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Automatic Water Quality and Fish Feed Monitoring System in Aquarium Using LORA

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ABSTRACT

Keeping ornamental fish, especially guppies, is a type of ornamental fish that is widely kept because it has a very beautiful color pattern. The growth of guppies is influenced by environmental factors, including water temperature, water pH, and water turbidity. Fish feed is also a very important factor in the survival of fish. Caring for ornamental fish becomes a challenge if the owner of ornamental fish is not at home for a long time such as while working in the office or while traveling. The thing that is often forgotten is to feed the fish kept in the aquarium. To maintain ideal water conditions, it is also necessary to conduct research to maintain the stability of water conditions in the aquarium. From these problems, a technology is needed to monitor water quality and manage fish feed remotely. In general, the ideal temperature that can make guppies develop well is between the range of 23-30°C, the pH of the water is in the range of pH 6-8. and guppy water turbidity requires a water turbidity level of 0-2500 NTU.

The purpose of this study was to design and create a water quality monitoring system for guupies using LoRa and automated feeding in realtime. The hardware used is Arduino Uno as microcontroller, LoRa SX1278 as long distance communication, Turbidity Sensor, DS18B20 temperature sensor, water pH sensor as LCD 16x4, RTC, Relay, water pump. The system created can monitor the water temperature, water turbidity level, and Ph of aquarium water automatically. Testing is carried out by detecting the quality of aquarium water with all sensors simultaneously to determine the condition of the water which will later be monitored using LoRa. The test results determine whether the state of turbid water with a range of >2000 NTU, the water pump will automatically turn on until the water state reaches the range of <2000 NTU.

Keywords: Sensor DS18B20, LoRa SX1278, Monitoring, Sensor pH, Sensor Turbidity

INTRODUCTION

Raising ornamental fish is one of the hobbies favored by most Indonesians, because the care is not so difficult(Kadir, 2019). In addition, the costs incurred are relatively affordable. Fish feed is the main factor to be considered because regular fish feeding provides the best quality of fish(DIA TRIUTAMI, 2021). Caring for ornamental fish becomes a challenge if the owner of ornamental fish is not at home for a long time such as when working in the office or while traveling. The thing that is often forgotten is to give feed to fish kept in the aquarium(Mardiyono et al., 2022). To maintain ideal water conditions, research needs to be carried out to maintain stable aquarium water conditions(Kusumaraga et al., 2021).

From these problems, a technology is needed to monitor water quality and manage fish feed remotely (Wisjhnuadji & Fauzi, 2017). To support the maintenance of water quality in the aquarium. Currently, the technology that allows for this is to utilize LoRa (Long Range) as a long-distance communication that will monitor the quality of water in the aquarium(Indriyanto et al., 2020).

This Monitoring System is made using the LoRa SX1278 (Long Range) concept that can be communicated over long distances, Turbidity Sensor to detect water turbidity, PH-4502C to detect water pH level, DS18B20 Sensor to regulate temperature, which is controlled using Arduino(Musfita, 2022). For the automatic fish feeding system itself using a servo motor as an opening and closing the container valve

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on fish feed, and RTC DS3231 as a timer that provides real time(Zakaria et al., 2020).

By using the above components and shoftware that supports the running of the tool, this water quality monitoring can be monitored remotely and fish feeders can automatically work according to the specified real time.

METHOD

The method in this study uses the IMRAD method, which is a method with an introduction, method, result, and discussion structure. This method contains relevant literature and solutions to the problem under study, apart from wiring diagrams, block diagrams, and flowcharts.

. In the research conducted by Bima Setya Kusumaraga is making internet of things-based monitoring of aquarium water quality. This tool is designed to be able to maintain water temperature, water pH, and water turbidity in a certain range. Thus this tool is able to maintain ideal aquarium water quality for fish survival(Kusumaraga et al., 2021). In the research conducted by Hendra S. Weku, namely making a microcontroller-based automatic fish feeding device. This tool can create a fish feeding system that can work automatically by using the ATMega16 microcontroller as the main control and RTC as a timer that provides real time(Weku et al., 2015). In the research conducted by Muhammad Afif Askar is to make a feed control system and automatic aquarium water quality monitoring. This tool functions to monitor and regulate feed automatically by using the blynk application as a feed monitoring and control center(Askar, 2022). The research conducted by Dia Triumani is to design a prototype water quality monitoring system for ornamental fish in aquariums using LoRa. This tool designs a water quality monitoring system using 2 parameters, namely temperature using the DS18B20 sensor and clarity using a Turbidity sensor where the results will be sent using LoRa 915 Mhz(DIA TRIUTAMI, 2021). The research conducted by Yohanes Karmani is to create a system for monitoring the level of water turbidity and feeding fish in IoT-based aquariums. This tool can monitor the level of turbidity of water in the aquarium and automatically filter aquarium water when the aquarium water has reached the turbidity level of 3000 NTU and fill the pond again with clean water. But in this system, the sensor value reading is still not fully stable because it is influenced by the surrounding light. The sensor value readings can be displayed on the aquarium owner's Blynk application(Karmani et al., 2022).

In the current study, monitoring is carried out using LoRa as long-distance communication(Nanda, 2019). This tool works starting from connecting the LoRa tranceiver to the receiver, then monitoring starts by conditioning the pH sensor between the range of 6-8 pH, turbidity sensor between the range 0-2000 NTU, sensor DS18B20 between the range of 27-30 °C by Arduino. After the sensor data is obtained then the data will be sent to the LoRa receiver. In the automatic fish feed system, it starts from the RTC reading which will detect when the servo will open according to the hours previously set with the specified water quality state, if the turbidity of the water is more than the range of 2000 NTU then the water pump will turn on and the servo does not function while if the water is less than 2000 NTU then the servo will open and the pump will die.

System Design

There are several stages for the design part starting from software design which includes several input and output components, block diagrams, wiring systems and flowcharts. In the block section, the diagram describes the input and output components and the microcontroller used. Flowchart explains the flow of research design. Wiring system describes the input and output components that will be connected to the microcontroller.

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Wiring System

In the wiring system section explains about the input and output components of the tranceiver part connected to the microcontroller, the input component consists of pH Sensor, Turbidity Sensor, DS18b20 Sensor, RTC, then for the output component consists of MG966r Servo Motor, Water Pump and LoRa.

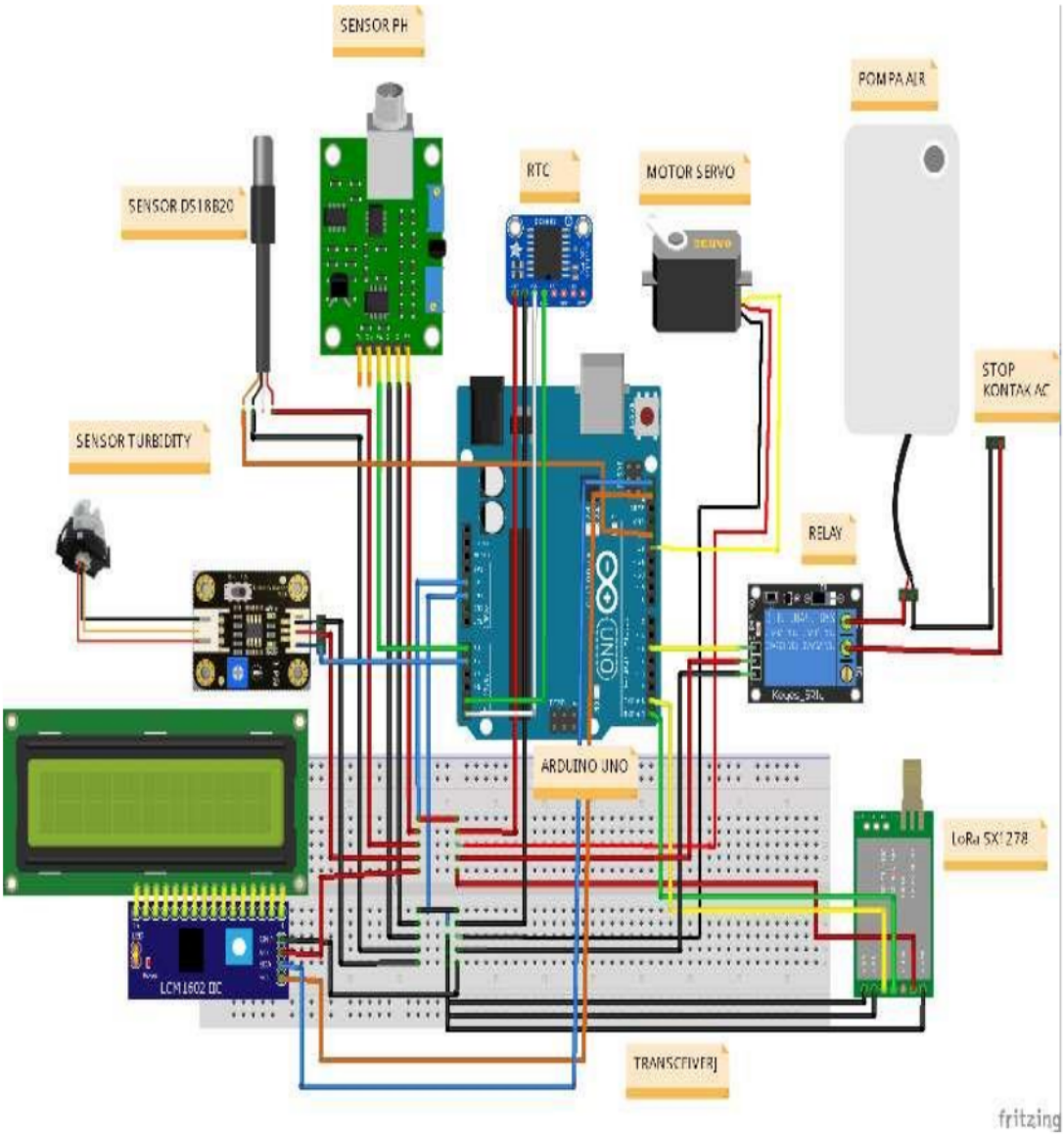

Fig.1 Wiring Design Transceiver

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Table 1
Arduino Uno port usage

No	Component	They compose Pin Address	Arduino Pin Address 1
1	Sensor Turbidity	VCC	5V
		GND	GND
		A0	A1
2	Sensor DS18B20	VCC	5V
		GND	GND
		Data	D13
3	Sensor pH	VCC	5V
		GND	GND
		GND	GND
		P0	A0
4	RTC	VCC	5V
		GND	GND
		SCL	A5
		SDA	A4
5	Motor Servo	VCC	5V
		GND	GND
		Pulse	D12
6	Relay	VCC	5V
		GND	GND
		Signal	D5
7	LoRa SX1278	VCC	3V
		GND	GND
		TXD	RXD
		RXD	TXD
		M1	GND
		M0	GND
8	LCD 16x2 I2C	VCC	5V
		GND	GND
		SDA	SDA
		SCL	SCL

Table 1 describes the pinout of the Arduino microcontroller connected to the input output components such as Turbidity Sensor, DS18B20 Sensor, pH Sensor, RTC, MG966r Servo Motor, Relay, LoRa SX1278,

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LCD 16x2 I2C(Prasetyo et al., 2023). In figure 1 describes the Turbidity Sensor there are 3 pins, 2 pins connected to GND and VIN 5V arduino, pin A0 sensor to IO A1 arduino. DS18B20 sensor has 3 pins, 2 pins connected to GND and VIN 5V arduino, sensor data pin to pin D13 arduino. pH sensor there are 4 pins, 3 pins to GND, GND and VIN 5V arduino, pin P0 sensor to pin IO A0 arduino. RTC has 4 pins, 2 pins to GND and VIN 5V arduino, SCL RTC pin to A5 pin arduino, SDA pin to A4 pin arduino. Servo motor there are 3 pins, 2 pins to GND and VIN 5V arduino, pulse pin Servo to pin IO D12 arduino. There are 3 relays, 2 pins to GND and VIN 5V arduino, pin signal relay to IO pin D5 arduino. LoRa SX1278 has 6 pins, 2 pins LoRa to GND and VIN 3V arduino, pin TXD LoRa to pin IO RXD arduino, pin RXD LoRa to pin IO TXD arduino, pin M1 LoRa to pin IO GND arduino, pin M0 LoRa to pin IO GND arduino. LCD 16x2 I2C has 4 pins, 2 pins LCD to GND pin and VIN 5V arduino, SDA pin LCD to IO pin SDA arduino, SCL pin LCD to IO pin SCL arduino.

Furthermore, in the wiring system section, the receiver describes the components connected to the microcontroller, the components consist of LCD 16x2 I2C, and LoRa.

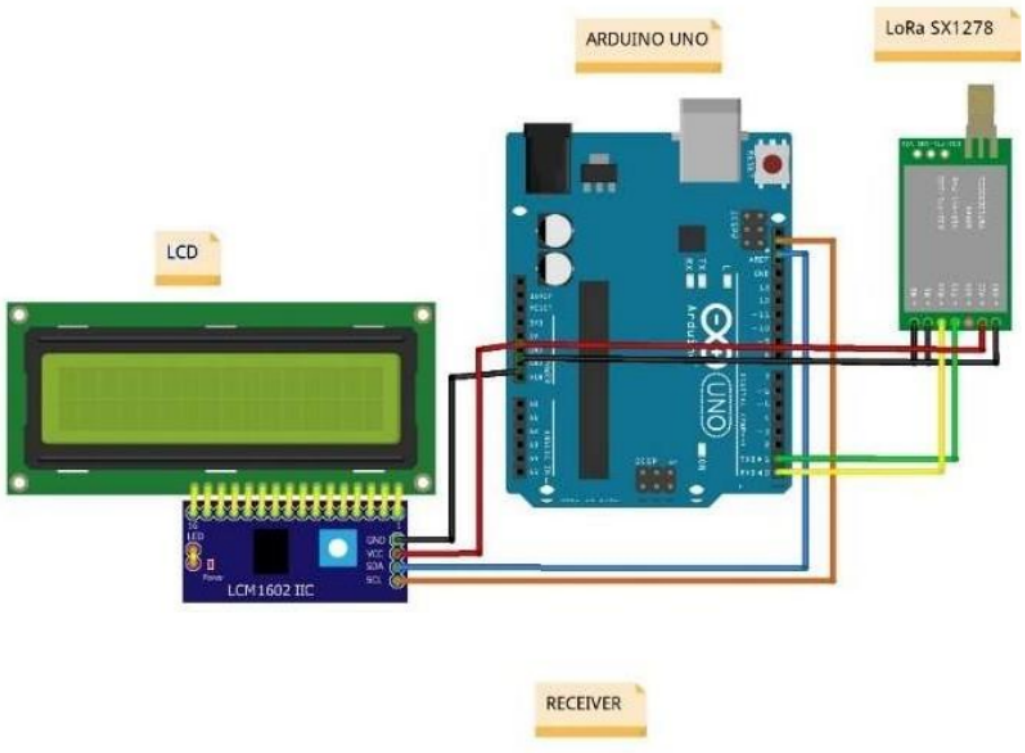

Fig 2. Wiring Design Receiver

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Table 2

No	Component	Component Pin Address	Arduino Pin Adress 2
1	LCD I2C	VCC	5V
		GND	GND
		SDA	SDA
		SCL	SCL
2	LoRa SX1278	VCC	3V
		GND	GND
		TXD	RXD
		RXD	TXD
		M1	GND
		M0	GND

Table 2 describes the pinout of Arduino microcontrollers connected to input output components such as 16x2 I2C and LoRa SX1278 LCDs. In figure 2 describes the 16x2 I2C LCD there are 4 pins, 2 LCD pins to the GND pin and VIN 5V arduino, SDA LCD pin to SDA IO pin arduino, SCL LCD pin to IO pin SCL arduino. LoRa SX1278 has 6 pins, 2 pins LoRa to GND pin and 3V arduino, TXD LoRa pin to RXD IO pin arduino, RXD LoRa pin to IO pin TXD arduino, M1 LoRa pin to IO GND pin, M0 LoRa pin to IO GND pin arduino.

Block Diagram

The block diagram system can be seen in the picture below

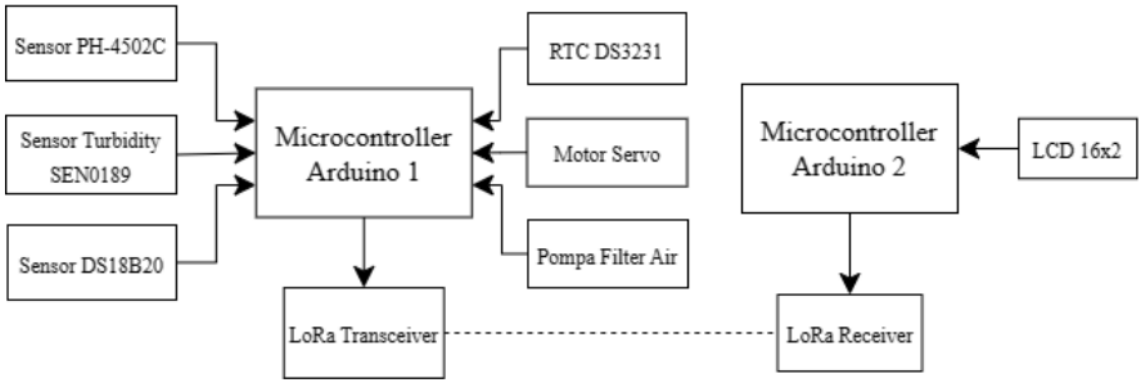

Fig 3. system Block Diagram

In the picture above, it can be explained that there are several input and output components of Arduino Uno 1 and 2. For input components connected to Arduino 1 there is a pH sensor, DS18B20 sensor, Turbidity Sensor that can see the quality of water to be sent to the LoRa Receiver, for RTC itself determines the time if the servo will open at a certain time for fish feed. The output component consists of a servo motor and a water filter pump used to regulate fish feed will go down and filter the water if the water state is cloudy then the water filter pump will turn on. On Arduino 2 there is an LCD that can display the parameters of the water state value according to the display on Arduino 1.

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System Flowchart

For the flowchart system there are two parts, the first part is the tranceiver flowchart system and the second is the receiver flowchart as shown below:

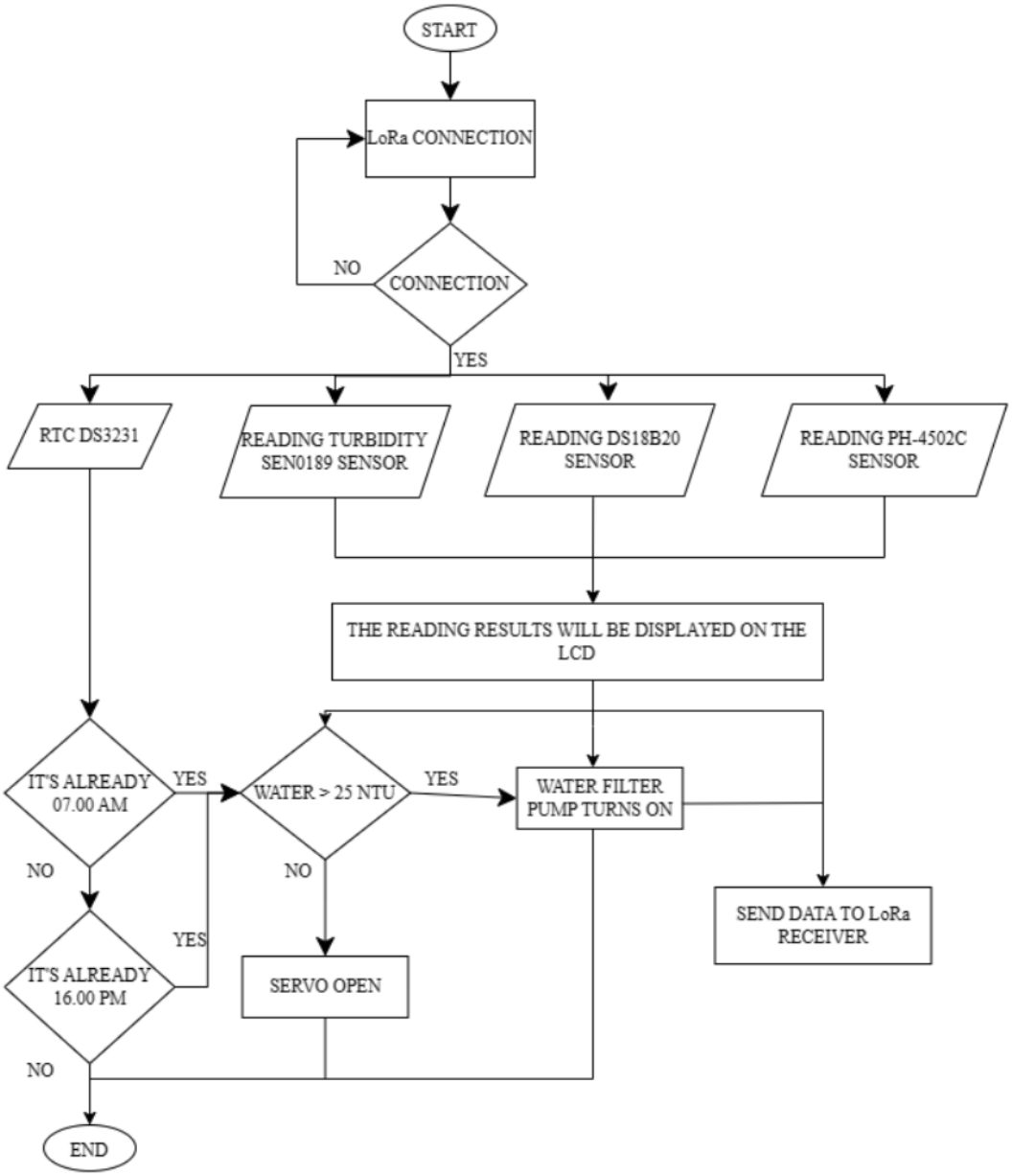

Fig 4. System Flowchart transceiver

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The figure above describes the first part of the transceiver flowchart system starting with connecting the LoRa tranceiver to the LoRa Receiver. Once connected, it will read all sensors that will later be connected to the LoRa receiver. The RTC will display the time that will determine when the servo motor will open on the automatic fish feed system. RTC is programmed by specifying two times of the day, namely at 07.00 am and 4.00 pm. Next, the Turbidity sensor reads the turbidity of the water and will display the turbidity results on the LCD. Then the DS18B20 sensor detects the temperature in the water and displays the results on the LCD. The last sensor is the PH-4502C sensor which is used to measure the acidity level of water and the results are also displayed on the LCD. If it is 07.00 and the turbidity of the water is above 25 then the water pump will turn on, otherwise if the water is still clear then the servo will open and the fish feed will go down. And the results of sensors which include turbidity sensor, D818B20 Sensor, PH Sensor and water filter pump can be displayed through LoRa.

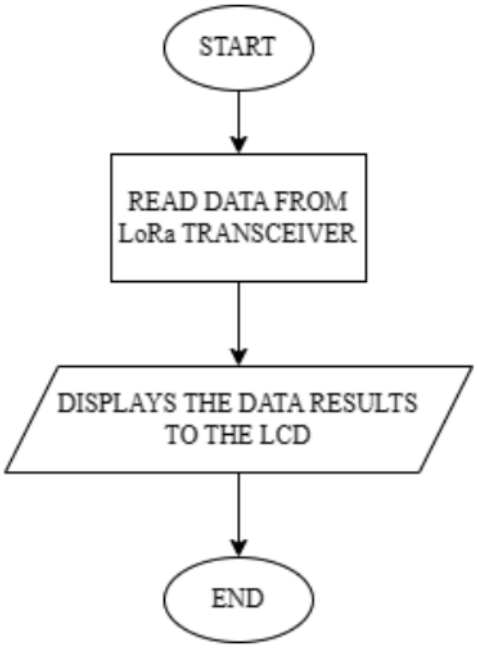

Fig 5. System Flowchart Receiver

While in the picture above explains about the second part of the Receiver flowchart system, it starts by reading sensor data sent from the LoRa Transceiver, then the results will be displayed to the LCD which can later be monitored remotely.

RESULT

This section is about testing and discusses the inner workings of automated water quality monitoring and fish feed systems in aquariums using LoRa. This test used guppies as the object of research and the study was carried out for four days between morning and evening. The test was carried out by testing all input output components connected to the Arduino Uno microcontroller, for input components including Turbidity Sensor SEN0189, Sensor DS18B20, Sensor PH-4502C, RTC DS3231, then for output including Servo Motor MG90S, LoRa SX1278. Its realization and how it works can be seen in the picture below:

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Fig 6. Tool Realization Results

The tests to be carried out in this study include SEN0189 Turbidity Sensor testing, DS18B20 Sensor testing, PH-4502C Sensor testing, DS3231 RTC testing, MG90S Servo Motor testing, LoRa SX1278 testing and overall tool testing. Testing tools can be seen below.

Sensor Turbidity Sen0189 Testing

Below are the test results of Turbidity Sensor SEN0189, this sensor is used to detect the level of turbidity in water. The test was carried out for 5 days with morning and evening information to determine the state of the water when the fish were fed. In the table below the morning test shows a value of 689NTU while the afternoon time shows a value of 1000NTU, the value in the test changes because the sensor receives more light intensity in the morning than in the afternoon. This study explained that if the water is below 2000 NTU, the water condition is still clean, while if the water condition is above 2000 NTU, it can be ascertained that the water condition is turbid(Trevathan et al., 2020).

Table 3.
Sensor Turbidity Sen0189 Testing

Trial	Jam	Water clarity value (NTU)	Accuracy
1st test	07.00	689	Good
	16.00	1000	Good
2nd test	07.00	689	Good
	16.00	1000	Good
3rd test	07.00	1000	Good
	16.00	1289	Good
4th test	07.00	1000	Good
	16.00	1555	Good
5th test	07.00	1555	Good
	16.00	1798	Good

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Sensor DS18B20 Testing

Below are the test results of the DS18B20 sensor, this sensor serves to detect the temperature in the water(Noor et al., 2019). with testing for 5 days and the time needed is between morning and evening. The test below obtained an average temperature in the morning of 28.8 ° C while in the afternoon obtained an average value of 29 ° C.

.

Table 4.
Sensor DS18B20 Testing

Trial	Jam	Sensor value DS18B20	Accuracy
1st test	07.00	28°C	Good
	16.00	29°C	Good
2nd test	07.00	29°C	Good
	16.00	30°C	Good
3rd test	07.00	29°C	Good
	16.00	28°C	Good
4th test	07.00	29°C	Good
	16.00	28°C	Good
5th test	07.00	29°C	Good
	16.00	30°C	Good

Sensor PH-4502C Testing

Below are the test results of the PH-4502C sensor, this sensor serves to detect the acidity level in water. Good acidity levels in fish are in the range of 6-8 pH. In the table below is the result of a ph sensor that is carried out at a certain time with an output pH value between the range of 6-7 pH.

Table 5.
Sensor PH-4502C Testing

Trial	Jam	Sensor value DS18B20	Accuracy
1st test	07.00	6,92	Good
	16.00	6,85	Good
2nd test	07.00	7,08	Good
	16.00	6,98	Good
3rd test	07.00	6,75	Good
	16.00	7,21	Good
4th test	07.00	6,85	Good
	16.00	6,75	Good
5th test	07.00	7,02	Good
	16.00	7,11	Good

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RTC DS3231 Testing of Servo Motors

Below are the results of RTC testing of servo motors. This test aims to find out whether this servo motor will work or not at the specified time. This test is carried out to regulate the release of fish feed at certain hours.

Table 6.
RTC DS3231 Testing of Servo Motors

Day	Hour	Description of Servo motor	Description
Monday	07.00	Open	Succeed
	16.00	Open	Succeed
Tuesday	07.00	Open	Succeed
	16.00	Open	Succeed
Wednesday	07.00	Open	Succeed
	16.00	Open	Succeed
Thursday	07.00	Open	Succeed
	16.00	Open	Succeed
Friday	07.00	Open	Succeed
	16.00	Open	Succeed

Motor Servo Testing

Below is the result of servo motor testing, this test is carried out to determine the degree of servo motor in the fish feed container that will open the fish feed valve with a specified degree. The table below shows the degree input coded with the servo motor hardware output according to the realized.

Tabel 7.
Motor Servo Testing

No	Servo Motor MG966r		Description
	INPUT	OUTPUT	
1	90°	90°	Success
2	90°	90°	Success
3	90°	90°	Success

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LoRa SX1278 Testing

Below are the test results of LoRa SX1278. This test is performed to determine the distance between the LoRa transceiver and the LoRa receiver. Based on the table below there are 5 distance indications that determine the connection of LoRa transceiver with LoRa receiver between distances of 50m, 100m, 150m, 200m and 250m. At a distance of 50m LoRa is still connected up to a distance of 200m, for a distance of 250m on the Lora part the receiver cannot generate data. In this case, LoRa SX1278 when tested the distance traveled with obstacles or without obstacles up to a distance of 200m.

Table 8.
LoRa SX1278 Testing

Transceiver to Receiver distance	Distance Results		Accuracy
	Unhindered	With a hitch	
50m	▯	▯	Good
100m	▯	▯	Good
150m	▯	▯	Good
200m	▯	▯	Good
250m	▯	▯	Bad

Overall Testing Tool

Below is the overall result of the research of monitoring tools and automatic fish feed, in the table below it is explained where the distance reached by LoRa transceiver with a receiver between a distance of 50m to a distance of 200m was examined within a period of 4 days per day carried out 2 experiments namely morning and evening, in the first day to the last day for water quality results of turbidity sensors, DS18B20 sensor, PH sensor is at the safe value needed for guppy criteria, then the servo fish feed system opens according to the specified schedule. The water pump section of the test table shows a dead state, the water pump will run if the turbidity sensor results >2000NTU.

Table 9.
Overal Testing Tool

LoRa Transceiver to Receiver Distance	Water Quality			Automatic Fish Feed			Description
	Turbidity Sensor Results	DS18B20 Sensor Results	PH-4502C Sensor Results	RTC Results	Servo Results	Water Pump Results	
50m	689	28°C	6,92	Morning	Open	Die	Succeed
	1000	29°C	6,85	Afternoon	Open	Die	Succeed
100m	689	29°C	7,08	Morning	Open	Die	Succeed
	1000	30°C	6,98	Afternoon	Open	Die	Succeed
150m	1000	29°C	6,75	Morning	Open	Die	Succeed
	1289	28°C	7,21	Afternoon	Open	Die	Succeed
200m	1000	29°C	6,85	Morning	Open	Die	Succeed
	1555	28°C	6,75	Afternoon	Open	Die	Succeed

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DISCUSSIONS

In the study above, the results were in accordance with the criteria needed by guupy fish, but for LoRa it can only be connected up to a distance of 200m. For further research, there are several suggestions that can be taken into consideration for the next author, namely on LoRa SX1278 carried out in research only up to a distance of 200 meters. It is expected that the next test can be more than a distance of 200 meters.

CONCLUSION

Based on the test results of the tools used, this tool uses guppies as research objects with the provision of water quality at turbidity levels between 0-2500NTU, water temperatures between 23-30 ° C, and water pH 6-8 pH. In testing the tool above, it can be concluded that (1) testing on turbidity sensors gets good results with the required range provisions in guppy criteria with a range of 0-2000NTU. (2) DS18B20 sensor testing can conclude that DS18B20 sensor can detect Temperature between 28-30°C and can function properly. (3) pH sensor testing obtained a range between 6-8PH and can function well for the acidity level required by guppies. (4) In the detection of the RTC test for servo output will be opened at 07.00 WIB and 16.00 WIB, the RTC test results are running well. (5) servo motor testing can be concluded that the servo will be open when the clock is set on the RTC component and this speaker runs well. (6) LoRa SX1278 testing is carried out by detecting the connected distance between the LoRa transceiver and the LoRa receiver, the test results that LoRa can be connected up to a distance of 200 meters, more than 200 meters LoRa cannot be connected.

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