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RESEARCH ARTICLE

Fuzzy Logic-Based Aquaculture Climate Control System Design on A Fishpond

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Abstract: Tilapia farming is highly dependent on optimal water climate conditions, including temperature, pH, dissolved oxygen, and other environmental factors. However, fluctuations in pool water climate due to seasonal changes, management practices, and external factors can impact fish growth, health, and productivity. Fish farmers typically rely on irrigation and rain, which cause the aquatic climate to change. There is a need to assess how different water climate conditions affect the growth performance of tilapia and develop strategies to maintain an ideal environment in controlled pool systems. Aquatic animals need a good water climate in aquaculture to survive, such as fish and other aquatic organisms. To maintain it, it can be controlled by the aeration rate and by monitoring the amount of water with a microcontroller. Therefore, this research proposed designing a system to maintain the climate of the water and the amount of water so that they remain at the levels required by the fish. In general, a water climate control system has been implemented using the Mamdani fuzzy logic control method, which is used to manipulate output equipment in the form of aeration speed based on water climate parameters as input. This system will also automatically control for the draining or refilling of water if the water pump is needed. This system consists of materials, components, and sensors to obtain the data. A pond-type aquarium is used as a simple test. Fuzzy logic is used based on the available input, categorizes it into several criteria, then provides knowledge-based principles, inference mechanisms, and the defuzzification phase. The results showed success in controlling the quality of the water climate and maintaining the amount of water, with a success rate of 88, 89% and 91, 67%. This shows that the proposed system has worked effectively to control the quality of water in the climate and maintain the amount of available water.

Keywords: aeration rate, controlled, fuzzy logic, sensors, water climate, water pump

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1 Introduction

Indonesia is a country with waters with many islands and there are various animals that live in the waters. There are various types of freshwater fish that can be consumed or used as decoration in the household [1]. In this case, the water is the most vital indicator in fisheries cultivation. It also has an important role for many organisms, including humans, animals, and plants. Aquatic biota relies directly on water as their environment. Water quality parameters are critical for sustaining aquatic life. When water quality declines, aquatic ecosystems can be disrupted, inhibiting growth and potentially resulting in an aquatic biota mortality. The various factors that can impact fish behavior must be managed [2,3]. Key elements that influence fish growth include monitoring water quality and adhering to maintain water amount [4,5].

Temperature is a vital physical characteristic that is used to gauge and regulate across multiple applications. It acts as a signifier that illuminates surrounding conditions, rendering it a fundamental aspect in any environment [6]. Temperature deviations from ideal ranges can significantly impact organisms, especially aquatic life. Understanding the suitable temperature for fish breeding is critical [7]. Water temperature, influenced by factors such as season, location, and depth, plays a pivotal role. Optimal freshwater fish farming generally flourishes within the temperature scope of 25°C to 32°C [8]. Within aquatic ecosystems, oxygen levels are maintained through reciprocal interactions between plants, microbes, and other organisms that rely on oxygen for cellular respiration. Low oxygen concentrations pose a serious threat to aquatic biota. Balanced oxygen levels must be maintained to protect aquatic habitats [9].

The fish farming industry faces two significant challenges [10]. The first is insufficient oxygenation of water, which is crucial for fish health and survival. Accurately monitoring growth and precisely timing feed delivery with limited labor resources is also problematic [11]. Fuzzy logic approaches have been effectively applied to enhance the assessment of water quality parameters. Specifically, fuzzy set theory has been leveraged to define membership functions, fuzzy rules have been developed based on knowledge-based rule, an inference engine has been utilized to evaluate the outputs, and defuzzification methods have aggregated the results into clear classification or recommendations [12,13].

Elevated water temperatures have been shown to negatively impact the production of important species such as tilapia, constituting yet another industry headwind [13,14]. Advancing automation and sensor technologies may help address some of these issues and enhance sustainability and productivity over the long term. To optimize growth conditions for tilapia, maintaining stable levels of temperature and dissolved oxygen across seasons is advisable. The controlling over these environmental factors can support increased tilapia yields [15]. Farm owners must carefully monitor water levels and feed distributions to maximize crop yields. Maintaining optimal water volumes regulates amounts, preventing waste from leaks, evaporation or overflow [16]. Water monitoring is especially important during summer and rainy periods. Traditionally, farmers visually inspect water level marks directly on ponds [17]. Reliance on irregular irrigation and rainfall alone can cause issues, specifically during dry seasons. Close attention to critical resource management ensures consistent and productive harvests over multiple growing cycles [18,19].

A stable climate with proper temperature, pH, and oxygen dissolution promotes optimal growth conditions for tilapia throughout the seasons. Recent work has utilized various sensors integrated with the Internet of Things (IoT) and machine learning algorithms [20–22]to enable real-time water monitoring. Fuzzy logic approaches have been employed to enhance the evaluation of water quality [23, 24]. In fuzzy logic, the concepts of fuzzy sets, the design of knowledge-based rules, the inference process, and the defuzzification process were implemented [25–27]. The design and implementation of a filter pump controller for monitoring water quality in an aquarium utilized fuzzy logic.

The fuzzy logic controller utilizes a microcontroller that is combined with various supporting components [28]. Additionally, other applications of this system include automatic irrigation control [29] and decomposition of rice straw [30]. Fuzzy logic was also applied as a dynamic feed technique combined with mathematical functions to optimize monitoring

Tilapia farming is highly dependent on optimal water conditions, including temperature, pH, dissolved oxygen, and other environmental factors. However, fluctuations in pool water climate due to seasonal changes, management practices, and external factors can impact fish growth, health, and productivity. There is a need to assess how different water climate conditions affect tilapia growth performance and to develop strategies for maintaining an ideal environment in controlled pool systems.

So, there are need to analyze the effects of water temperature, pH, and dissolved oxygen on tilapia growth and survival in pool systems and purpose to management strategies for maintaining a stable and productive pool water climate for tilapia farming. A design system with using Mamdani fuzzy logic to maintain water climate with water temperature, pH and dissolved oxygen sensor as input system and aerator with water pump module as output for maintaining the climate.

Many studies were conducted to minimize challenges in monitoring pond water levels and quality. Several methods are used to monitor the water status in a fishpond [3, 6] with only single parameter input or monitoring water level only [19–21]. Several studies also used any filter pump [4, 14] to control water in a freshwater fish aquarium. However, no research has been done any design to control fish water climate based on input parameters or maintaining water amount with water level sensor-time based. Due to these challenges, this study aims to propose the design and implementation of an integrated fishpond aquaculture monitoring and climate control system. The system will automatically open valves to drain or fill the pond with a water pump based on climate data readings. Different sensors, materials, and components will be used to collect environmental data. As traditional ponds rely on irrigation and rainfall, the proposed system utilizes an aquarium-style pond for ease of prototype testing and evaluation. Water conditions and levels will be monitored based on data collected. This monitoring aims to maintain the pond water at an appropriate level to allow fish adequate space to move and exercise. Calculations have been made regarding the prototype size and water volume.

2 Research Method

2.1 Research Flow Diagram

The research was proposed as Figure 1. It shows the research flow, while the research stages will be carried out as follows.

In the flow chart work system, the system started with input readings, namely: 1) dissolved oxygen sensors (DO) that function to measure the rate of oxygen, 2) pH to measure the acidity, and 3) temperature sensors to measure the internal water temperature water sample. The data from the sensor reading are then processed by Arduino Nano. The de-

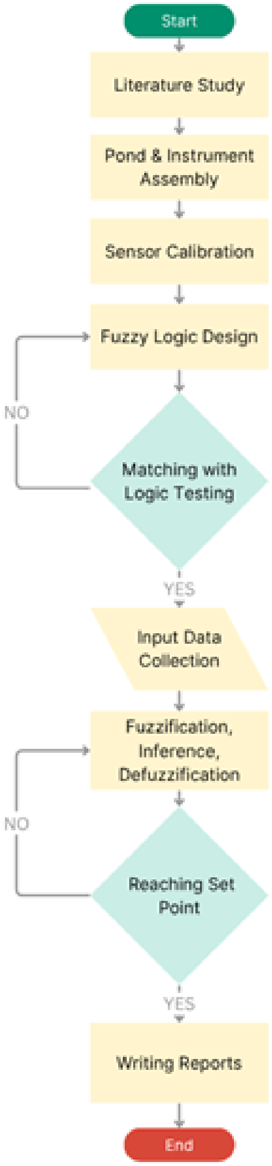

Figure 1: Research flow.

vice was then implemented with an Fuzzy Logic Controller (FLC) control algorithm that will perform the aerator pump manipulation speed based on the results of the defuzzification.

In this research, system control of oxygen-dissolved-based Arduino was performed with control of Mamdani's fuzzy logic. The output system will control the aerator, so the rate of oxygen in the water will increase. The motor driver is used to arrange the high decisive voltage level aerator speed. The fuzzy set is shown in Table 1.

Table 1: Fuzzy set

Variable types	**Variables in water**	Fuzzy sets	
		Linguistics	**Numeric**
Input	DO (mg/l)	Abundant	8, 10
		Growth	6, 8
		Spawning	5, 7
		Stressful	2, 4
	pH	Alkaline	7, 9
		Neutral	6, 8
		Acidic	5, 7
	Temperature (OC)	Hot	33, 36
		Moderate	27, 33
		Cold	24, 27
	Water Level (cu. ft.)	Critically High	3.1, 5.5
		Normal	2.5, 3.0
		Critically Low	0.0, 2.4
Output	Aerator	Fast	360, 540
		Slow	180, 360
		Off	0, 180
	Water pump	On	120, 240
		Off	0, 120

The schematic diagram of system planning can be shown as Figure 2.

2.2 Materials and Component

To create a good climate for fish, some materials and components were used in this research;

2.2.1 Sensors

The input water level sensor is utilized to gauge the present water level within the aquarium pond environment. The sensor connects directly to the microcontroller unit, which then transmits a signal that dictates the water pump operations accordingly.

2.2.2 Clock and Timer Configuration Module

This serves as the water pump controller that regulates drain/refill water to be released on the pond if needed according to the managing water level data.

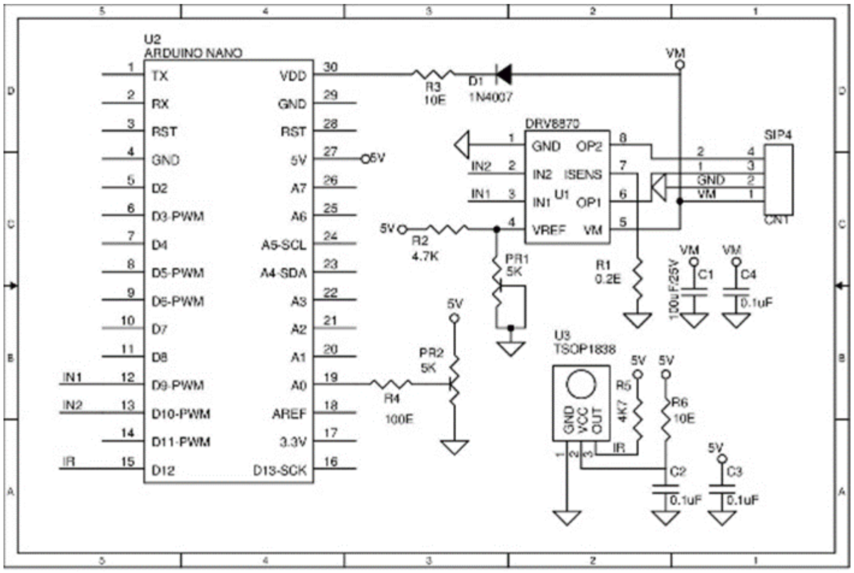

Figure 2: Schematic design input and output system.

2.2.3 Relay Aerator and Water Pump

This device can automatically control the flow of water in the aquarium pond through refilling and draining based on readings from the water level sensor.

2.2.4 Liquid Crystal Display (LCD)

This component is used to visualize the status of the water climate and the monitoring of water level condition. It is also used to demonstrate the given inputs to the system output.

2.2.5 Gate Valves

This device is utilized to regulate the decrease in water from an aquarium-style pond.

2.3 Fuzzy Rule-Based System Design and Implementation

The diagram illustrates the concept of fuzzy logic applied to an aquarium control system, which consists of three main stages: fuzzification, rule-based processing, and defuzzification. In the fuzzification stage, sensors collect input data such as temperature, pH, dissolved oxygen (DO), and water level, which are then converted into fuzzy values. These values are processed by an inference engine through a rule-based system that uses modules like relays and water level monitoring to determine appropriate responses. In the defuzzification stage, the fuzzy outputs are converted into precise actions, such as activating the aerator pump to release air bubbles or operating the water pump to refill or drain water when levels reach critical points. This fuzzy logic system ensures optimal and stable conditions in the aquarium pond by intelligently responding to changing environmental factors. One approach involves developing a system to automatically regulate the rate of oxygen dissolution in water. The proposed system would have the ability to precisely control oxygen levels. It would operate connected aeration equipment to increase oxygen when required, ensuring optimal water quality is sustained.

There are three main steps in the fuzzy logic implementation for an automatic water climate controller and level controller system. As shown in Figure 3, Mamdani fuzzy rule-based control system contains elements that perform fuzzification, development of a rule base, and defuzzification. Each of these functions will be discussed separately below.

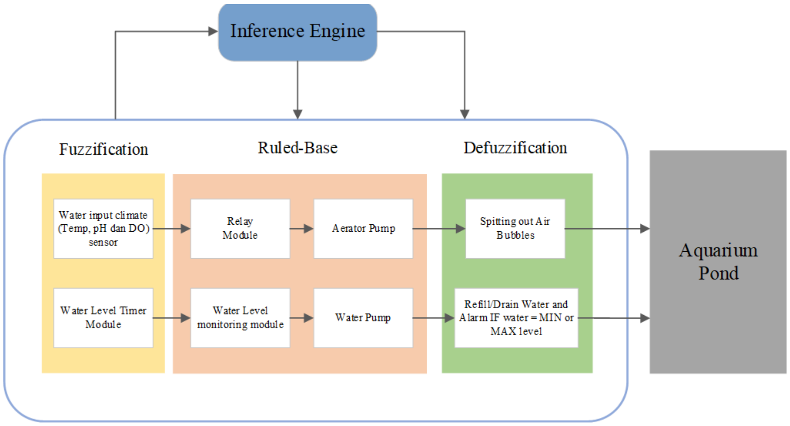

Figure 3: Fuzzy fishpond aquaculture block diagram control system.

Figure 3 illustrates a fuzzy logic-based control system for an aquarium pond, consisting of three main stages: Fuzzification, Rule-Base, and Defuzzification, all managed by an Inference Engine. In the Fuzzification stage, data is gathered from sensors monitoring water input climate (temperature, pH, dissolved oxygen) and water level timer module. The Rule-Base processes this information using a relay module, water level monitoring module, aerator pump, and water pump to determine appropriate actions. Finally, in the Defuzzification stage, actions such as spitting out air bubbles to maintain oxygen levels and refilling or draining water based on minimum and maximum thresholds are executed, ensuring a well-regulated aquarium pond environment.

3 Results

3.1 Fuzzy Rule-Based Implementation for Water Climate

3.1.1 Fuzzification

The water climate quality control system consists of three inputs and one output, which are assigned to the fuzzy sets. The fuzzy variables used as inputs are temperature, pH, and dissolved oxygen. The fuzzy variable used as output is the length of time required for the process of returning water quality conditions to neutral. Table 2 defines the fuzzy variable membership functions.

Table 2: Variable and ranges for fuzzification water climate controller

Variable reading in the Fuzzy Set	**System action**	**Indicator to be performed**
DO = Stressful pH = Not Neutral TMP = Moderate	Trigger Aerator Pump	Fill With Bubble
DO = Stressful pH = Not Neutral TMP = Not Moderate	Trigger Aerator Pump	Fill With Bubble
DO = Stressful pH = Neutral TMP = Moderate	Trigger Aerator Pump	Fill With Bubble
DO = Stressful pH = Neutral TMP = Not Moderate	Trigger Aerator Pump	Fill With Bubble
DO = Stressful pH = Not Neutral TMP = Moderate	Trigger Aerator Pump	Fill With Bubble
DO = Stressful pH = Not Neutral TMP = Not Moderate	Trigger Aerator Pump	Fill With Bubble
DO = Spawning pH = Not Neutral TMP = Moderate	Trigger Aerator Pump	Fill With Bubble
DO = Spawning pH = Not Neutral TMP = Not Moderate	Trigger Aerator Pump	Fill With Bubble
DO = Spawning pH = Neutral TMP = Not Moderate	Trigger Aerator Pump	Fill With Bubble
DO = Spawning pH = Neutral TMP = Moderate	Trigger Aerator Pump	Fill With Bubble
DO = Growth pH = Not Neutral	No Action (Continue Reading)	LED (Closed Solenoid)

TMP = Moderate		
DO = Growth pH = Not Neutral TMP = Not Moderate	No Action (Continue Reading)	LED (Closed Solenoid)
DO = Growth pH = Neutral TMP = Not Moderate	No Action (Continue Reading)	LED (Closed Solenoid)
DO = Growth pH = Neutral TMP = Moderate	No Action (Continue Reading)	LED (Closed Solenoid)
DO = Abundant pH = Not Neutral TMP = Moderate	Trigger Aerator Pump	Fill With Bubble
DO = Abundant pH = Not Neutral TMP = Not Moderate	Trigger Aerator Pump	Fill With Bubble
DO = Abundant pH = Neutral TMP = Not Moderate	No Action (Continue Reading)	LED (Closed Solenoid)
DO = Abundant pH = Neutral TMP = Moderate	No Action (Continue Reading)	LED (Closed Solenoid)

3.1.2 Fuzzy Rule-based

The fuzzy logic rules for the aquarium system define responses based on combinations of dissolved oxygen (DO), pH, and temperature (TMP). When DO is Stressful or Spawning, the Aerator Pump is activated in all conditions to stabilize the environment. When DO is in the Growth or Abundant phase, the response depends on pH and temperature: if conditions are not optimal, the LED is triggered—likely for signaling or light regulation. In summary, the system primarily activates the aerator pump during stress or spawning phases and uses LED indicators during growth or abundance, adjusting to pH and temperature variations accordingly. Fuzzy rule based can be proposed to conduct the climate as follows:

RULE 1: IF DO IS Stressful AND pH IS Not Neutral AND TMP IS Moderate THEN Triggered Aerator Pump

RULE 2: IF DO IS Stressful AND pH IS Not Neutral AND TMP IS Not Moderate THEN Triggered Aerator Pump

RULE 3: IF DO IS Stressful AND pH IS Neutral AND TMP IS Moderate THEN Triggered Aerator Pump

RULE 4: IF DO IS Stressful AND pH IS Neutral AND TMP IS Not Moderate THEN Triggered Aerator Pump

RULE 5: IF DO IS Stressful AND pH IS Not Neutral AND TMP IS Moderate THEN Triggered Aerator Pump

RULE 6: IF DO IS Stressful AND pH IS Not Neutral AND TMP IS Not Moderate THEN Triggered Aerator Pump

RULE 7: IF DO IS Spawning AND pH IS Not Neutral AND TMP IS Moderate THEN Trigger Aerator Pump

RULE 8: IF DO IS Spawning AND pH IS Not Neutral AND TMP IS Not Moderate THEN Trigger Aerator Pump

RULE 9: IF DO IS Spawning AND pH IS Neutral AND TMP IS Not Moderate THEN Trigger Aerator Pump

RULE 10: IF DO IS Spawning AND pH IS Neutral AND TMP IS Moderate THEN Trigger Aerator Pump

RULE 11: IF DO IS Growth AND pH IS Not Neutral AND TMP IS Moderate THEN Triggered LED

RULE 12: IF DO IS Growth AND pH IS Not Neutral AND TMP IS Not Moderate THEN Trigger LED

RULE 13: IF DO IS Growth AND pH IS Neutral AND TMP IS Not Moderate THEN Trigger LED

RULE 14: IF DO IS Growth AND pH IS Neutral AND TMP IS Moderate THEN Trigger LED

RULE 15: IF DO IS Abundant AND pH IS Not Neutral AND TMP IS Moderate THEN Trigger Aerator Pump

RULE 16: IF DO IS Abundant AND pH IS Not Neutral AND TMP IS Not Moderate THEN Trigger Aerator Pump

RULE 17: IF DO IS Abundant AND pH IS Neutral AND TMP IS Not Moderate THEN Triggered LED

RULE 18: IF DO IS Abundant AND pH IS Neutral AND TMP IS Moderate THEN Triggered LED

3.1.3 Defuzzification

The defuzzification process of the water climate in this stage is shown in Table 3.

Table 3: Variable and ranges for defuzzification water climate controller

Variable reading in the Fuzzy Set	**Action to be performed by actuator**	
	Aerator	**LED**
DO = Stressful pH = Not Neutral TMP = Moderate	Fast	OFF
DO = Stressful pH = Not Neutral TMP = Not Moderate	Fast	OFF

DO = Stressful pH = Neutral TMP = Moderate	Fast	OFF
DO = Stressful pH = Neutral TMP = Not Moderate	Fast	OFF
DO = Stressful pH = Not Neutral TMP = Moderate	Fast	OFF
DO = Stressful pH = Not Neutral TMP = Not Moderate	Fast	OFF
DO = Spawning pH = Not Neutral TMP = Moderate	Slow	OFF
DO = Spawning pH = Not Neutral TMP = Not Moderate	Slow	OFF
DO = Spawning pH = Neutral TMP = Not Moderate	Slow	OFF
DO = Spawning pH = Neutral TMP = Moderate	Slow	OFF
DO = Growth pH = Not Neutral TMP = Moderate	Closed Solenoid (No action)	ON
DO = Growth pH = Not Neutral TMP = Not Moderate	Closed Solenoid (No action)	ON
DO = Growth pH = Neutral TMP = Not Moderate	Closed Solenoid (No action)	ON
DO = Growth pH = Neutral TMP = Moderate	Closed Solenoid (No action)	ON
DO = Abundant pH = Not Neutral TMP = Moderate	Slow	OFF
DO = Abundant pH = Not Neutral	Slow	OFF

TMP = Not Moderate		
DO = Abundant pH = Neutral TMP = Not Moderate	Closed Solenoid (No action)	ON
DO = Abundant pH = Neutral TMP = Moderate	Closed Solenoid (No action)	ON

3.2 Fuzzy Rule-Based Implementation for Water Level

3.2.1 Fuzzification

The table presents a fuzzy logic-based approach to regulating water levels by defining system actions and corresponding pump operations. It categorizes water levels into three fuzzy sets: Critically High (CH), Normal (NL), and Critically Low (CL). When the water level is critically high, the system triggers the drain p ump to open the valve and drain water. If the water level is normal, the system continues reading without taking any action, keeping the valve closed. When the water level is critically low, the system triggers the refill pump to refill water with the valve closed. This structured decision-making process ensures efficient water level management in an aquarium or similar environment. Stage of defining the fuzzy variable membership functions for implementation of water level controlling can be shown in Table 4

Table 4: Variable and ranges for water level controller

Fuzzy set of Water Level Reading	**System Action**	**Action to be Performed by the Water Pump**
Day = 3 CH = Critically High	Trigger Drain Pump	Drain Water (Open Valve)
Day = 3 NL = Normal	Continue Reading	No Action (Closed Valve)
Day = 3 CH = Critically Low	Trigger Refill Pump	Refill Water (Closed Valve)

3.2.2 Fuzzy Rule-based

The fuzzy rule-based system for water level control consists of three key rules to regulate the water pump based on the water level reading during Day Time = 3. Rule 1 states that if the water level is Critically High (CH), the system will trigger the drain pump to lower the water level. Rule 2 specifies that if the water level is Normal (NL), the system will continue reading without taking any action. Rule 3 dictates that if the water level is Critically Low (CL), the system will trigger the refill pump to increase the water level. These fuzzy logic rules enable an automated and efficient water level management system.So, the Fuzzy rule based can be proposed to conduct the water level as follows:

RULE 1: IF Day Time IS Equal to 3 AND Water Level Reading IS CH THEN Trigger to DRAIN PUMP

RULE 2: IF Day Time IS Equal to 3 AND Water Level Reading IS NL THEN CONTINUE READING

RULE 3: IF Day Time IS Equal to 3 AND Water Level Reading IS CL THEN Trigger to REFILL PUMP

3.2.3 Defuzzification

Defuzzification rule based can be proposed to control the water pump and alarm as follows:

Table 5: Variable and ranges for defuzzification water level controller

Water Level Reading	Drain Water Pump	Refill Water Pump	Alarm Notification
Day = 3 CH = Critically High	OPEN	CLOSED	ON
Day = 3 NL = Normal	CLOSED	CLOSED	OFF
Day = 3 CH = Critically Low	CLOSED	OPEN	ON

In designing a fuzzy inference system, it consists of two inputs and one output. The fuzzy method used is Mamdani method. Input section from FIS design consists of two variables namely DO error and percentage DO saturation. The DO error input is difference between mark oxygen measurable dissolved with the specified setpoint. Whereas input percentage DO saturation is percentage from mark rate oxygen dissolved to mark DO saturation at measured water temperature. From both inputs, FIS will produce an output form level DC aerator speed for increased rate of oxygen dissolved.

4 Discussion

This research report covers findings from tool testing and discussion of experiments that have been conducted. There are two primary challenges faced by fish farmers today. Firstly, insufficient monitoring of growth factors in the aquatic environment, such as temperature, pH levels, and dissolved oxygen concentration. Secondly, maintaining an adequate water volume until harvest. Testing was performed using a tool proceeding through several stages, including evaluating initial response rates to changes in dissolved oxygen levels, assessing response rates to oxygen saturation when temperature is varied, and conducting setpoint calibration tests. The fuzzy logic in the controller provided power to the filter pump operation based on details regarding the turbidity degree of water obtained from a photodiode sensor and the acidity of water gathered from sensors.

4.1 Working Instruments

The following is a realization from the design system that has made as shown in Figure 4 Figure 5

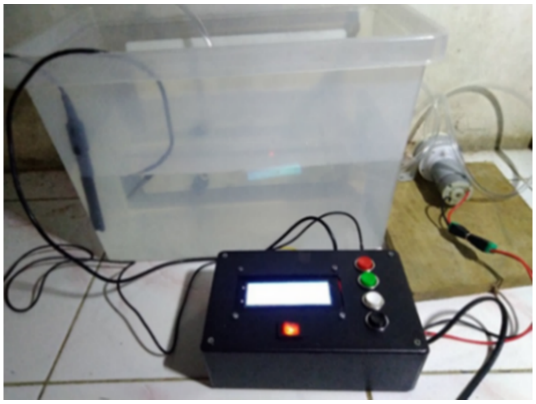

Figure 4: Fuzzy Fishpond Aquaculture Block Diagram Control System

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Set Point:5.00
Suhu: 25.06 Celcius
DO: 3.76 mg/L
Aerator: CEPATT
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Figure 5: Fuzzy Fishpond Aquaculture Block Diagram Control System

4.2 Testing Result

4.2.1 Water Climate Testing

The test was carried out within 1 month. Two devices of tests are carried out, namely aerator and LED as no-action indicator. 18 types of experiments were carried out over a week. The testing of the components on the system was conducted first to ensure its functionality to trigger the aeration rate and turn on the LED. Table 6 shows the summary of the experiments performed.

Table 6: Test results of the automatic water climate controller system

Variable condition read in pond	**System action**			**Result**
	Aerator		**LED**	
	Status	**Action performed**		
DO = Stressful pH = Not Neutral TMP = Moderate	Triggered	Fast	OFF	Successful
DO = Stressful pH = Not Neutral TMP = Not Moderate	Triggered	Fast	OFF	Successful
DO = Stressful pH = Neutral TMP = Moderate	Triggered	Fast	OFF	Successful
DO = Stressful pH = Neutral TMP = Not Moderate	Triggered	Fast	OFF	Successful
DO = Stressful pH = Not Neutral TMP = Moderate	Triggered	Fast	OFF	Unsuccessful
DO = Stressful pH = Not Neutral TMP = Not Moderate	Triggered	Fast	OFF	Successful
DO = Spawning pH = Not Neutral TMP = Moderate	Triggered	Slow	OFF	Successful
DO = Spawning pH = Not Neutral TMP = Not Moderate	Triggered	Slow	OFF	Successful
DO = Spawning pH = Neutral TMP = Not Moderate	Triggered	Slow	OFF	Successful

DO = Spawning pH = Neutral TMP = Moderate	Triggered	Slow	OFF	Successful
DO = Growth pH = Not Neutral TMP = Moderate	No Action (Continue Reading)	Closed Solenoid	ON	Unsuccessful
DO = Growth pH = Not Neutral TMP = Not Moderate	No Action (Continue Reading)	Closed Solenoid	ON	Successful
DO = Growth pH = Neutral TMP = Not Moderate	No Action (Continue Reading)	Closed Solenoid	ON	Successful

4.2.2 The Water Level Testing

The clock and timer were manually configured to test the pond water pump controller that regulates the release of drain / recharge water into the pond. Through the LCD display, the set time and measured status of water storage could be easily verified to check if the input configuration was correctly implemented. Table 7 shows the results of the tests carried out to determine if the system produced the expected necessary output.

Table 7: Test results of the automatic water level controller system

#Trials	**Time Date and Time (dd/mm/yyyy - hh:mm)**	**Water Level Readings**	**Remarks**	**Pump Action**	**Result**
1	Day 0 07/01/2024 - 10:11	2.65 cu ft	NL = Normal	Continue Reading	Succesful
2	Day 3 10/01/2024 - 08:11	2.45 cu ft	CL = Critically Low	Refill Pump	Succesful
3	Day 6 13/01/2024 - 09:00	4.21 cu ft	CH = Critically High	Triggered Drain Pump	Succesful
4	Day 9 16/01/2024 - 20:32	2.85 cu ft	NL = Normal	Continue Reading	Succesful
5	Day 12 19/01/2024 - 20:32	1.55 cu ft	CL = Critically Low	Refill Pump	Succesful
6	Day 15	2.98 cu ft	NL = Normal	Continue	Succesful

	21/01/2024 - 11:21			Reading	
7	Day 18 24/01/2024 - 09:11	2.15 cu ft	CL = Critically Low	Refill Pump	Unsuccesful
8	Day 21 27/01/2024 - 10:15	4.55 cu ft	CH = Critically High	Triggered Drain Pump	Succesful
9	Day 24 30/01/2024 - 11:21	4.75 cu ft	CH = Critically High	Triggered Drain Pump	Succesful
10	Day 27 02/02/2024 - 10:16	2.25 cu ft	CL = Critically Low	Refill Pump	Succesful
11	Day 30 05/02/2024 - 11:10	4.75 cu ft	CH = Critically High	Triggered Drain Pump	Succesful
12	Day 33 08/02/2024 - 20:15	2.85 cu ft	NL = Normal	Continue Reading	Succesful

5 Conclusion

Several methods are used to monitor the water status in a fishpond [3,6] with input only of a single parameter or to monitor the water level only [19–21]. Several studies also used a filter pump [4,14] to control water in a freshwater fish aquarium. However, no research has been done on any design to control fish water climate based on input parameters or maintaining water amount with water level sensor-time-based. Due to these challenges, this study shows that the fuzzy logic-based control is proven to maintain the amount of water and the climate in the pond. The fuzzy system can provide an intelligent and automated water level control mechanism for an aquarium pond, ensuring optimal environmental conditions. Using fuzzification, the system collects real-time data from sensors. The rule-based module processes this data and makes decisions using predefined fuzzy rules. The defuzzification stage then translates these decisions into actions. This system enhances efficiency, adaptability, and precision compared to traditional threshold-based controllers, ensuring a stable and well-regulated aquatic environment without human intervention. It can be known from the results of the proposed system that the sensors can measure temperature, pH, and DO as input system by a microcontroller. The system will automatically open valves to drain or fill the pond with a water pump based on climate data readings as boundaries for maintaining the fish pond. After being applied and tested on the system, any design to control fish water climate based on input parameters or maintaining water amount with water level sensor-time-based, and it is very useful for fish farmers in maintaining water climate and increasing tilapia productivity. The proposed system successfully works to control the aquarium using fuzzy logic and displays the measurement data with all indicators as climate data in the control system for each measurement. In our further plan, this system will be integrated with the Internet of Things (IoT) technology for easy controlling and supervision.

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