Review Article

Modern Farming Biofloc ponds for tilapia aquaculture based on the internet of things use a fuzzy logic algorithm

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Abstract:

This study aims to create a smart system in controlling tilapia biofloc ponds. The type of research is laboratory experiments and the category of system testing, namely Functionality testing, is used to measure the performance of the system hardware. Testing the functionality of the prototype is tested in 2 stages, the first test begins with knowing the accuracy of sensor data and testing manually. The second test is to test the prototype as a whole, namely by giving treatment so that the performance of the prototype can be known as desired. The results obtained when the temperature is cold, the water heater heater will turn on and treatment to the pH sensor is obtained, namely an acidic pH condition, then the water pump will turn on and drain the water until the ultrasonic sensor detects the maximum water level that can be drained. Testing on feeding is by monitoring the servo successfully rotating, opening and closing the feed storage container based on the time that has been set. The results of monitoring feeding in the morning, afternoon and evening are successful and can send notifications. Based on the test results, the resulting " Modern Farming Biofloc ponds for tilapia aquaculture based on the internet of things use a fuzzy logic algorithm" can run as expected.

Keywords: Smart system, Biofloc, Fuzzy Logic, Prototype, Functionality

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Citation:J.M.Parenreng,Syahrul, A.Wahid,D.W,sary,"Modern Farming Biofloc ponds for tilapia aquaculture based on the internet of things use a fuzzy logic algorithm". *Iota*, **2022**, ISSN 2774-4353, Vol.02, 04. https://doi.org/10.31763/iota.v2i4.548

Academic Editor : P.D.P.Adi

Received : Oct, 03 2022

Accepted : Oct, 16 2022

Published : Nov, 19 2022

1. INTRODUCTION

Freshwater fish farming is an activity to produce controlled biota or organisms for profit. Aquaculture activities can be carried out in cities and even in rural areas. Fish will live and reproduce well if the environmental conditions provided in accordance with their living conditions are met or close to their natural habitat. Tilapia (Oreochromis Niloticus) is one of the most widely cultivated freshwater fish. This type of fish can be cultivated in various habitats (fresh, brackish and marine water) because tilapia is tolerant of a wide range of salinities [1].

Aquaculture generally requires a large area to place several ponds. Therefore, the biofloc system is a new and interesting solution. Rusherlistyani 2017 also stated that the biofloc system has privileges compared to conventional cultivation, including the fact that it can be applied on limited land, the cultivation time is relatively short, the capital is relatively low, and it is environmentally friendly [2]

According to the 1962 Law on Regional Companies, it provides an understanding of regional drinking water companies (PDAMs) as regionally owned enterprises (BUMDs) that provide services and provide benefits in the distribution of clean water to the community. PDAM provides clean and healthy drinking water that meets the needs of local residents, which is also a form of service provided by the government to residents. However, the current PDAM system mostly uses a manual recording system, which is prone to fraud, inconsistent in measuring water use, lacking flexibility, and lacking transparency in community water use. Head of the Sukabumi Freshwater Aquaculture Fisheries Center (BBPBAT) Supriyadi said tilapia was chosen as an advanced commodity for the Biofloc system because tilapia is in the herbivore group, so the enlargement process is faster [3].

Scale monitoring of fish ponds generally requires a lot of time and is still carried out directly at the location, which is certainly ineffective and inefficient. Monitoring is important because fish growth is strongly influenced by pond water conditions. Fish breeders will always do a variety of things to return the pond water to optimal or neutral conditions. So that the water conditions are good, they usually neutralize the water by adding substances or some natural ingredients, but the administration of these natural substances and ingredients is still classified as manual, and there is no system that can help fish breeders control ponds remotely.

Technological developments in the field of conventionally controlling a device have become autoTurn Offc; one form of implementation is called "smart control," which utilizes an electronic device as a microcontroller. A smart pond control system is implemented to increase the convenience of farmers in controlling fish ponds. In addition, the condition of the pond greatly affects the growth of fish, so it is necessary to monitor it regularly so that control and action in the pond water can be carried out quickly.

Given the importance of continuous monitoring of tilapia biofloc ponds on the success of aquaculture, it is necessary to design a system that can monitor ponds remotely using smart methods [5]

2. THEORY

2.1. Component System

Multimedia comes from the words multi and media. Multi comes from Latin, namely noins, which means many and various. While the word media comes from the Latin medium, an intermediary or something used to deliver, convey, or carry something. The American 17 Heritage Electonic Dictionary (1991) defines the word medium as a tool for distributing and presenting the information. Multimedia is a combination of various media or file formats in the form of text, images (vector or bitmap), graphics, sound, animation, video, interaction, etc., to deliver messages to the public. Multimedia is a combination of data or media to convey information to be presented more attractively [5].

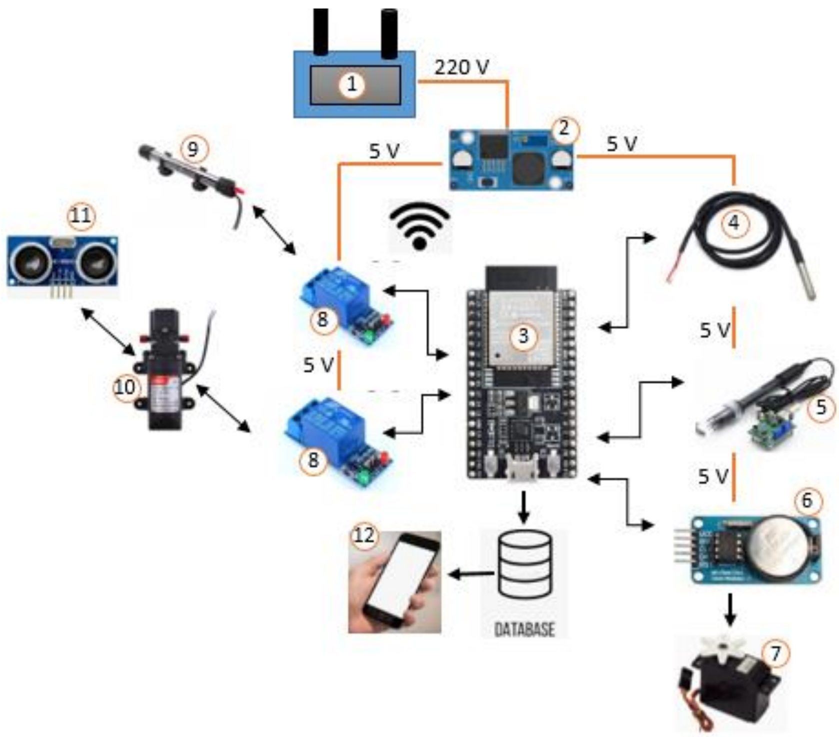


Fig.1. The complete system circuit

From figure 1, it can be seen that the components that are connected to each other form an Internet of things system, having the parts shown in Table 1, so Table 1 and Figure 1 are interrelated.

Table 1. Component number and Function

No.	*Component name*	*Function*
1	DC Power Supply tool	Power Supply
2	Regulator Step Down	DC voltage reducer
3	ESP32	Microcontroller and Communication device use Wi-Fi module
4	Waterproof Temperature sensor DS18B20	Temperature detector
5	pH sensor	pH detector
6	Real-time Clock (RTC)	Timer
7	Servo Motors	Actuators
8	Relay	Controlling Current
9	Heater	Heater
10	Water Pump	Pumping water
11	Ultrasonic sensor	For distance detection
12	Smartphone	GUI User

Figure 1 presents the overall system circuit diagram. The 220 AC voltage is taken directly from the power source, PLN, which supplies voltage to a DC power supply, which can change the amount of electricity from 220 volts to 12 volts. Then the electricity going to the components will be divided into 5 volts using a step-down regulator. The electricity that has been reduced to 5 volts will provide a voltage supply to the ESP32, which will control the DS118B20 waterproof temperature sensor and pH sensor [5, 6] Make sure it is connected to the network or connected to wifi, and then it will be connected to the microcontroller, namely the ESP32. If it is already connected to the ESP32, what the system will then do is read the sensor data. After successfully reading the sensor data, it will continue to save data to the internet, and the stored data will also be autoTurn Offcally stored in the database. Data in the database will be displayed in the application. Then the input from the temperature sensor, pH, and time reading by the RTC will enter the microcontroller [11,12,13], which will provide output according to the input parameter data. After that, the data will be fuzzy-fied or used to determine the output based on the rule. The temperature sensor will turn on the water heater, the pH sensor will turn on the water pump, and the servo feeding component will rotate to open the feed container cover when the set time arrives [9]

3. METHOD

3.1 Flowchart System

The type of research used in this study is experimental research. Experimentation is a research method used to find the effect of certain treatments on others under controlled conditions. This research is basically laboratory-based experimental research. A laboratory experiment is a study that examines the variants of all or almost all of the independent variables that may have an effect, and variables that are not relevant will be kept to a minimum.

System testing is performed to determine several aspects of the quality of the system under test. As for the system testing category, namely functional testing, in this study, the functionality aspect is used to measure the performance of hardware as a whole, such as sensors, microcontrollers, and prototypes, so that it can be seen whether the designed prototype can run well or not.

In this study, the data analysis technique used is descriptive analysis. A descriptive data analysis technique is an analysis technique used to analyze data by describing or illustrating the data that has been collected soberly without any intention of making generalizations from the research results. The data analyzed is obtained from the results of testing the smart control prototype for biofloc ponds for tilapia cultivation using a fuzzy logic algorithm. These tests produce test data that will later support the overall conclusion.

Moreover, Figure 2 explains the flowchart of the entire biofloc pond prototype. It starts with sensor initialization and then reads the input variables from the sensor used. After that, enter the testing phase of the fuzzy logic algorithm; if it is successful, the data from the fuzzy calculation results will produce output based on the needs of the pool and proceed to the conclusion stage until it is finished, but if it fails, it will return to the fuzzy testing stage.

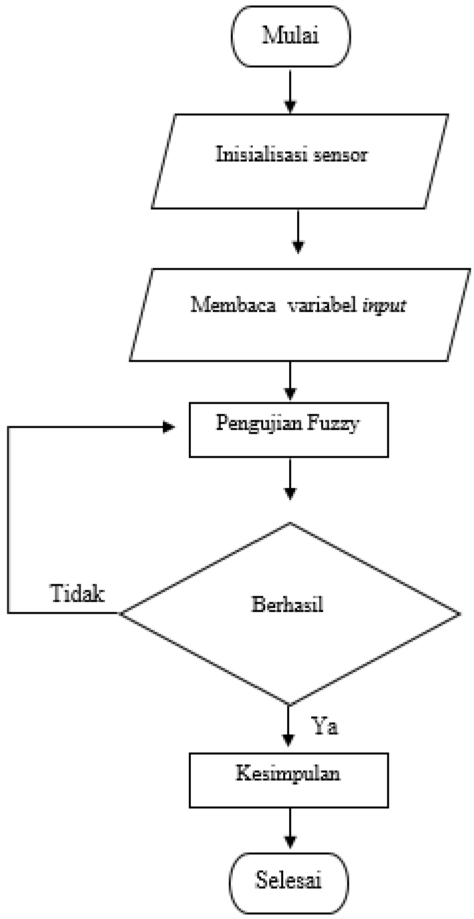


Fig.2. Flowchart System

3.2 Mamdani Fuzzy logic to smart control

The fuzzy logic methods that are used in modern ponds use this method to determine the output based on the data from the parameters attached to the pool, and then the data will be grouped and used to determine the output to the pond so that it is again optimal. The processes used consist of fuzzification and clipping inference processes.

a. Fuzzyfication

In the Mamdani method, it is necessary to determine the input data from the parameters used so that the output can match the input data.

1) Set of Temperature Conditions

Moreover, Table 2 explains the data set for pool water temperature conditions, which are said to be cold when the temperature is at a variable value of 10°C–25°C, normal when the temperature is at a variable value of 25°C–35°C, and hot when the temperature is at a variable value > 35°C.

Table 2. Pool water temperature condition input set

No	Variable Name	Variable Value
1	Cold	10°C - 25°C
2	Normal	25°C – 35°C
3	Hot	> 35°C

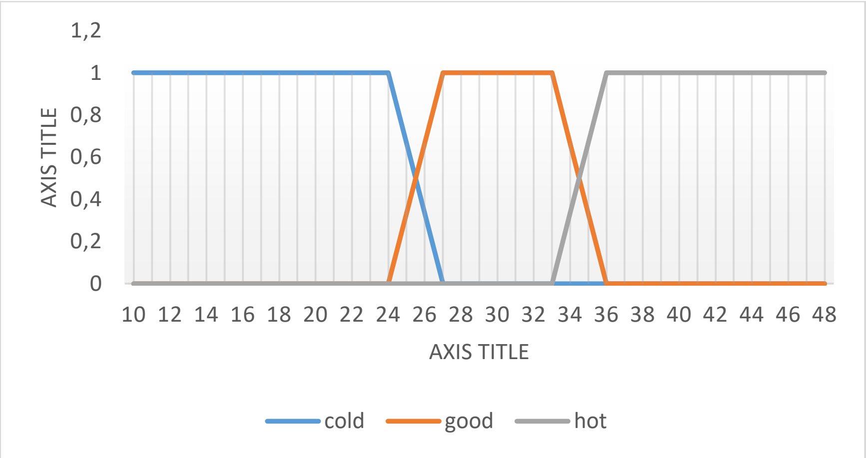


Fig.3. Curve set of temperature conditions

Figure 3 is a fuzzy set curve figure for the pool water temperature condition variable, which is made for cold, normal , and hot temperature variables.

Table 3. Set of pool water temperature output condition

No	Variable Name	Variable Value
1	*Heater* Turn ON	1
2	*Heater* Turn OFF	0

Table 3 explains the set of pond water temperature output conditions. When the heater is on, the variable value is 1, and when the heater is off, the variable value is 0.

2) *Set of pH conditions*

Table 4. Set of pond water pH input conditions

No	Variable Name	Variable Value
1	Acid	0 - 6,5
2	Neutral	6,5 – 8,6
3	Base	> 8,6

Table 4 explains the set of pond water pH input conditions. Temperature conditions are said to be acidic when the variable value is 0-6.5, neutral when it is 6.5-8.6, and alkaline when it is > 8.6.

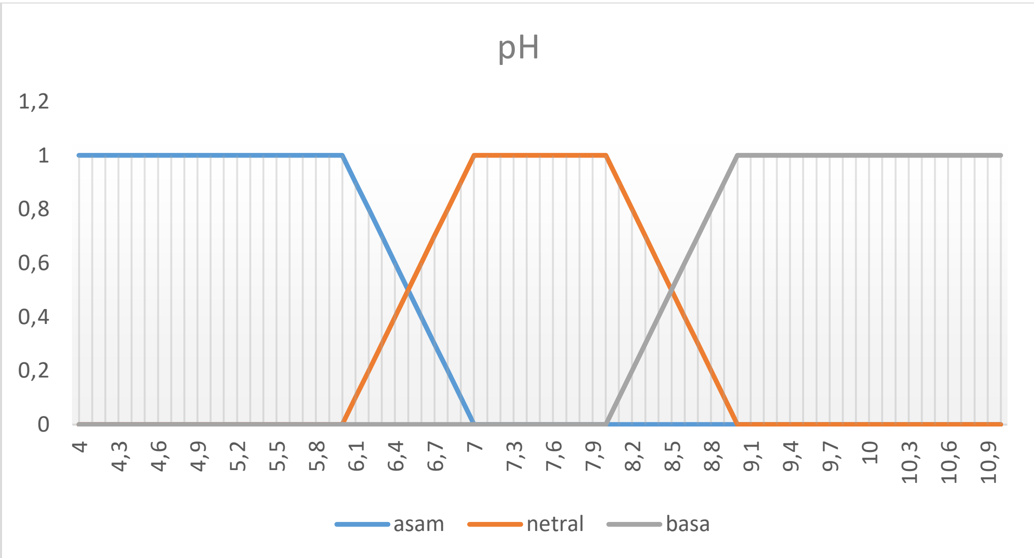


Fig.4 Fuzzy set curve for pond water pH conditions

Figure 4 is a fuzzy set curve for the variable pH conditions of pool water for acid, neutral, and alkaline pH variables.

Table 5. Set of pool water pH output conditions

No	Variable Name	Variable Value
1	Water Pump Turn ON	1
2	Water Pump Turn OFF	0

Table 5 explains the set of pond water pH output conditions. When the water pump is on, the variable value is 1, and when the water pump is off, the variable value is 0. The process of reference or inference is the process of creating a mapping from the parameters' input or input data and then determining the pool's output or output. In the process of the Mamdani fuzzy logic method, there are several rules to assist in making decisions. In this study, there were six fuzzy inputs, including cold, normal, hot, acidic, neutral, and alkaline. Then the process of clipping inference by selecting the minimum degree of membership of the linked linguistic values so as to obtain:

1) *If* Temperature Cold And pH Asam *Then* Heater Turn ON, pompa Turn ON
2) *If* Temperature Cold And pH Normal *Then* Heater Turn ON, pompa Turn Off
3) *If* Temperature Cold And pH Base *Then* Heater Turn ON, pompa Turn ON
4) *If* Temperature Normal And pH Asam *Then* Heater Turn Off, pompa Turn ON
5) *If* Temperature Normal And pH Normal *Then* No Action
6) *If* Temperature Normal And pH Base *Then* Heater Turn Off, pompa Turn ON
7) *If* Temperature Hot And pH Asam *Then* Heater Turn Off, pompa Turn ON
8) *If* Temperature Hot And pH Normal *Then* No Action
9) *If* Temperature Hot And pH Base *Then* Heater Turn Off, pompa Turn ON

3) Inference

Table 6 describes the differentiation process in modern biofloc ponds. The reference table contains the input data from the sensor and the output that will be given to the pool based on the condition of the sensor input data.

Table 6. Inference Process

No	Input		Output
	Temp	**pH**	
1	Cold	Acid	*Heater* Turn ON, *pump* Turn ON
2	Cold	Normal	*Heater* Turn ON, pump Turn Off
3	Cold	Base	*Heater* Turn ON, *pump* Turn ON
4	Normal	Acid	*Heater* Turn Off, *pump* Turn ON
5	Normal	Normal	No Action
6	Normal	Base	*Heater* Turn Off, *pump* Turn ON
7	Hot	Acid	*Heater* Turn Off, *pump* Turn ON
8	Hot	Normal	No Action
9	Hot	Base	*Heater* Turn Off, *pump* Turn ON

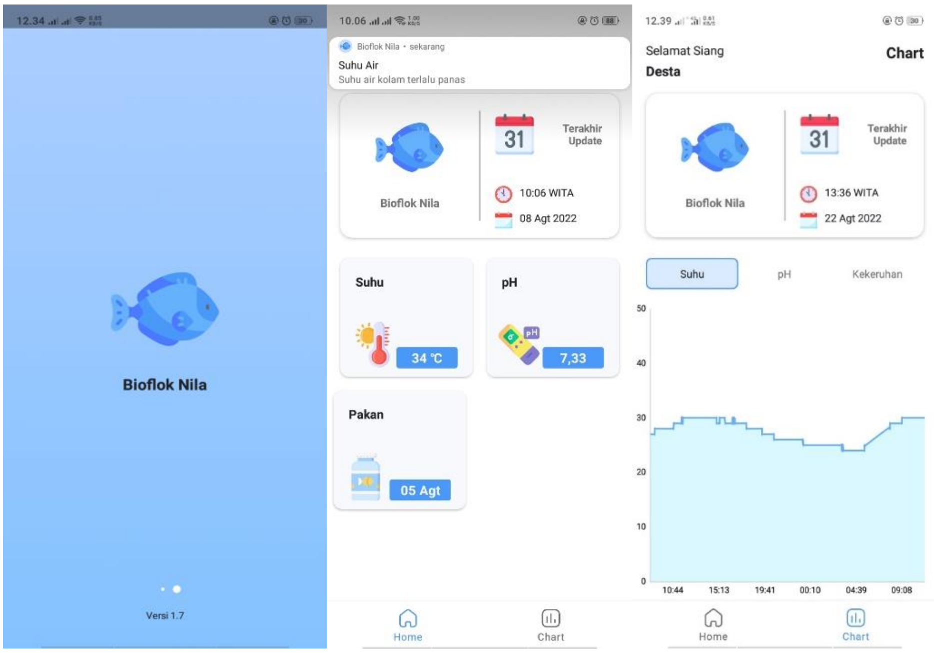
4. RESULT AND DISCUSSION

4.1 Description of the resulting product

Good water quality greatly affects the growth of fish, and it is necessary to monitor on a large scale so that the water is always in optimal condition. Usually, breeders will need a lot of time to manually monitor their ponds. With the Smart Control tool for tilapia biofloc ponds using a fuzzy logic algorithm and equipped with an application for monitoring and displaying notifications based on data from parameters, it will help the work of tilapia breeders because they can monitor the performance of the tools applied to the pond through the application and provide output based on fuzzy rules. The fuzzy logic method is used in smart control, where this method determines the output based on the data from the parameters attached to the pool, and then the data will be grouped and the results of the fuzzy rule will determine the output to the pool so that the pool is again optimal. This tool is made up of several parts, including a temperature sensor and a pH sensor, and it is fed automatically by an ESP32 microcontroller [7].

The smart control prototype design will be installed in the aquarium. Parameters will work to measure the quality and condition of the water to determine whether it is in optimal condition for tilapia or not, and the water quality measurement data will be stored on the microcontroller. If it is in optimal condition, then no action is taken by the tool; in this case, what happens is only monitoring, where the data results from the parameters can be seen in the application. If, after the temperature measurement is obtained, the temperature range is 10°C–24°C, which means the temperature is cold, then the water heater will turn on until the optimal temperature returns. The pH measurement is said to be bad if the pH is acidic in the range 0–6.5 and the pH base is in the range >7.9; then the water will be pumped and replaced with new water. The pumped water will not be drained completely because an ultrasonic sensor is used to detect the water level.

Application Display



(a) (b) (c)

Fig. 5 (a) Splash screen display, (b) Home menu display, (c) Charts menu display

The water pump will turn off when the ultrasonic sensor detects a height of 30 cm from the surface of the aquarium. The application in this study is used to monitor conditions in ponds. The following is the result of a screenshot of the application that was built using the Android Studio used in this study. Moreover, Figure 5 (a) is a splash screen or opening page that is only seen temporarily when entering the application menu. Figure 5 (b) contains the home view, which contains monitoring data from the parameters used. On the home menu, there is data on the results of temperature, pH, and feed, as well as time and date reports in real time. And Figure 5 (c) is a display of the Chart menu, which contains a graph of the changes from the monitoring parameters used in the report. In this menu, you can see every graph report from temperature and pH.

1) Notification Display

In Figure 6, there is a notification display that appears when there is a change in conditions in the pond that is measured using parameters. Notifications in this study are also used as reminders or timely information to notify farmers about conditions in the ponds being monitored using an application and to open the application or take action directly from the notification.

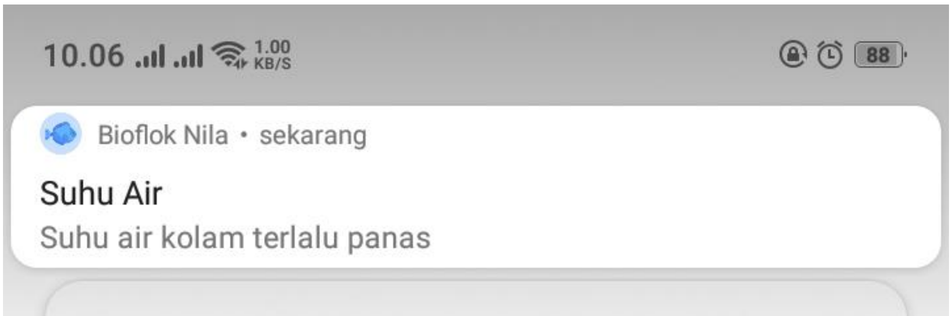


Fig.6. Notification display

2) *Trial Result*

At this stage, the system design was tested using Blackbox to determine system performance in terms of functionality on the devices used. The following are the results of testing the smart control system for biofloc ponds for tilapia cultivation using a fuzzy logic algorithm.

4.2.1 Hardware Testing

In this research, hardware testing includes testing all the components that make up the tool to determine whether they can work properly or not.

1. *Testing the ESP32 microcontroller port*
   Testing on port esp 32 as a microcontroller is intended to determine whether the input and output data work as described on the system.In testing, the Arduino IDE program was used to find out the analog input from the sensor that entered the microcontroller port, and the input data sent to the Android-based application went well [4].

2. *Testing sensor-to-temperature*
   The temperature sensor used in this study is the DS18B20 from Maxim IC, which is capable of reading temperature with 92 to 212-bit accuracy and a range of -55 °C to 125 °C with accuracy (0.5 °C). This sensor uses 1-wire communication, which means it only requires one pin and has 64-bit storage. The manual measuring tool used is a thermometer, which will measure the accuracy of the temperature sensor.

Table 7. A thermometer with a temperature sensor is used to make the measurement.

Thermometer	*Sensor Temperature*	*Error*
30°C	29°C	1
15,78°C	15°C	0,78
24°C	25°C	1
26°C	25°C	1
14°C	15°C	1
5,50°C	25°C	0,50
9°C	10°C	1

To calculate the average error value of the tool, then:

Number of total errors/number of samples

=1+0,78+1+1+1+0,50+1/7

=6,28/7 = 0,89

4.2.2 pH Sensor Testing

The pH sensor used serves to measure the level of acidity or wetness of the solution. Manually measuring the pH of water with two litmus papers The pH measurement experiment using a sensor and litmus paper was tested 10 times in water that had been added to a pH up and pH down solution. Then it will be tested for the application of smart control using an algorithm.

Table 8. Measurement results on litmus paper with a pH sensor

Litmus Paper	*pH Sensor*	*Error*
10	10,30	0,30
5,49	5	0,49
10	10,39	0,39
9	9,68	0,68
3	3,18	0,18
10	10,83	0,83
4	4,57	0,57
10	10,56	0,56
10	9,99	0,1
5	5,36	0,36

To calculate the average value of the tool error, then:
Total number of errors/number of samples
=0,30 + 0,49 + 0,39 + 0,68 + 0,18 + 0,83 + 0,57 + 0,56 + 0,1 + 0,36
=4,46/10 = 0,44

4.2.3 Feed Testing

In this study, a servo motor was used for feeding, that is, opening and closing the lid of the container where the container is used to store tilapia feed. The servo will work according to the measurement results inputted by the sensor into the microcontroller. If the time has been set in the program, the servo will open the feed container cover and leave it open for 10 seconds, and at that time an application notification will appear on the cellphone. The feeding times that have been set in the program are morning (08:00 WIB), afternoon (12:00 WIB), and afternoon (18:00 WIB). Servo testing is done by observing whether the feed container cover moves at the set time and successfully sends notifications to the application. Moreover, table 9 is a overall Product Testing.

Table 9. Overall product performance description

Component	Function	Description
ESP 32	as a prototype control center and also as a program repository.	working properly
Temperature sensor	Measuring the temperature value in pool water	working properly
pH Sensor	Measuring the pH value of pool water	working properly
Feeding	able to provide feed according to a predetermined schedule	working properly
Application	able to monitor and provide notification of the results of the prototype.	working properly

```
Entrance:
        Temperature: 24, PH: 7.92
Send Firebase Cloud Messaging...
        Temperature: Cold-> 1.00, Good-> -0.00, Hot-> 0.00
Input:
        PH: Asam-> 0.00, Normal-> 1.00, Basa-> 0.00
Output:
        Heater: IncTemp-> 1.00, AvrTemp-> 0.00, DecTemp-> 0.00
        Pump: IncPh-> 0.00,  AvrPh-> 1.00,  DecPh-> 0.00
Result:
        Heater: 6.48, and Pump: 0.00
        Heater: NYALA
        Pump: MATI
Range : 20.22
13/7/18
Range : 20.22
13/7/23
Range : 20.22
13/7/26
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Fig.7. Display serial monitor arduino IDE

In Figure 7, a performance monitor is displayed on the Arduino IDE when the system is running and working properly and there are no errors according to the input parameter data. On the display there is a report of a temperature condition of 24 °E when the system is running and working properly and there are no errors according to the input parameter data. On the display there is a report of a temperature condition of 24 °C, which means cold is worth 1.00, which is where the heater will turn on for 6.48 seconds until the temperature returns to normal, and pH 7.92 is categorized as normal, which is worth 0.00, where the water pump is off.

3. CONCLUSIONS

The results of the smart control design for biofloc ponds for tilapia cultivation using a fuzzy logic algorithm, which produces a system that can control the pond remotely, are as follows: a. All parameters used will provide input to ESP 32 and will provide output according to sensor requirements using fuzzy logic algorithm rules. The temperature sensor will give an output in the form of a notification or warning about temperature conditions, and then the water heater will turn on if the temperature is cold. The pH sensor will give an output in the form of a notification about the pH condition of the water, and a new water change for the pool that is draining water will not cause water to run out because researchers use ultrasonic sensors that are able to detect the maximum water level to be drained, which is at a height of 30 cm. Furthermore, in the feeding process, a servo is used to open and close the feed container, whose time is set in the morning (08:00 WIB), afternoon (12:00 WIB), and evening (18:00 WIB) on the Real Time Clock (RTC) sensor. Based on the results of system testing in terms of functionality, namely hardware testing and overall testing, Furthermore, overall testing shows that the prototype works according to the input to the microcontroller and also provides output based on fuzzy logic algorithm rules.

AUTHOR CONTRIBUTIONS

Conceptualization; J.M.Parenreng [J.M.P], Syahrul [SS], A.Wahid [AW], D.W,sary [DWS], methodology; [JMP],[SS],[AW],[DWS]; validation; [JMP],[SS],[AW],[DWS], formal analysis; [JMP],[SS],[AW],[DWS], investigation; [JMP],[SS],[AW],[DWS], data curation; [JMP],[SS],[AW],[DWS], writing—original draft preparation; [JMP],[SS],[AW],[DWS], ;writing—review and editing; [JMP],[SS],[AW],[DWS], visualization; [JMP],[SS],[AW],[DWS], supervision; [JMP],[SS],[AW],[DWS], project administration; [JMP],[SS],[AW],[DWS], funding acquisition; [JMP],[SS],[AW],[DWS], have read and agreed to the published version of the manuscript.

ACKNOWLEDGMENTS

Thanks to all parties, especially at Makassar State University who have helped to complete this research, perfect the data, and process the data so that this article can be finished. Thanks to everyone, especially my parents Agustinus Wempi and Veronica Sesa and my younger siblings Atjuan Gunawan Selang, Wallensius Po'tonan and Februona Daun Rara. Hopefully this research can be useful for many people.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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