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IoT-based guppy fish farming monitoring and controlling system

Periyadi, Gita Indah Hapsari, Zahir Wakid, Sobran Mudopar
Telkom University/School of Applied Science, Indonesia

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ABSTRACT

Nowadays, monitoring of guppy fish farming is still done manually. A monitoring and control system is needed to make it easier for guppy fish farmers. This system consists of a sensor module and monitoring module. Sensor module detects the value of pH and salinity of water and send it to the monitoring module. Monitoring is used as a web-based system using IoT technology. This web-based system serves to monitor and control the pH value and only monitor the salinity value. The workings of the monitoring and control system send data on pH and salinity sent by the sensor and then stored and in database hosting. Data on the database will be displayed on the website using wireless media, making it easier for users to view data and information remotely. Beside, farmers are facilitated in knowing the value of pH and salt content dissolved in water. For the value of a dangerous salt content worth less than 160 and more than 210, if for a pH of less than 6.5 and more than 7.5. Farmers are also facilitated to control pH with servo motors through the website, so farmers can prevent if the pH content dissolved in water is dangerous for guppy fish.

Corresponding Author:

Periyadi,
Telkom University/School of Applied Science,
Telecomunication street, Indonesia.
Email: periyadi@tass.telkomuniversity.ac.id

1. INTRODUCTION

Freshwater ornamental fish farming is in great demand in Indonesia compared to seawater aquaculture. This is because freshwater ornamental fish cultivation is easier than seawater fish cultivation. Ornamental fish is also very beautiful. One type of fish that is in demand is guppy. Although guppy fish have small shape, it has the beauty of color throughout its body and its many types of guppy fish. In Indonesia, many people do cultivation of guppy fish as a business. Although apparently guppy fish farming is not an easy thing. Many farmers often fail due to a lack of care in preparing guppy fish.

In guppy fish farming, there are several aspects must be considered by farmers. Various methods carried out by guppy fish farmers like feeding methods [1] and how to maintain water quality in guppy fish ponds [2]. If the farmers do not pay attention to the water content carefully, of course, it will produce guppy fish with low quality. Even poor water quality is very dangerous for the survival of fish or can cause death.

Water quality parameters on fish farms include levels of nitrogen in the water, oxygen levels, water temperature [3]. pH is one of the important water parameters in determining water quality. pH values that are too high or too low can cause threats and are dangerous for the survival of fish life [4]. Based on one study it is said that certain water content can produce guppy fish production with certain genes [5]. Temperature can also affect the amount of guppy fish production with the sex of particular sex [6]. Some farmers add other ingredients to maintain water quality, in order to produce good quality guppy fish [7].

Water Salinity can also affect the quality of guppy fish produced. High salinity can cause death for guppy fish. One study said guppy fish can live up to 30 ppm salinity but are accompanied by a bioacoustic sound -44 dB at 40-50 seconds of time range [8]. Water temperature is also an important factor to maintain the quality of guppy fish growth. Paliwal suggests that fish growth increases with increasing water temperature [9]. Tarang kumar shah in his research stated that water temperature that is good for guppy fish growth is 28ºC to 30ºC [10]. Temperature water also accelerates the process of fish metabolism and increases the appetite of Guppy Fish [11].

Several studies have been developed in fish farming using various types of measurement variables and various methods and technologies. Several studies proposed an automatic system for the fish feeder. One of them was stated by Hidayatul Nur Binti Hasim, et al, who developed a system of fish feeding through web applications using Raspi [12]. Another researcher also suggested a fish feeding system using the IoT method [13]. Other researchers proposed automatic fish feeders that combine mechanical and electronic systems using PLC (Programmable Logic Circuit), GSM (Global System for Mobile) and motors [14].

The technology to support fish cultivation was not only in feeding fish, but they were proposed a system to monitor the quality of water. It is important to maintain the water quality of fish cultivation. The aquaculture will influence the quality of fish. The low quality of water will cause fish disease and it will impact directly to fish growth and harvesting yield [15, 16]. Monitoring water quality using technology was proposed by Daudi S. Simbeye, namely by making water quality monitoring and control systems using wireless sensor network technology [17]. Monitoring systems for pH levels and temperature control in fish farming using IoT were put forward by several researchers. One of them is Al Qalit which makes a tribal control system and pH for catfish [18]. Eng. Nocheski conducts water monitoring including temperature, light intensity and level on fish farming using IoT [19]. Mochammad Hannats Hanafi Ichsan proposed another method to monitor water quality. They used fuzzy logic control based on graphical programming [20].

There are still not many studies that research in automation and monitoring systems of guppy fish cultivation. One study of applied technology on guppy fish farming is the use of the biomimetic fish robot to investigate individual differences in social responses in guppies [21]. Research on the application of technology about farming is mostly done in arowana fish [22, 23]. Other Studies are more about applying technology for raising fish in an aquarium [24, 25]. After studying the results of several guppy fish studies and technology which are implemented in guppy fish farming, in this research we built a system that can monitor the pH and salinity of water remotely and control feature on liquid pH neutralizing based on IoT technology to maintain pH levels stability in water.

2. PROPOSED SALINITY MONITORING AND pH CONTROL ON GUPPY FISH FARMING

The entire block diagram of the system is shown in Figure 1. The system consists of two parts, The automation/controlled module (CM) and the monitoring module (MM). The CM is a part that consists of pH and salinity in a water sensor. This module uses Arduino to process input parameters obtained from sensors. The servo motor in this module serves to open the valve of the pH-rising liquid and Ph-lowering liquid. While the buzzer is used to provide a warning indicator if the pH or temperature of the water is abnormal. All values on the sensor are processed on the microcontroller and displayed on the LCD. All state parameters detected on the sensor are then sent by Arduino to the monitoring module.

The MM is a part that handles remotely monitoring using a web application. In the monitoring module, Raspi is used as a processor and sends data to database cloud storage. The web application is made to display all data regarding pH and salinity. The process of controlling the opening of the pH neutralizing valve can also be done through a web application via the virtual button.

The system implementation starts with establishing a connection between the pH sensor and Arduino. The sensor is connected to the Analog A0 pin on Arduino. While the salinity sensor is connected to pin A1 on Arduino. The servo is connected via PWM 2 and 3 digital pins. Whereas the buzzer is connected to pin 13 on Arduino. The Arduino is connected directly to the USB Raspi port using a serial cable to be able to connect Arduino with the Raspi to send data to one another.

The CM flow chart is shown in Figure 2. Initially, the module will detect the value of the pH and Salinity sensor. If the salinity is more than 210 or pH value is more then 7.2 then the buzzer will turn on. Then salinity data and pH values are sent to the monitoring module. The process continued by receiving data from the monitoring module. If there is a control signal from the monitoring module on the motor via the virtual button, the system will check whether the pH reduces button or the pH raising button is pressed. The button type is detected and action will be taken on the motor to open the valve. Figure 3 shows the flowchart of the MM. In the beginning, the module will receive data from the CM and then send the data to the cloud database. If buttons to reduce pH in web application is pressed then the data '1' will be sent to the CM and if the button to increase pH is pressed, the data sent is '2'.

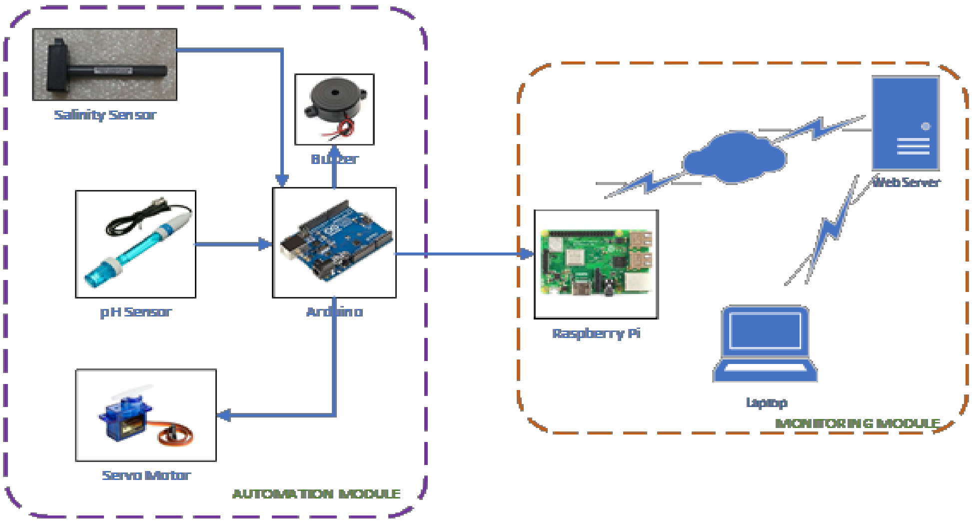


Figure 1. Salinity monitoring and pH control on guppy fish farming block diagram

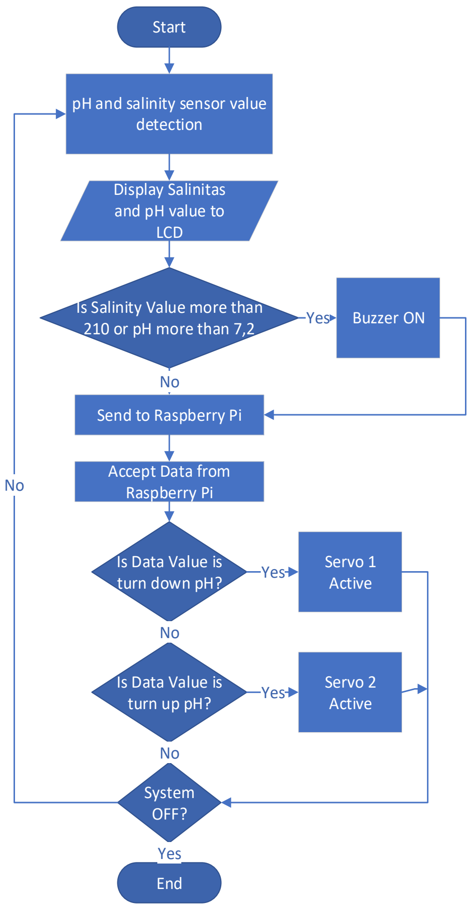


Figure 2. Sensor module flowchart

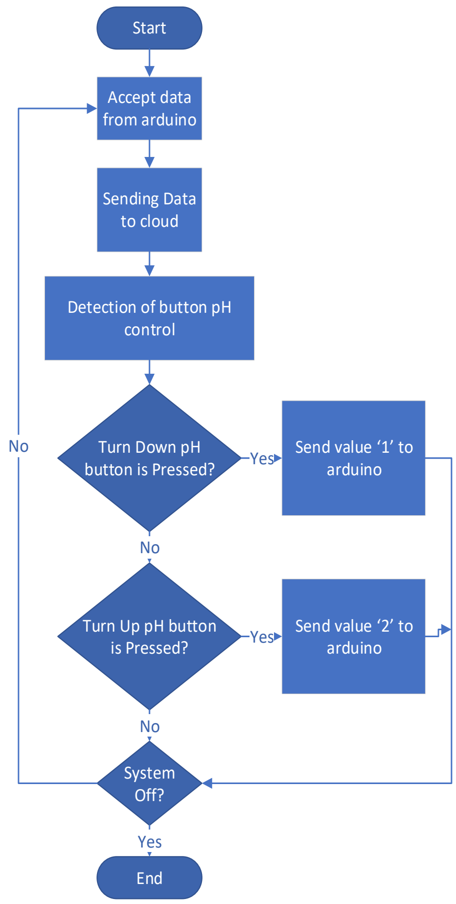


Figure 3. Monitoring module flowchart

The process of sending data of sensor pH and salinity to Raspi is carried out using the data protocol as shown in Figure 4. For example, if the data is sent ‘Salinity Value=150 and pH_Value is 7.15 then the salinity value and the pH value is sent to raspi using data protocol as shown in Figure 4. Figure 5 shows the protocol for sending data from Raspberry Pi to Arduino. For example, if the data sent is ‘User_id=1, ph=7.15, salinity=150 then the data protocol configuration is shown in Figure 5. The user interface of the web application is shown in Figure 6. The application web consists of a panel that displays the pH sensor value, salinity value, and their classification. There are 2 buttons, pH UP button and pH Down Button. pH down button is used to open the valve of pH-lowering liquid while the pH Up button is used to open the valve of pH-rising liquid.

Byte	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Data	Header + Salinity Value															Sto	Header and Ph Value														Stop Bit
Example	"Salinity Value =", 150																"pH_value =", 7.15														

Figure 4. Arduino to raspi protocol

Byte	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Data	Header + User Id									Stop Bit	Header + pH Value							Stop Bit	Header + Salinity Value												Stop Bit
Example	"User_Id=", 1										"pH=", 7.15								"Salinity=", 150												

Figure 5. Raspi to arduino protocol

Figure 6. Web application user interface

3. RESEARCH METHOD

The research method is a waterfall methodology. The first step is analyzing the requirements to design the system. There is a literature study of all the knowledge about guppy fish farming and collect data value about the variable that will use in the system. It is also studying several technologies that have been implemented by other researchers on fish farming to know the right method for designing automation and monitoring system, especially guppy fish. Literature study about guppy fish is based on journal and interview with the farmer.

The next step is arranging the system requirements analysis based on literature studies that have been carried out and continued by determining the needs of hardware and software components and designing the system. Implementation process is the next step which the process is started by testing of each sensor is carried out to determine the specifications of the sensor. The yield produced will be specified as a reference to determine the normal state of salinity and pH. Especialy for salinity sensor, there isn’t enough information about the specification of the sensor. This has to be done to get an affordable system, this implementation used a sensor that is quite cheap. It causes we need to do a series of a calibration test to produce an accurate result as we did on this research for the salinity sensor. So there is a several test to get information about the value of salinity sensor compared to salinity value in ppm (part per million). The data of salinity sensor value is processed using interpolasi newton polinom methode to get the equation formula. The final step in implementation is to integrate all the component of the system. Next is continued by conducting a series of tests to know the performance of the system.

4. RESULTS AND DISCUSSION

The testing is carried out in several stages to find out the performance of the tool. Testing consists of the salinity sensor test, pH sensor test, sending data from the sensor module and control to the monitoring module, integration testing.

3.1. Salinity sensor testing

Salinity sensor testing is carried out to measure the correlation of the salinity value in mol/liter with the voltage produced. Tests are carried out by dissolving as much weight of salt into 1 liter of water. The salt used is a special salt for ornamental fish. The salt is stirred in the water until it dissolves. The salinity sensor is inserted into the solution then the value that comes out of the sensor is measured. From the sensor value, the average value is calculated and processed using Newton polynomial interpolation to determine the analog value of salinity.

The result of the equation from the polynomial interpolation is shown in (1). From this equation, a graph is formed as shown in Figure 7. A good salinity value is 1 ppm or equal to 0.001 grams/liter. Based on the equations and graphs, the value of 1 ppm or 0.001 grams/liter is represented by an analog value equal to 180.12. This value will be used as a normal or no limit to the state of water salinity.

$$p_n(x) = 179.09375 + 2x^3 - 1172{,}92x^2 + 1035.4025x \qquad (1)$$

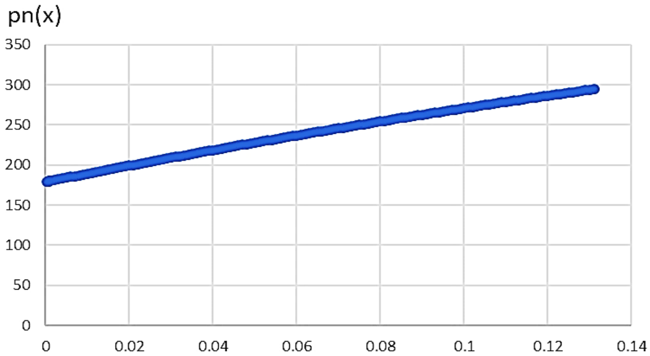


Figure 7. Graph of water salinity

3.2. Testing of pH sensor and time length valve opened to the volume of liquid

Testing the water pH sensor is done by dissolving the pH-lowering solution and increasing the pH by 1 tablespoon (15 ml) into the water with a volume of 300 mL Table 1. This pH liquid is a special liquid for ornamental fish. The water used is filtered water specifically for guppy fish. Based on the test results shown in Table 1, for a volume of 300 mL of water if given 15ml of pH lowering, the pH of the water will drop by 0.96. Whereas if given a pH rising liquid, the pH of the water will increase as much as 1.52.

The next experiment is to test the delay in opening the pH-neutralizing fluid valve to the volume of liquid coming out Table 2. Experiments are carried out by opening the valve with a certain delay and measuring the volume of fluid coming out. The measurement of the liquid that comes out is done using a measuring spoon. The results of this test are used to determine the length of time delay for opening the fluid valve, which is 2.9 seconds delay for once opening the valve. Based on this result, the time delay will be used to open the pH liquid is 1 second.

Table 1. pH sensor test

Solution	pH Value
Water	6.94
Water 300ml + 15 ml pH down	5.98
Water 300ml + 15ml pH up	8.46

Table 2. Testing the time length the valve is opened to the volume of liquid

Liquid pH volume (ml)	Time lenght valve opened (second)
5	1
7.5	1.6
10	2.1
15	2.9

3.4. Integration testing

Integrated testing is done by integrating all parts and running the entire system. Integrated testing is carried out in various stages, namely:

- Testing the pH value and appearance on the web application and its classification
- Testing the value of Salinity and its appearance on the web application and its classification.
- Servo control testing in ascending and pH-lowering liquids through we application

Testing the pH value and appearance on the web application aims to determine whether the pH measurement value can be displayed on the web properly. The results of displaying pH values on the web application are shown in Figure 8. Based on the test results it was found that the pH value measured in the sensor module and control was sent and displayed properly on the web application. Similarly, the classification is in accordance with what has been determined. The test was carried out three times, which can be seen in Table 3. The data entered in the database differs from the date so that farmers can see the changes by displaying graphs as shown in Figure 8. Salinity values and pH values will be displayed as in Table 3, where only the last enter the database displayed. Testing the virtual button pH down and pH up is done to find out whether the button function can move or control the servo attached to the valve for pH-lowering and pH-Rising fluid. Testing is done by pressing the virtual button and observing what happens to the servo. The test results can be seen in Table 4.

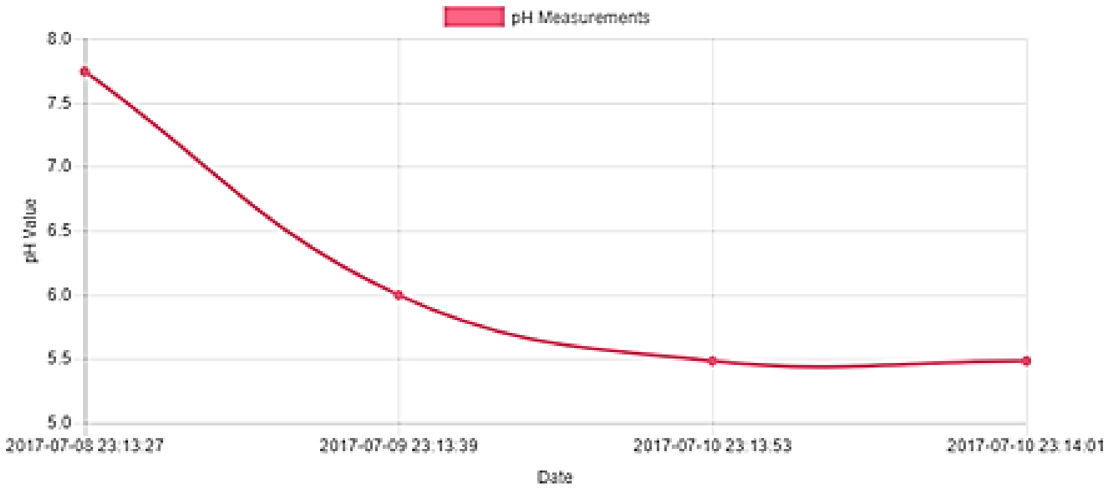


Figure 8. Graph of pH sensor on web application

Table 3. pH sensor test

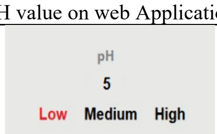
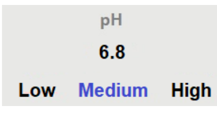
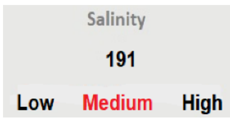
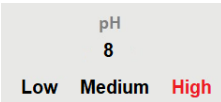
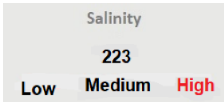
No	pH value displayed on LCD	pH value on web Application	Salinity	Salinity Value on web application
1	5		135	
2	6.8		191	
3	8		223	

Table 4. pH sensor test

Button	Servo	Explanation
pH up	Servo 1 active (pH-Lowering Liquid)	The valve is opened for 1 second
pH Down	Servo 2 active (pH-Rising Liquid)	The valve is opened for 1 second

3.4 Response time test

The data in Table 5 is obtained by looking at the time on the Rasberry Pi with web hosting to find out the difference in time data entered on the Raspberry Pi with the website. In Table 5 the time for sending data from the sensor module controls the pH and salt content in the form of pH and salinity values sent from the Raspberry Pi to the website using an internet connection. The internet connection can affect the time difference between the data entered on the Raspberry Pi and the data displayed on the website. The response time of the servo motor movement until pH liquid mixed well to the water is showed in Table 6. Besides, the greater the number of droplets given, the more data will be entered on the Raspberry Pi and database hosting so that the information displayed on the website with the LCD in the system module controls the pH and salt content so that it takes longer.

Tabel 5. Response time data from raspberry Pi to website

No	pH value	Salinity	Data Entry	Time difference (second)
1	7.11	152	21:28:33	-
2	7.11	152	21:28:38	5
3	7.11	152	21:28:40	2
4	7.11	151	21:28:43	3
5	7.11	151	21:28:45	2
6	7.11	151	21:28:48	3
7	7.11	152	21:28:54	6
8	7.11	152	21:28:56	2
9	7.11	151	21:29:02	7
10	7.11	151	21:29:05	3

Tabel 6. Response time servo motor movement until pH liquid is mixed well

No	Frequency of virtual button pressed	Initial pH value	Final pH value	Response Time (minutes, seconds)
1	1 x	7.8	7.4	03:03
2	2 x	7.8	7.14	03:57
3	3 x	7.8	6.9	06:09

5. CONCLUSION

Based on the test result, the whole system can work properly. This is indicated by the value of salinity and pH can be displayed continuously on the web application and value according to the value stated on the LCD. The valve opening system in pH neutralizing fluids can function properly but there is still a delay in response. Data transmission can be done with a time difference of about 2 to 7 seconds. For future development, the system can be added with a temperature sensor and equipped with temperature settings so that the water temperature can be adjusted according to the needs of farmers.

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