alive	There are 4 remaining fish

Based on test results, all fish in aquariums that use the system can live and still move normally, this is due to irregular feeding. The high or low survival rate is influenced by external factors such as competition for space, quality and quantity of feed, careless and careful handling and catching, especially when sampling. Providing adequate feed and stocking it in the same size is also a factor in the success of keeping Goldfish (C. auratus) where the feed given during the research was sufficient and controlled to prevent cannibalism in the fish which could cause death in the fish being kept. According to [6] non-uniform goldfish (C. auratus) will cause competition in utilizing feed so that small growth will be hampered.

(1) Life graduation rate

Table 23. Comparison of survival rates in testing groups.

Testing Pool	Start (Ekor)	End (Ekor)	Survival Rate (%)

Experimental Group	5	5	100%
Control Group	5	4	80%

In the table above, based on survival values, satisfactory results were obtained for the Experimental Group Aquarium, namely 100% for the maintenance of Goldfish (C. auratus). whereas in the Control Group Aquarium treatment it was only 80%. This is thought to be due to real differences between treatments giving different feed doses which causes the fish to become stressed and result in death. In the Experimental Group Aquarium, feeding was carried out by a system that ensured that the feed was sufficient and that the distribution of doses of the same size was also a factor in the success of keeping Goldfish (C. auratus) where the feed given during the research was sufficient and controlled.

This is confirmed by research conducted [6] which states that the survival of Goldfish (C. auratus) seeds is greatly influenced by the availability of food. Goldfish fry (C. auratus) will die if they are unable to obtain food for a short time due to starvation and exhaustion of energy. The feed used will affect the survival and growth of Goldfish (C. auratus) seeds.

Apart from that, there are differences in treatment regarding controlled checks on water quality management in aquarium A which is well maintained for the life of Goldfish (C. auratus). Meanwhile, in the Control Group Aquarium, the absence of controlled checks on the water quality in the Control Group Aquarium caused the fish to become stressed and resulted in death because the water quality did not meet their living needs.

[8] stated that a good survival rate also proves a good and appropriate adaptation process so that goldfish (C. auratus) fry are able to survive and grow in a controlled rearing container.

(2) Absolute Weight Growth

Table 24. Specific growth rate in the testing group.

Fish To-	**Experimental Group**		**Control Group**	
	Start (g)	**End** (g)	**Start** (g)	**End** (g)
1	24.0	29.3	16.5	19.6
2	20.3	26.9	19.5	23.6
3	22.3	27.2	21.2	17.6
4	24.5	29.7	21.3	Dead
5	19.1	24.8	25.2	25.2
AVG	22.04	27.58	20.02	22.9
W	5.54 g		2.88 g	

(3) Specific Growth Rate

Table 25. Percentage of experimental and control group.

Experimental Group	**Control Group**
$\frac{5.54}{60} = \mathbf{9.23\%}$	$\frac{2.88}{60} = \mathbf{4.80\%}$

The treatments in the Experimental Group Aquarium had high absolute length growth values and individual growth rates, this was thought to be because the available food was in quantities that suited the fish's needs. This is confirmed by research by [9] Energy obtained from feed can not only be used to maintain the body, fish movement and replace damaged cells, but can also be used for growth. Goldfish (C. auratus) in semi-outdoor spaces had a significant effect on absolute growth but had no significant effect on specific growth rate, feed conversion and survival rate.

4. Conclusions

From the planning process to system design in the Smart Urban Farming tool, it can be concluded that the system can normalize water quality if it does not match the set point. Water heating and cooling systems can react when they do not match the temperature set point. With temperature accuracy of 96.4%, with a heating system of 70 seconds/Celsius and a cooling system of 587.5 seconds/Celsius. Aquarium water replacement system if the water turbidity, water dissolved solids and water acidity do not match the set point. With a pH sensor accuracy of 95.2%, a turbidity sensor of 95.8% and a dissolved solids sensor of 95.8%. and the average speed of changing water is 0.098 L/s. The system can provide feed on a scheduled basis at 08.00 and 16.00. with a feed weight accuracy of 98.7% and a difference in servo response to the system of 4 seconds. The system can be controlled and monitored via an Android device.

Acknowledgment

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