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Jurnal Nasional Teknik Elektro

| ISSN (Print) 2302-2949 | ISSN (Online) 2407-7267 |

Water Quality Control in Carp Fish Ponds Using Fuzzy Logic

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ARTICLE INFORMATION

Received: August 14, 2023
Revised: December 7, 2023
Accepted: July 27, 2024
Available online: July 29, 2024

KEYWORDS

Temperature, Acidity Level, Water Level, Blynk, FuzzyLogic

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A B S T R A C T

Regularly monitoring pond water quality in fish farming is a crucial practice often neglected, negatively impacting goldfish yields. Addressing this issue, a sophisticated device leveraging fuzzy logic has been engineered to accurately regulate acidity, temperature, and water levels, with real-time data accessible through the Blynk smartphone application. This innovative system employs a trio of sensors—namely an acidity sensor, a DS18B20 temperature sensor, and an HCSR04 ultrasonic sensor—coupled with three output mechanisms: an inlet pump, an outlet pump, and a heater, to ensure precise control. Rigorous testing under various conditions at different times of the day, lasting approximately one hour each, demonstrated the device's capability to adjust water's acidity by about 0.1 units per minute, reflecting the influences of fish activity and water temperature, with a deficient accuracy error of 0.19%. Additionally, the system's effectiveness in maintaining a consistent water level was confirmed, exhibiting a refill rate of 1.2 cm per minute as detected by the sensor. This integrated system is instrumental in safeguarding goldfish health and optimizing their productivity by ensuring water quality remains within the desired acidity, temperature, and volume parameters.

INTRODUCTION

In cultivating goldfish, it is necessary to maintain the water quality in goldfish ponds [1]-[3]; otherwise, the water quality of goldfish ponds will decrease over time. Therefore, a tool that can control the water quality of goldfish ponds based on pH, temperature, and water level is needed [4], [5]. Water that can be used for goldfish cultivation must have quantity and quality standards that meet the needs of goldfish life. The quality of water that can be used as a medium for goldfish living must be maintained so that goldfish as aquatic organisms can be cultivated according to human needs [6]-[8].

The environment greatly influences the quality and quantity of water in goldfish farming. A good environment will provide stimulation for the growth and development of goldfish. In contrast, a poor aquatic environment will inhibit the stimulation given in the growth and development of goldfish [9]. Specifically, maintaining optimal levels of acidity and temperature is crucial for preventing stress and diseases in goldfish, which can significantly affect their growth and reproduction rates.

Water quality in goldfish ponds consists of 3 components: the quality of physics, chemistry, and biology [5]—physical factors such as temperature, brightness, and depth. Chemical factors include pH, CO2, and NH3. Biological factors are related to living things in water, including fish. If the water quality does not meet the standards, it will hurt the survival of the fish being cultivated; as a result, the fish can become stressed [10], sick and even die if they cannot withstand environmental changes. Therefore, special measures or human intervention are usually required to maintain optimal water quality [11]-[13]. The requirements for a goldfish pond in standard conditions include pH 6.5 ÷ 8, Salinity 0 ÷ 5 per millimeter, water temperature 25 ÷ 30 °C, and Dissolved Oxygen (DO) 4 ÷ 10 ppm.

Several articles discuss maintaining the quantity and quality of fish pond water by involving several methods [14], [15], including Arduino-based water Consumption Monitoring System, Microcontroller Pond Water Quality Monitoring System, Prototype of Industrial Waste pH Control Using the Fuzzy Mamdani Method [16], [17].

Therefore, we need a system that can monitor [15] and control the quality and quantity of goldfish pond water according to standard conditions [18]. For this reason, a system for controlling the quantity and quality of goldfish pond water is created based on the pH, temperature, and water level. Using a water pH regulator in goldfish pond water will maintain and control the pH according to tolerance standards. In addition to detecting pH, the control device can remove water from the pool when the detected pH value exceeds the expected value. The water that comes out (pump off) will automatically stop when the pH value returns to normal and if the pH value is less than its normal value. The temperature sensor measures the temperature value in the goldfish pond water. When the water temperature exceeds a

https://doi.org/10.25077/jnte.v13n2.1136.2024

predetermined value, the heater will automatically turn on, and vice versa. The heater will turn off when the temperature reaches a predetermined value—the ultrasonic sensor functions as a gauge for the goldfish pond water level. When the pond water conditions are less than a predetermined limit, the pump will continue to fill the goldfish pond water until the pond water level has been determined. In this way, a goldfish aquaculture farming system [19], [20] is created, and the fuzzy logic method[21], [22] is used to assist the system in making decisions. And the use of the Blynk application to monitor the condition of goldfish ponds remotely (IoT) [23].

METHODS

Fuzzy logic controls the duration of the 'on' pump out and 'on' heater in goldfish pond water based on the values obtained by the pH sensor, temperature sensor, and ultrasonic sensor. This control aims to maintain the pond water quality with the final pH value after being controlled within the ideal range of 6.5 ÷ 7.5 and maintaining the pool water temperature within the ideal range of 25 ÷ 30 °C. The water level of the Goldfish pond is maintained <15 cm (water distance to the ultrasonic sensor) as measured by the ultrasonic sensor, as shown in Figure 1.

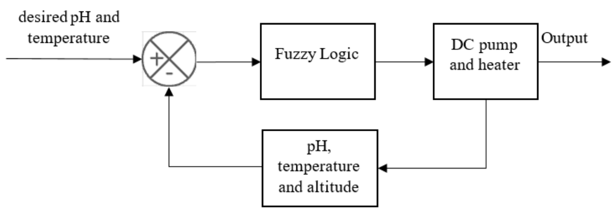

Figure 1. Block Diagram of Goldfish Pond Control System

The flowchart of the goldfish pond control and monitoring system is shown in Figure 2, and Figure 3. Flowchart on Arduino Uno, Figure 4. Sketch of control and monitoring of goldfish ponds. Use a neutral water vessel for the source of water that will be channeled into the goldfish pond. The neutral water vessel is connected to a pump that injects water into the goldfish pond vessel based on the readings of the water level sensor in the goldfish pond. And for the output (disposal) section, a pH reading is carried out, which will activate the drain pump, which sucks the water into the goldfish pond vessel if the pH value is outside the specified value. The pH sensor will be input for the pump to suck up the goldfish pond water until the pH value returns to normal. The temperature sensor is the input to activate the heater. If the temperature is less than 25°C, the heater will automatically turn on until the temperature returns to normal. The water level sensor serves as input to activate the pump so that water enters the goldfish pond when the water level is less than the predetermined water level, as shown in Figure 2

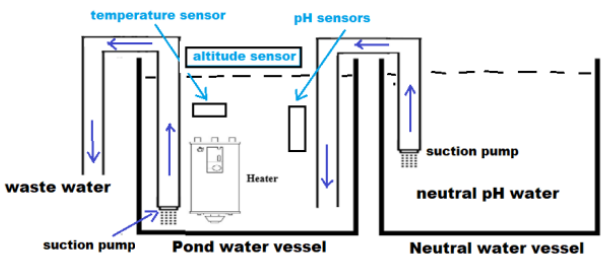

Figure 2. Sketch of control and monitoring of goldfish ponds

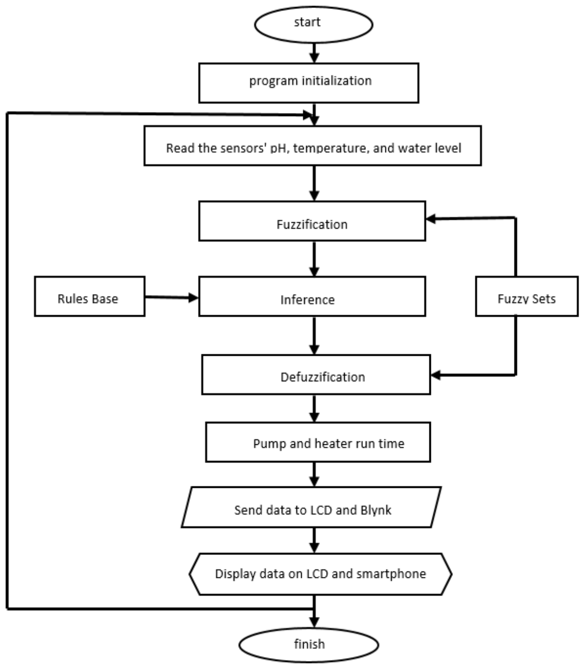

Figure 3. Flowchart of the Goldfish Pond Control and Monitoring System

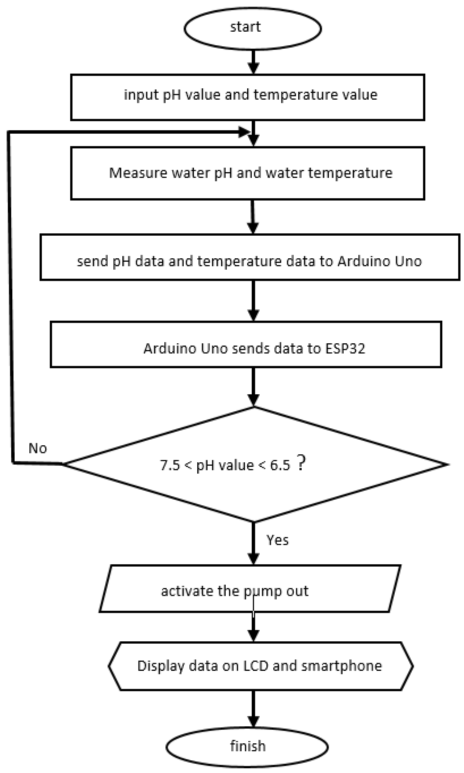

Figure 4. Flowchart on Arduino Uno

Arduino Uno functions to receive input from the pH sensor (SKU SEN0161) and sends the data directly to ESP32. ESP32 will receive input from all sensors, namely a pH sensor through an Arduino Uno intermediary to provide a water pH value, a temperature sensor (DS18B20) provides a water temperature value, and an ultrasonic sensor (HCSR04) provides distance input to water content. All output from each sensor is displayed on the LCD. In the pH sensor circuit, a pump (DC motor) functions as a water regulator in the pond. The pump works when the Arduino

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Uno receives an input water pH value and is sent to ESP32. When the pH value exceeds 7.5 or less than 6.5, the system will carry out an order in the form of disposing of pool water by the pump and will stop when the pH value reaches a value between 6.5 ÷ 7.5. The temperature sensor circuit has a heater that functions as a water temperature regulator in the pool. The heater works when the ESP receives input from water temperature. When the water temperature gets colder, the system will execute a command to turn on the heater to raise the water temperature. The system will be able to detect when the water in the pond is full, employing a signal or input from the water level sensor. The system will process the input received by ESP32 and will stop the process of filling water by the pump, as shown in Figure 5.

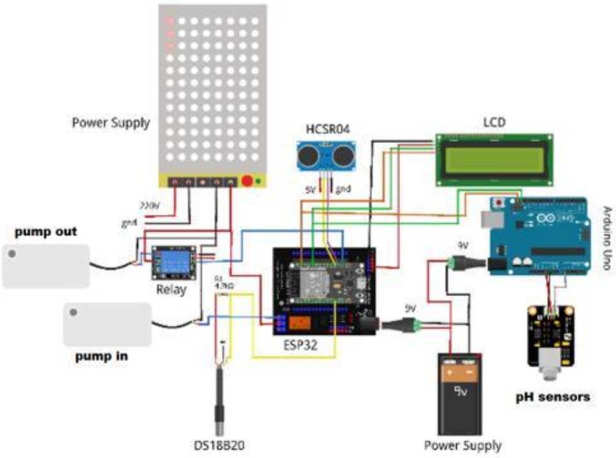

Figure 5. Complete range of control and monitoring of goldfish ponds

The membership function and degree of membership of each input and output are shown in Table 1 to Table 4.

Table 1. pH input

No	Membership Function	Membership Degree
1	Very Sour	0, 0, 3
2	Sour	2, 4, 5
3	Slightly Sour	4, 5, 6,5
4	Neutral	6,5, 7, 7,5
5	Little base	7,5, 8, 9
6	Base	9 ,11, 12
7	Very Alkaline	11, 12, 14

Table 2. Temperature Input

No	Membership Function	Membership Degree
1	Very cold	0, 0, 12
2	Cold	10, 15, 20
3	Little Cold	18, 23, 26
4	Normal	25, 27, 30
5	A little bit hot	29, 33, 38
6	Hot	36, 42, 45
7	Very hot	44, 50, 55

Table 3. Pump

No	Membership Function	Membership Degree
1	Dead	0
2	A moment	10
3	Long	20
4	Very long	30

Table 4. Heater

No	Membership Function	Membership Degree
1	Off	0
2	On	1

The Rule viewer for controlling goldfish ponds is shown in Figure 6.

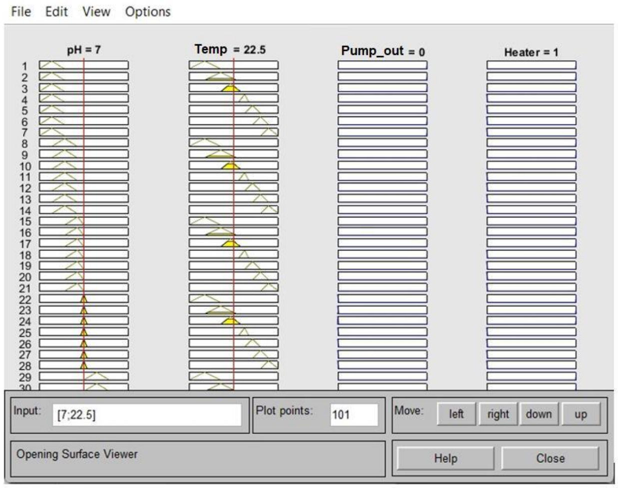

Figure 6. Rule viewer for goldfish pond control

RESULTS AND DISCUSSION

(a)

(b) (c)

Figure 7. Photo of the location and testing equipment for the goldfish pond control system

Before measuring the pH of the goldfish pond water, a pH sensor calibration was first carried out using each solution (pH buffer dissolved in 250 ml of water) of pH buffer (pH4.0@25℃, pH6.86@25℃, and pH9.18@25℃). Then insert the pH sensor probe and look at the measurement results from the pH sensor which obtained an average error of 0.76%. And calibration of the temperature sensor (DS18B20) with a couple of thermometers (thermocouple-thermometer HTI HT9815) gets an average error of 0.125%. Thus, the measuring instrument meets national and international standards and the material that can be submitted as a reference has been certified.

The volume of goldfish pond water is 1.134 cubic meters with a length of ±1.35 m, a width of ±1.20 m and a height of ±0.7 m. Photos of the place and equipment for testing the goldfish pond control system are shown in Figure 7.

The monitoring system that has been connected to WiFi directly displays the data that has been set in the program, as shown in Figure 8.

Figure 8. Display of the Monitoring System in the Blynk Application

From Figure 9, based on the block diagram Figure 1. The pump remains 'on' as long as the pH value of the water is above 7.5, which is alkaline. Gradually, the pH value tends to decrease [4] to the set point value (6.5 7.5), which takes 26 minutes on the 26th data. On the other hand, in Figure 9, the pump remains 'on' as long as the pH value of the water is below 6.5, which is acidic. Gradually, the pH value tends to rise to the set point value (6.5 - 7.5), which takes 25 minutes for the 25th data set. Thus, lowering and increasing the pH value by around 0.1/minute takes time. By obtaining short-time conditions [24] and under the needs of real conditions in the field because it uses actual field data (non-symmetrical data) [21], [22].

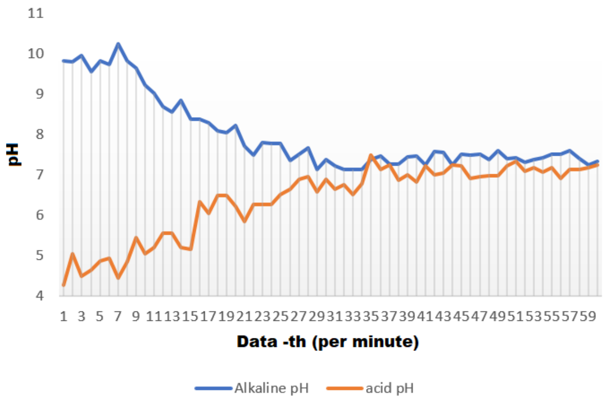

Figure 9. Graph of pH values of water in acidic and alkaline conditions

Based on the test block diagram in Figure 1, the pH value is very high during the day because, before testing, the goldfish pond was first given fish food. That way, the pH value in the goldfish pond water becomes high, and the hot temperatures during the day also affect the pH value contained in the pond water. Likewise, in the afternoon, when the pH value is still high, it is caused by moving fish that are still active so that substances that settle to the bottom of the pond are lifted. However, based on the data obtained, it shows a graph of the pH value tends to decrease due to water circulation from neutral water vessels to goldfish pond vessels. Fish pond water continues to be channeled to disposal until the water stops flowing later if the pH value has been met. The pH of the goldfish pond water at night and in the morning is still in the desired condition, namely 7 ÷ 7.5. This is because the fish move less than during the day and evening. The substances found at the bottom of the goldfish pond are not lifted to the surface, and the temperature is not too high, which results in the pH value of the goldfish pond water being lower, as shown in Figure 10.

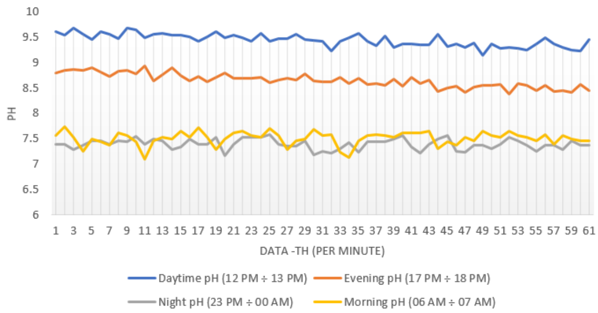

Figure 10. Graph of water pH values during the day, evening, night, and morning in goldfish ponds

Based on the block diagram of Figure 1. where most of the water temperature conditions are within tolerance limits (desirable), except during the day, the water temperature slightly exceeds 30 °C (tends to rise) with an error of 0.19% (still below 2%). Meanwhile, the water level in the goldfish pond is still controlled according to the set point where the time needed to fill the pond water is 1.2 measured distance from the sensor/minute, as shown in Table 5.

Table 5. Value of water temperature and water level in neutral, acid, and alkaline conditions, day, evening, night, and morning in goldfish ponds

Condition	**Temp = 25 – 30°C, < 25°C, heater on**		**Fluctuation (in tolerance)**	**Water Level >=15 cm, pump on**	
	Max	**Min**		**Max**	**Min**
Neutral	Average = 27.82		0.25	Average = 6.83	
	27.94	27.69		12	4
Acid	Average = 28.51, trend to decline		0.25	Average = 15	
	28.69	28.44		20	6
Alkaline	Average = 27.7, trend to rise		0.43	Average = 15	
	28.87	28.44		26	9
Morning	Average = 26.53, trend to rise		0.25	Average = 15.57	
	26.69	26.44		22	14
Daytime	Average = 30.22, trend to rise		1.2	Average = 17.95	
	30.95	29.75		32	14
Evening	Average = 28.57, trend to decline		0.18	Average = 13.38	
	28.62	28.44		20	10
Night	Average = 27.61, trend to decline		0.25	Average = 13.39	
	27.75	27.5		19	13

For example, the display on the LCD and the Smartphone is the data that each sensor has measured and then sent to the microcontroller and displayed to the LCD and the smartphone (via Blynk) in the form of a pH value, temperature value, and water level distance. For heater(H) conditions that are inactive (off) to display on the LCD and pump in(off) and pump out(on) conditions for display on a smartphone, as shown in Figure 11.

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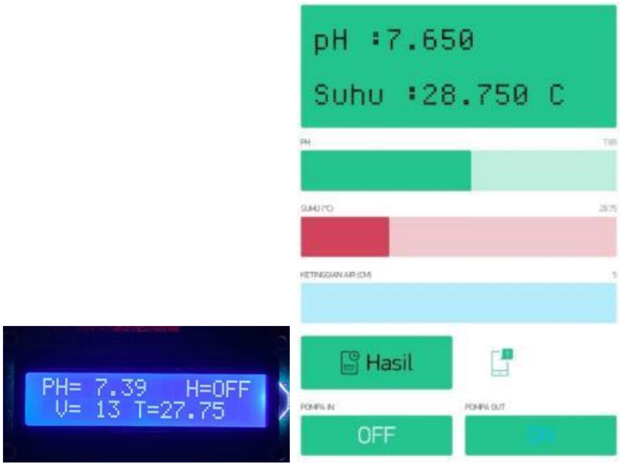

(a) (b)

Figure 11 Data display on LCD and smartphone

CONCLUSIONS

Using the Fuzzy Logic method, the water quality and quantity control system in the goldfish pond (volume 1,134 cubic meters) has worked according to the desired conditions based on input from the pH sensor, temperature sensor, and water level sensor. The conclusion that can be drawn is that it takes time to lower and increase the pH value of about 0.1/minute. With active fish movements during the day, the water temperature can be high, with an error of 0.19%. In all conditions, the water level in the goldfish pond is still controlled according to the desired height with the time for filling water into the pond, which is 1.2 measured distance from the sensor/minute. As for suggestions for improvement to accelerate the achievement of the pH value, temperature, and water level according to the provisions, you can add additional liquid to increase and decrease the pH value. And for the temperature value, you can add a water source whose temperature has been controlled according to the provisions.

ACKNOWLEDGMENT

This Research was supported by Dana Hibah Jurnal Departemen Teknik Elektro Fakultas Teknik Universitas Andalas.

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