THE PROTOTYPE OF AQUARIUM WATER QUALITY MONITORING SYSTEM

[1]Andres Dito Wira Oktianto [2]Rosita Herawati
[1,2]Informatics Engineering, Faculty of Computer Science,
Soegijapranata Catholic University
[2]rosita@unika.ac.id

ABSTRACT

One of the Indonesian people's hobbies is keeping ornamental fish. Ornamental fish are kept in ponds or aquariums. One thing that is very important to consider in maintaining ornamental fish in an aquarium is water quality. Dirty water quality can inhibit the growth and development of fish. The optimal temperature range for the life and development of aquatic organisms ranges from 25 to 35oC, while the acidity level in the aquarium model is at pH 6.8-7.5 [7]. Turbidity does not use NTU units but is as a voltage that is read by the sensor. If the low voltage is below 1 volt or less than 2 volts, then the water is said to be cloudy, but if the voltage is above 2 volts, then the water is declared clean [2]. The fuzzy algorithm will process data from the sensor, which is used to determine whether the buzzer is on or off. With this tool, it will be easier for the owner to monitor the aquarium water.

Keywords: sugeno fuzzy logic, Aquarium, pH sensor, Turbidity, Temperature

INTRODUCTION

Fish are widely used in human life, both for consumption and as ornamental fish. One of the hobbies of the Indonesian people is keeping ornamental fish. Ornamental fish are generally kept in ponds or aquariums. One thing that is very important to note in maintaining ornamental fish in an aquarium is water quality. Dirty water quality can inhibit the growth and development of fish. Factors that cause aquarium water to quickly turn dirty include no water filter or water filter not working optimally, food residue that dissolves in water and makes water conditions change. In addition, the owner does not routinely monitor and change the aquarium water.

From the above problems, a tool is made to monitor the quality of aquarium water for ornamental fish habitats. This system applies the concept of Internet of Things (IoT) and fuzzy algorithms to process data from sensors into definite output. This aquarium water quality monitoring system uses several sensors that will read parameters that are indicators to see water quality, such as temperature, acidity (pH) and turbidity.

This system uses three sensors, namely turbidity, pH, and temperature sensors that will detect the content in the water, then the sensor sends data to be displayed on a 16x2 LCD. The fuzzy algorithm will process data from the sensor. Where the output of fuzzy is the sound of a buzzer, which serves as a reminder that the water is getting dirty and ready to be replaced.

The following are limitations on the aquarium water quality monitoring system. This system cannot display data online, only displays data on the LCD. The buzzer is just a reminder that the water in the aquarium is getting dirty and ready to be replaced. Water changes are still done manually. Using the Sugeno fuzzy algorithm to process the input data and map it to the output. The output produced by the turbidity sensor (Turbidity) is not 100% correct.

The aim of this project is to make it easier for the owner to monitor the aquarium water and remind the owner when it's time to change the water. Algorithm fuzzy logic can run on tools that are built. All sensors can work properly and the results displayed are in accordance with the existing data.

LITERATURE STUDY

In this process, the authors collect and read journals related to monitoring water quality in aquariums or water quality for fish farming. The data taken in the form of parameters that can affect the quality of aquarium water, such as pH, temperature and turbidity.

Research journal from Robinson A. Wadu et al. [2] discusses a circulation system in freshwater fish aquariums based on water turbidity. The purpose of this research is to create a system that can detect the turbidity of the water in the reservoir or aquarium automatically. The system they built uses a turbidity sensor, while for processing and control using Arduino Uno ATmega328 and Arduino Uno ATmega2560. This system will detect the turbidity of the water at the specified level. The system will monitor and send data to the user via SMS, if the system detects the water is getting cloudy then the system will drain and enter clean water automatically.

Research journal is from Shaifany Fatriana Kadir [6] discusses systems that can monitor water quality and control the feeding of ornamental fish in an aquarium. The purpose of this study is to create a system that can monitor the state of the water and automatically feed the aquarium. The hardware used in the implementation is Arduino Uno as a control tool, by applying the fuzzy logic method to the speed of the water pump in filtering water. System testing was carried out using a ds18b20 sensor to measure water temperature, a turbidity sensor to measure water turbidity, a pH sensor to measure water acidity, and an infrared sensor to detect feed.

The next research journal, from Riyan Kharisma and Suryadhi Thaha [7] discusses how to handle water quality with an Internet of Things-based system. The goal is to create a system that can display data in real-time using a pH sensor, a DS18B20 temperature sensor, and a TDS sensor as a reader of salinity levels in the water. Data processed from these sensors use the NodeMCU ESP8266 microcontroller, the processed data will be forwarded via IoT to be sent to the server and forwarded to the user (telegram) automatically. When the water conditions are not in accordance with normal conditions and the data is less or more than the normal water data entered, an automatic notification will appear and will be handled automatically.

Journal from Muchammad Cholilulloh [11], and his friends who discussed the use of fuzzy algorithms for monitoring catfish culture pond water based on temperature and turbidity. This journal said that the optimal water temperature for live catfish is 23-30^{o}C and the turbidity of the water can be seen based on the colour of the water. In this study, fuzzy Takagi-Sugeno was used to measure the water quality of catfish culture ponds. The output of this research is a water pump control that functions to replace and fill pool water.

From several journals that the author has read, there are several journals that have become references and inspire the author. This research will focus on monitoring water variables such as pH, turbidity and temperature. Fuzzy Sugeno is used to process sensor data, then the output will be a buzzer as a warning notification. This is also the difference between this study and others. In previous research, data can be accessed online and the output uses a pump to drain and fill water, while for this study, the data is only displayed via a 16x2 LCD and the output is a buzzer.

ANALYSIS AND DESIGN

Analysis

The optimal temperature range for the life and development of aquatic organisms ranges from 25 to 35^{o}C while the acidity level in the aquarium model is at pH 6.8-7.5 [7]. Table 1 results from testing the turbidity sensor, and the initial hypothesis of the relationship between water turbidity and the output voltage of the sensor can be taken. Where the smaller the output voltage, it shows the water has increased turbidity. From this explanation, conclusions can be drawn to determine the level of turbidity of the water. Voltage over 2 Volts is declared clean, Voltage is over 1 Volt and less than 2 Volts cloudy water, Voltage is less than 1 Volt very cloudy water [2].

According to Muhammad Cholilulloh in his journal, he explains that: fuzzy logic is logic that represents fuzzy values, uncertainties, or partial truths. Fuzzy logic is an improvement over Boolean logic which only values 0 and 1. Fuzzy logic allows memberships to be marked between 0 and 1, black and white, and in linguistics, uncertain concepts such as few, half and many.

In this project, the fuzzy used is the Sugeno fuzzy. Because of the output of this algorithm there are no fuzzy numbers except in the form of constants or linear equations. Figure 1 describes the important stages in the fuzzy algorithm, namely fuzzification, inference, defuzzification and also a rule base to determine the membership function of each sensor.

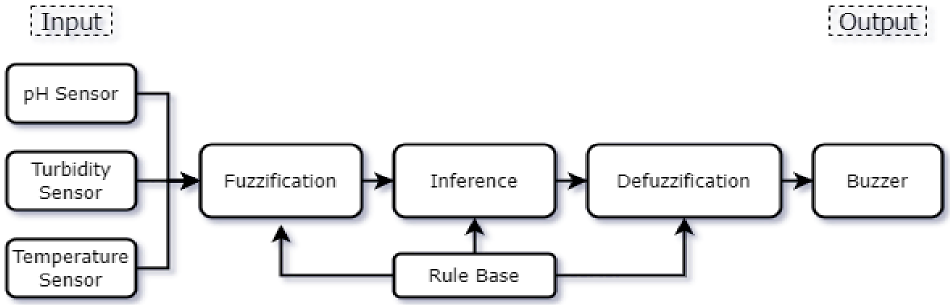

Figure 1. Fuzzy system block diagram

The first stage in the fuzzy algorithm is fuzzification. Fuzzification is changing the input as a firm value into a linguistic variable (fuzzy) using a membership function in the rule base. Next is inference, which is converting fuzzy input into fuzzy output (if-then) that has been determined in the rule base. Defuzzification is converting the results of the previous stage into an output that has a firm value using a predetermined membership function.

Membership Variable

The temperature variable has 3 sub-variables, namely cold, normal and hot. Cold conditions have a value of less than 25^{o}C. Normal conditions have a value range of 25-35^{o}C. While heat has a value of over 35^{o}C.

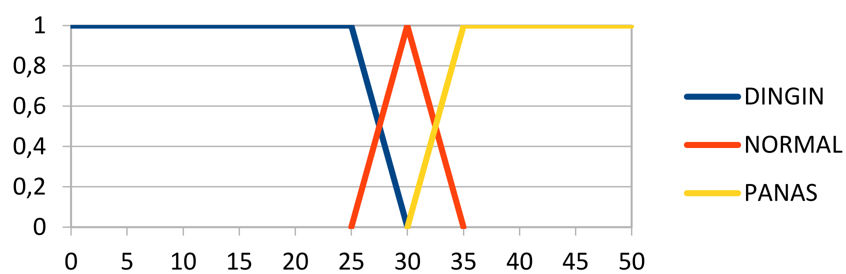

Figure 2. Temperature membership variable

The temperature membership function is formulated as follows:

$$\mu Dingin\ (x) = \begin{cases} 0; & x \geq 30 \\ \dfrac{30-x}{30-25}; & 25 \leq x \leq 30 \\ 1; & x \leq 25 \end{cases}$$

$$\mu Normal\ (x) = \begin{cases} 0; & x \leq 25\ or\ x \geq 35 \\ \dfrac{x-25}{30-25}; & 25 \leq x \leq 30 \end{cases}$$

$$\frac{35-x}{35-30};30\le x\le 35$$

$$\mu Panas\ (x)=\begin{cases}1; & x\ge 35\\ \frac{x-30}{35-30}; & 30\le x\le 35\\ 0; & x\le 30\end{cases}$$

The pH variable has 3 sub-variables, namely acid, neutral and alkaline. Acid has a value of less than 6.8. Neutral conditions have a range of values from 6.8 to 7.5. While for alkaline conditions, it has a value of over 7.5.

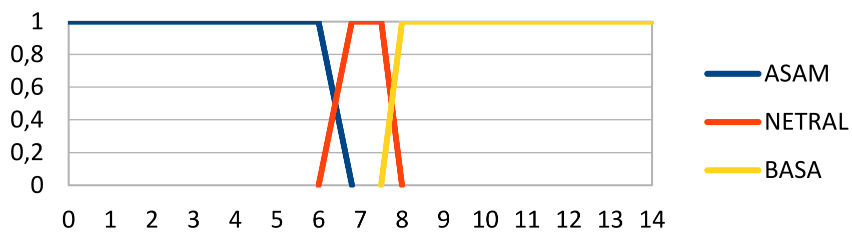

Figure 3. pH membership variable

The pH membership function is formulated as follows:

$$\mu Asam\ (x)=\begin{cases}0; & x\ge 7\\ \frac{7-x}{7-6{,}8}; & 6{,}8\le x\le 7\\ 1; & x\le 6{,}8\end{cases}$$

$$\mu Netral\ (x)=\begin{cases}0; & x\le 6{,}8\ or\ x\ge 7{,}5\\ \frac{x-6{,}8}{7-6{,}8}; & 6{,}8\le x\le 7\\ \frac{7{,}5-x}{7{,}5-7}; & 7\le x\le 7{,}5\end{cases}$$

$$\mu Basa\ (x)=\begin{cases}1; & x\ge 7{,}5\\ \frac{x-7}{7{,}5-7}; & 7\le x\le 7{,}5\\ 0; & x\le 7\end{cases}$$

The next variable is turbidity, it has 2 sub-variables. Clear has a voltage value range of less than 2, and cloudy has a voltage value of over 2.

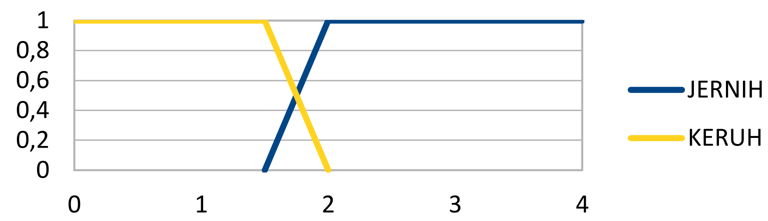

Figure 4. Turbidity membership variable

The turbidity membership function is formulated as follows:

$$\mu Jernih\ (x) = \begin{cases} 1; \ \ x \geq 2 \\ \dfrac{x - 1{,}5}{2 - 1{,}5}; \ \ 1{,}5 \leq x \leq 2 \\ 0; \ \ x \leq 2 \end{cases}$$

$$\mu Keruh\ (x) = \begin{cases} 0; \ \ x \geq 2 \\ \dfrac{2 - x}{2 - 1{,}5}; \ \ 1{,}5 \leq x \leq 2 \\ 1; \ \ x \leq 2 \end{cases}$$

Deffuzification

Defuzzification is converting the results of the previous stage into an output that has a firm value using a predetermined membership function. The method to find the defuzzification value in fuzzy Sugeno uses Weight Average (WA). Below is the formula to calculate the value of defuzzification.

$$Output = \frac{(R1 * z1) + (R2 * z2) + (R3 * z3) + \cdots (Rn * zn)}{R1 + R2 + R3 + \cdots Rn}$$

Description:

Rn = Rule value to … n

Zn = Rule output value to … n

DESIGN

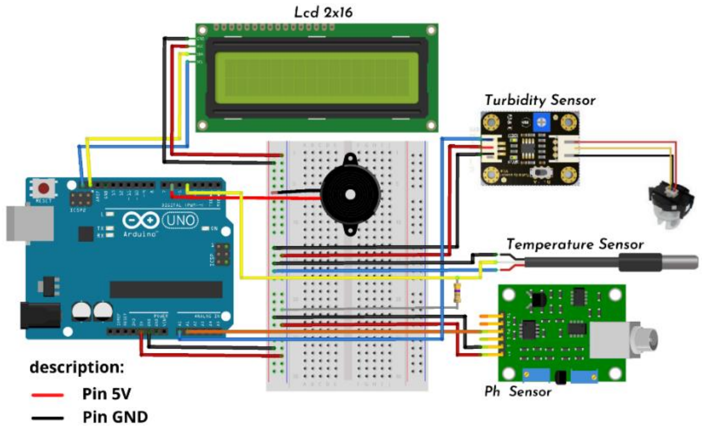

Figure 5. Hardware circuit sketch

Figure 5 is a complete overview of the prototype used in this project. The circuit comprises Arduino Uno as a microcontroller. Use a breadboard to connect the 5V voltage pins and the GND pins of the Arduino to each sensor. Cable with red colour is the cable connected to the 5V pin on the breadboard, while the cable with black colour is the cable for the GND pin. On a 16x2 LCD, connect the GND pin and the 5V pin to the breadboard. Then for the SDA pin (yellow cable) connect it to the SDA pin on the Arduino, as well as the SCL pin (blue) connect it to the SCL pin on the Arduino.

The next component is the buzzer. There are 2 pins on the buzzer, the GND pin which is connected to the GND breadboard and the 5V pin which can be connected to the 5V pin on the Arduino or can also be connected to the digital pin. In this project, the 5V buzzer pin is connected to pin 6. The turbidity sensor has 3 pins, the GND and 5V pins which are connected to the breadboard, then there is a digital output pin which is connected to pin A0 on the Arduino.

Next sensor is the temperature sensor. Temperature sensor has 3 pins namely, GND pin (black), DQ (data, yellow), VDD (blue). The GND pin and the VCC pin are joined and connected to the GND pin on the breadboard. The DQ pin is connected to the Arduino pin 4 via a 4.7k resistor connected to the 5V pin. The pH sensor has 6 sensors, but only 3 pins are used GND, VCC and Po pins. Just like the other sensors, the GND and VCC pins are connected to the breadboard, then the Po pin is connected to the A1 pin on the Arduino.

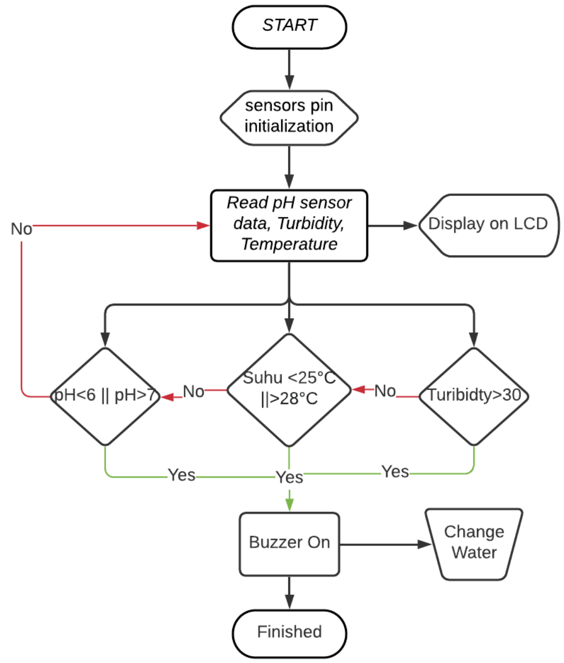

Figure 6. Flowchart

Figure 6 describes the flow of this system. Starting from the initiation of all sensors, then the sensor reads the content in the water, such as temperature, pH and turbidity. Then the data from the sensor is displayed on a 16x2 LCD. If the value of the water content is less or exceeds the predetermined value, the buzzer will sound to remind the owner to immediately change the water. And as a last act, the owner will change the water.

TESTING

Table 1 is the first trial sample, tested using aqua water with no water mixture. From the results of the first trial, it was found that the temperature was very stable at 26.31. The turbidity value is also stable, even though there are several errors. The pH value for the overall test is less stable, as the pH sensor is very sensitive to changes in water content. The test results get the average value for pH 6.50. The defuzzification result shows a value below 2, which means the buzzer is off. If the defuzzification value is 2 or more, the buzzer will turn on.

Table 1. Table testing 1

Temperature	Temperature Fuzzification			pH	pH Fuzzification			Turbidity	Turbidity Fuzzification		Deff
	Dingin	Normal	Panas		Asam	Netral	Basa		Jernih	Keruh	
26,31	0,74	0,26	0	6,71	0,64	0,36	0	2,23	1	0	1,42
26,31	0,74	0,26	0	3,9	1	0	0	2,23	1	0	1,74
26,31	0,74	0,26	0	7,44	0,28	0,72	0	2,23	1	0	1,18
26,31	0,74	0,26	0	7,78	0,11	0,89	0	2,22	1	0	1,09
26,31	0,74	0,26	0	6,01	1	0	0	2,22	1	0	1,73
26,31	0,74	0,26	0	6,01	1	0	0	2,22	1	0	1,73
26,31	0,74	0,26	0	6,89	0,55	0	0	0,45	1	0	1,36
26,31	0,74	0,26	0	4,03	1	0	0	2,22	1	0	1,74
26,31	0,74	0,26	0	5,03	1	0	0	2,21	1	0	1,74
26,31	0,74	0,26	0	7,5	0,25	0,75	0	2,2	1	0	1,17
26,31	0,74	0,26	0	7,35	0,32	0,68	0	2,2	1	0	1,21
26,31	0,74	0,26	0	7,14	0,43	0,57	0	2,2	1	0	1,28
26,31	0,74	0,26	0	6,19	0,9	0,1	0	2,2	1	0	1,63

Table 2 is the second program trial. In this second trial, aqua water was mixed with 250 ml of cold water, 250 ml of water mixed with soil, and 200 ml of soapy water. Water mixing is done every 15 minutes for 1 hour so that the sensor can read properly. In the second trial, the temperature and turbidity sensors were stable. The pH sensor for the second test is very unstable because the sensor is very sensitive to changes.

Table 2. Table testing 2

Temperature	Temperature Fuzzification			pH	pH Fuzzification			Turbidity	Turbidity Fuzzification		Deff
	Dingin	Normal	Panas		Asam	Netral	Basa		Jernih	Keruh	
24,75	1	0	0	5,4	1	0,0	0	1,8	0,0	1,0	2,0
24,75	1	0	0	-1,8	1	0,0	0	1,8	0,0	1,0	2,0
24,75	1	0	0	14,7	-3,4	4,4	0	1,8	0,0	1,0	2,0
24,75	1	0	0	6,4	0,8	0,2	0	1,8	0,0	1,0	1,8
24,75	1	0	0	0,2	1	0,0	0	1,9	0,0	1,0	2,0
24,75	1	0	0	-1,0	1	0,0	0	1,9	0,0	1,0	2,0
24,75	1	0	0	1,7	1	0,0	0	1,9	0,0	1,0	2,0
24,75	1	0	0	11,9	-2	3,0	0	1,9	0,0	1,0	2,0
24,75	1	0	0	11,5	-1,8	2,8	0	1,9	0,0	1,0	2,0
24,75	1	0	0	13,1	-2,5	3,5	0	1,9	0,0	1,0	2,0
24,81	1	0	0	4,2	-0,7	1,7	0	1,8	0,0	1,0	2,0
24,81	1	0	0	0,0	1	0,0	0	1,7	0,0	1,0	2,0
24,81	1	0	0	15	-3,5	4,5	0	1,3	0,0	1,0	1,8

Table 3 shows the results of the 3rd testing. The third test, mixing 200 ml of warm water and 200 ml of water mixed with soil, so that the sensor can read the maximum water mixing done every 10 minutes. The results of the third test show the sensor value is stable. The temperature sensor is at 30.3, the turbidity sensor is at 0.95-1.05 and the pH sensor is at 4.8-5.3. Shows a pH value below 6.8 which means the buzzer is on.

Table 3. Table testing 3

Temperature	Temperature Fuzzification			pH	pH Fuzzification			Turbidity	Turbidity Fuzzification		Deff
	Dingin	Normal	Panas		Asam	Netral	Basa		Jernih	Keruh	
30,62	0	0,88	0,12	5,83	1	0	0	0,93	0	1	2
30,5	0	0,9	0,1	6,44	0,78	0,22	0	0,88	0	1	2
30,37	0	0,93	0,08	4,36	1	0	0	0,92	0	1	2
30,31	0	0,94	0,06	4,64	1	0	0	0,95	0	1	2
30,31	0	0,94	0,06	5,31	1	0	0	1,04	0	1	2
30,31	0	0,94	0,06	4,88	1	0	0	1,04	0	1	2
30,31	0	0,94	0,06	5	1	0	0	1,05	0	1	2
30,31	0	0,94	0,06	4,82	1	0	0	1,04	0	1	2
30,31	0	0,94	0,06	4,91	1	0	0	1,05	0	1	2
30,31	0	0,94	0,06	5,49	1	0	0	1,03	0	1	2
30,31	0	0,94	0,06	4,67	1	0	0	1,04	0	1	2
30,31	0	0,94	0,06	5,31	1	0	0	1,03	0	1	2
30,25	0	0,95	0,05	5,12	1	0	0	1,04	0	1	2

CONCLUSION

Turbidity sensor and temperature sensor can read and work well. However, the pH sensor is less stable in reading sudden changes in water. The pH sensor will read data well in the long term if the water parameters do not change suddenly.

Sugeno fuzzy logic can be implemented in this project with several stages such as determining the membership function of each sensor or input that will be processed in fuzzification, then the rule base must be made carefully and correctly so that no errors occur in the next stage, the last stage is defuzzification, used to determine the output whether the buzzer will turn on or off.

It can be seen from the test table that the sensor can work optimally if it is used to detect water quality for a long time, provided that there are no sudden changes in water parameters. This system can be used and makes it easy to monitor the quality of aquarium water although the final results are not entirely accurate with the results of testing using aqua water where pH, temperature and normal turbidity have values of 26.31 for temperature, 6.71-7.78 for pH and turbidity with a voltage above 2 which means clear.

DAFTAR PUSTAKA

[1] Muhammad Hidayatullah, Jauharul Fat, Titi Andriani. 2018. Prototype Sistem Telemetri Pemantauan Kualitas Air Pada Kolam Ikan. PASITRON, vol 8, no. 2: Hal. 43-52.

[2] Robinson A. Wadu, Yustinus S. Bungin Ada, Indranata U. Panggalo. 2017. Rancang Bangun Sistem Sirkulasi Air Pada Akuarium/Bak Ikan Air Tawar Berdasarkan Kekeruhan Air Secara Otomatis. Jurnal Ilmiah Flash, vol 3, no.1.

[3] Ikhsan Efendi, Dwi Puspitasiari, Irsyad Arif Mashudi. 2020. Implementasi Monitoring Air Bersih Pada Aquarium Ikan Koi Dengan Nodemcu Esp8266 Menggunakan Metode Fuzzy Tsukamoto. Seminar Informatika Aplikatif Polinema (SIAP)

[4] Zaryanti Zainuddin, Asmawaty Azis, Riswan Idris. 2018. Sistem Monitoring Kualitas Air Pada Budidaya Udang Vannamae Berbasis Wireless Sensor Network Di Dusun Taipa Kecamatan Mappakasunggu Kabupaten Takalar. Prosiding Seminar Hasil Penelitian (SNP2M) 278-283.

[5] Robby Kurnia, A. Aminudin, M. Iryanti. 2019. Rancangan sistem alat ukur turbidity untuk monitoring kekeruhan air kolam tambak udang. Prosiding Seminar Nasional Fisika (SiNaFi), vol 1, no. 1: 449-454.

[6] Kadir, Shaifany Fatriana. 2019. Mobile Iot (Internet Of Things) Untuk Pemantauan Kualitas Air Habitat Ikan Hias Pada Akuarium Menggunakan Metode Logika Fuzzy. Institut Teknologi Nasional Malang, vol 3, no. 1.

[7] Riyan Kharisma, Suryadhi Thaha. 2020. Rancang Bangun Alat Monitoring Dan Penanganan Kualitas Ait Pada Akuarium Ikan Hias Berbasis Internet Of Things (IOT). Jurnal Teknik Elektro Dan Komputer Triac, vol 7, no. 2.

[8] Herryawan Pujiharsono, Danny Kurnianto. 2019. Sistem inferensi fuzzy Mamdani untuk menentukan tingkat kualitas air pada. Jurnal Teknologi dan Sistem Komputer, vol 8, no. 2:

[9] Pramana, Rozeff. 2018. Perancangan Sistem Kontrol dan Monitoring Kualitas Air dan Suhu Air pada Kolam Budidaya Ikan, vol 07, no. 01: hal. 13-23.

[10] Elsa Rana Wahyuni, R. Wahyu Tri Hartono, M. Yusuf Fadhlan. 2020. Sistem Monitoring Kualitas Air Tambak Ikan Melalui Jaringan GSM dan SMS Gateway Menggunakan Smartphone Android. Prosiding 11th Industrial Research Workshop and National Seminar (IRWNS), vol 11, no. 1.

[11] Muchammad Cholilulloh, Dahnial Syauqy, Tibyani. 2018. Implementasi Metode Fuzzy Pada Kualitas Air Kolam Bibit Lele Berdasarkan Suhu dan Kekeruhan. Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer, vol. 2, no. 5: hlm. 1813-1822.