Fish Feeding Automation and Aquaponics Monitoring System Base on IoT

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***Abstract*— Aquaponics is a cultivation technology that combines fish farming with plants. The degree of acidity (pH) and total dissolved solids (TDS) must be monitored for optimal fish and vegetable growth. In this research, a monitoring system was designed for pH and TDS in aquaponics and automation of fish feeding based on scheduling and level of need. Monitoring of pH and TDS as well as automation of fish feeding is done through an Android-based application. Fish feeding is carried out according to a schedule with a specified feed weight. The monitoring system for pH and TDS are carried out in real-time. The sensors used in this research are a pH sensor to measure pH values and an analog TDS sensor to measure total TDS. The communication system used is based on IoT technology. Based on the test results, it is found that the average difference between the readings of the pH sensor and the pH meter is 0.66% and the average difference between the readings of the TDS sensor and the TDS meter is 2.588%. The system has been able to provide fish feed according to a set schedule automatically and with a feed weight as needed with an error rate of only 1%.**

Keywords—Aquaponics, automation, IoT, pH, total dissolved solid, schedulling.

I. INTRODUCTION

The development of science and technology in the field of aquaculture continues to increase, indicated by the transition from traditional fish cultivation systems to intensive fish cultivation systems [1]. The success of a cultivation business is closely related to the optimum environmental conditions for the survival and growth of reared fish [2]. The condition parameters include the degree of acidity (pH) and the total dissolved solids (TDS) in water.

Aquaponics, the combined culture of fish and plants in recirculating systems, which can significantly increase land productivity by 30% to 40% [3]. This can happen because aquaponics technology is a combination of aquaculture technology with hydroponic technology in one system to optimize the function of water and space as a raising medium [4].

Currently, various monitoring and control systems for agricultural systems, especially aquaponics, already use Internet of things (IoT) technology. IoT makes it possible to connect things like sensors and actuators to the internet [5-6].

Feeding fish also sometimes becomes a problem when the owner is away from the fish pond, even though the feeding must be on schedule. In addition, overfeeding will cause the feed to rot. The dose of feed for goldfish in aquaponics is 5% of the total weight of goldfish and is given 2 times a day at 06.30 and 17.00 [7]. The development of a fish feed control system has been carried out by several researchers, including the control of feed in a fish pond containing 2000 catfish seeds through the website [8], a fish feeding system in a mini aquarium which is controlled via a website [9], and the automatic fish feeding system through the android application [10].

In addition, the value of acidity (pH) and total dissolved solids in the hydroponic system also affects the growth of existing fish and vegetables. Monitoring systems for pH values and dissolved solids have previously been developed and carried out in a river [11] and a lake [12]. Measurement of the value acidity of the water and the value of total dissolved solids in water is sometimes still done manually. IoT technology can be used in an attempt to overcome these problems.

This research aims to develop an automated system for fis feeding based on scheduling and the weight of feed required as well as monitoring pH and TDS using IoT technology. The system will help to manage and control the feeding of fish according to schedule and according to the required amount automatically. In addition, the system will also monitor environmental conditions including pH and TDS parameters through an Android-based application.

II. THE PROPOSED SYSTEM

A. Floating Raft Aquaponics System

The aquaponics system prototype designed is a floating raft aquaponics system. The aquaponics design of the floating raft system can be view in Figure 1. The floating raft aquaponics system consists of a plastic bottle, styrofoam, and aquarium. The styrofoam that gave four holes for storing plastic bottles, placed on top of the aquarium.

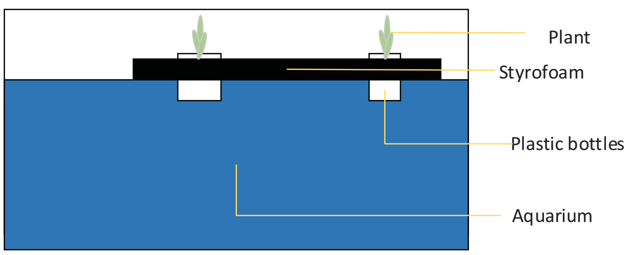

Fig. 1. Floating raft aquaponics system.

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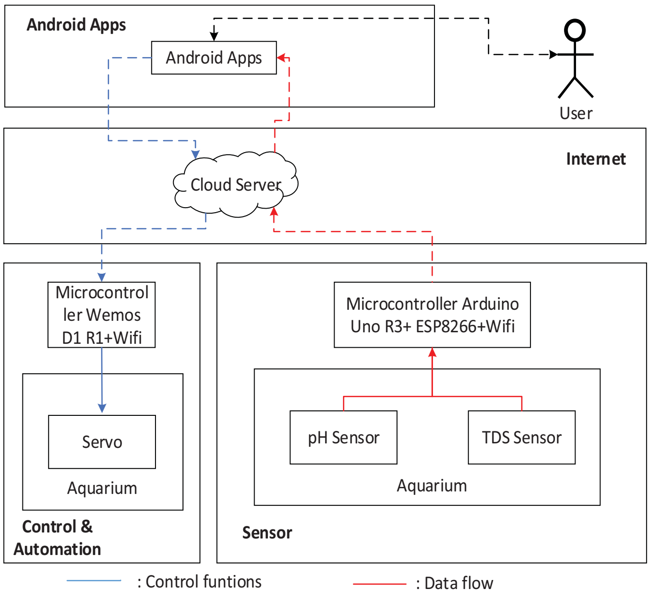


Fig. 2. Block diagram of the monitoring system and fish feeding automation.

B. *Monitoring System and Fish Feeding Control*

Monitoring system and automation of fish feeding in this research using 2 microcontrollers, namely the Wemos D1 R1 microcontroller as fish feeding control and the Arduino UNO R3 microcontroller as a data processor for pH sensors and TDS sensors. The user inputs the fish feeding schedule through an application built with the Blynk platform. In addition, users can view pH and TDS in real-time through the application. Monitoring system scheme and fish feeding automation are shown in Figure 2.

The Arduino Uno R3 microcontroller functions as a data processor for reading the TDS sensor and pH sensor. The ESP8266 Wifi module forwards the processed data to the cloud server via a Wifi network. The Wemos D1 R1 microcontroller functions to control fish feeding. Users only need to enter the fish feeding schedule twice a day through the designed application, then the Wemos D1 R1 microcontroller will command the servo to open at the specified time. The weight of fish feed released according to the schedule is set as needed, which is 10 grams. Monitoring system design and control of fish feed can be seen in Figure 3.

The functionality of the system is illustrated by the usecase diagram shown in Figure 4. Functionally, the system is designed to provide login functions, monitoring pH, monitoring TDS, and schedulling and controlling fish feeding.

Meanwhile, the Android-based system interface developed with the Blynk Platform shown in Figure 5. Through this application interface, users can input the morning and evening feeding times and monitor pH values and total dissolved solids in graphical form.

III. Results and Analysis

The automation circuits of fish feeding systems designed, stored in a black box as shown in Figure 6 and the circuit of monitoring systems for pH and TDS shown in Figure 7.

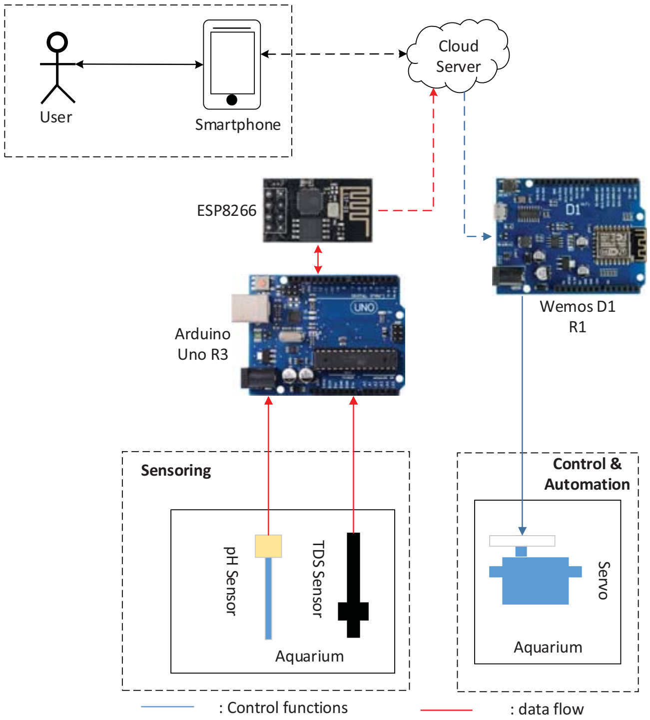


Fig. 3. Monitoring system design and feed control.

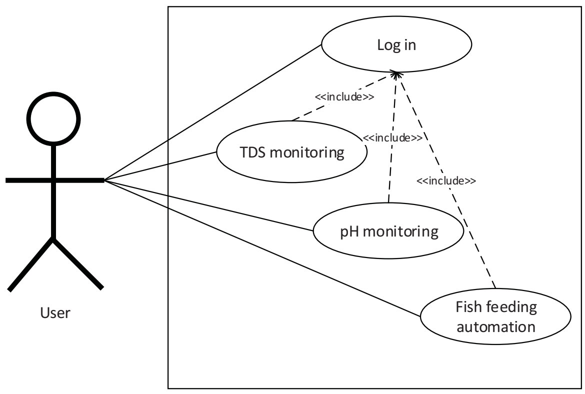
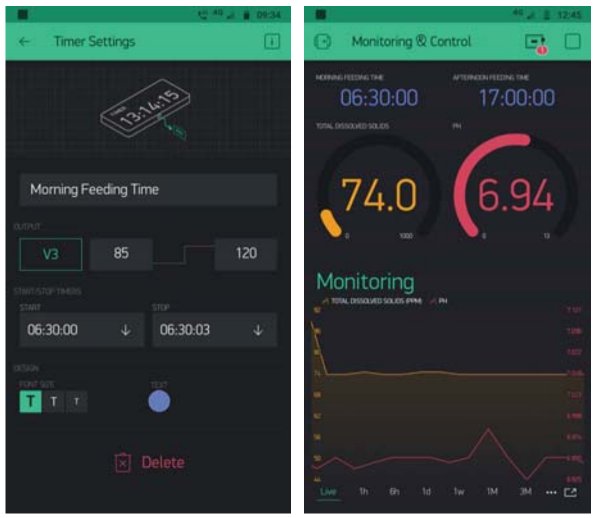


Fig. 4. Use case diagram sistem monitoring dan kontrol pakan ikan.



(a) (b)

Fig. 5. System interface: a). schedule arrangement, b). monitoring.

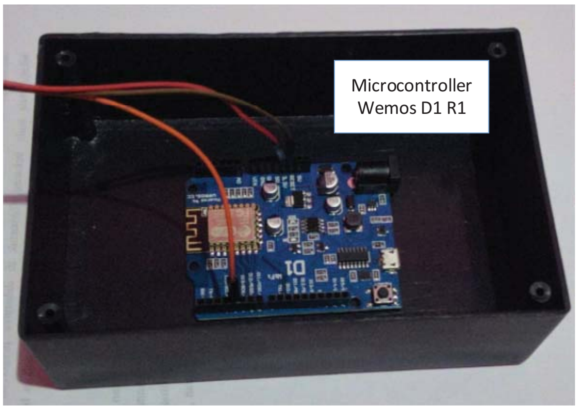


Fig. 6. The automation circuits of fish feeding systems.

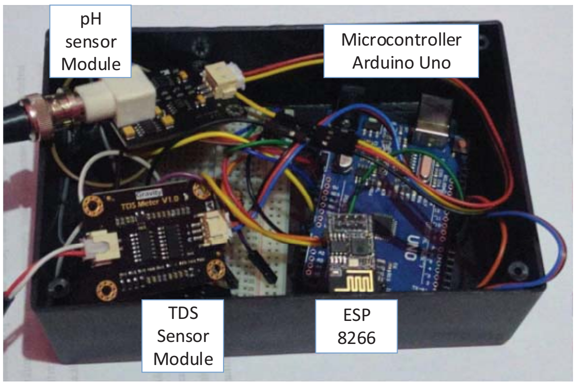


Fig. 7. the circuit of monitoring systems for pH and TDS.

The aquaponic system prototype built in this study is shown in Figure 8. The pH sensor, TDS sensor, and fish feeder are placed in the aquarium.

A. *Calibration and Testing of pH Sensors*

pH sensor testing is done by comparing the results of the pH meter measurement with the pH sensor. But before this test is carried out, the pH sensor needs to be calibrated first. The pH sensor calibration uses the linear line equation formula [13]

$$y=m.x+C, \quad (1)$$

where y is the measured value of the pH meter, m is the measurement value of the pH sensor calibration, x is the pH measurement value of the volt sensor and C is the sensor constant.

Calibration is carried out on 2 types of fluids, namely alkaline and acidic liquids. The alkaline liquid used is soapy water while the acidic liquid used is vinegar water. At the initial measurement the value was obtained y_1 = 4, y_2 = 13, x_1 = 1.56 volt and x_2 = 2.31 volt. The initial value is entered in the gradient equation so that the sensor calibration measurement value is 8. After obtaining the sensor calibration measurement value, then input the value into equation (1) so that the sensor constant value is 8.4.

After the sensor is calibrated, the actual aquaponics system is tested. The results of the aquaponics system test are shown in Table I.

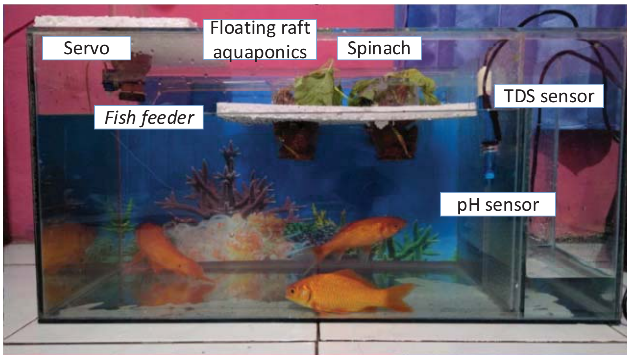


Fig. 8. Aquaponic floating raft.

TABLE I. TESTING OF PH SENSOR ON AQUAPONICS.

No	Date	Time	pH Sensor	pH meter	Δ of pH	Δ (%)
1.	1 July 2020	07:00	7.36	7.4	0.04	0.54
2.	1 July 2020	07:30	7.37	7.3	0.07	0.95
3.	1 July 2020	08:00	7.46	7.4	0.06	0.81
4.	1 July 2020	08:30	7.42	7.4	0.02	0.27
5.	1 July 2020	09:00	7.43	7.4	0.03	0.4
6.	1 July 2020	09:30	7.48	7.4	0.08	1.08
7.	1 July 2020	10:00	7.37	7.4	0.03	0.4
8.	1 July 2020	10:30	7.49	7.5	0.01	0.13
9.	1 July 2020	11:00	7.32	7.4	0.08	1.08
10.	1 July 2020	11:30	7.47	7.4	0.07	0.94
Average of Δ					**0.049**	**0.66**

The data obtained from the pH sensor readings is not too much different from the results of measurements made using a pH meter. The test is done by comparing the pH sensor reading with the pH meter reading. Readings from the pH sensor have an average difference of 0.66%.

B. *Testing of TDS Sensor*

Testing of the TDS sensor is carried out by comparing the reading of the TDS sensor with the TDS meter measuring instrument. Table II is the result of testing the TDS sensor in aquaponics.

TABLE II. TESTING OF TDS SENSOR ON AQUAPONICS.

No	Date	Time	TDS Sensor	TDS meter	Δ of TDS	Δ (%)
1.	4 July 2020	12:20	720	740	20	2.7
2.	4 July 2020	12:25	725	740	15	2.02
3.	4 July 2020	12:30	723	737	14	1.89
4.	4 July 2020	12:35	714	727	13	1.78
5.	4 July 2020	12:40	723	724	1	0.13
6.	4 July 2020	12:45	726	744	18	2.41
7.	4 July 2020	12:50	674	718	44	6.12
8.	4 July 2020	12:55	679	714	35	4.9
9.	4 July 2020	13:00	706	724	18	2.48
10.	4 July 2020	13:05	703	695	8	1.15
Average of Δ					**18.6**	**2.558**

The results of measuring the TDS show that the difference in the readings between the analog TDS sensor and the TDS meter is not much different. The difference between the measurements made by the TDS analog sensor and the measurements made by the TDS meter has an average difference of 2.588%.

C. *Application of Monitoring and Automation of Fish Feeding*

Fish feeding tests are carried out to ensure that the feeding time is in accordance with the set schedule and dosage. The results of the fish feeding test are shown in Table III.

TABLE III. FISH FEEDING TECHNIQUE ON AQUAPONIC.

No	Date	Time	Feeding	Weight of feed out (gr)
1.	4 July 2020	06:30	Done	10
2.	4 July 2020	17:00	Done	9
3.	5 July 2020	06:30	Done	11
4.	5 July 2020	17:00	Done	10
5.	28 July 2020	17:00	Done	10
6.	29 July 2020	06:30	Done	10
7.	29 July 2020	17:00	Done	10
8.	30 July 2020	06:30	Done	10
9.	30 July 2020	17:00	Done	11
10.	31 July 2020	06:30	Done	10
Average of Δ (%)				**1%**

The sensor readings are sent to the cloud server and then displayed on the monitoring and control application for fish feed that has been built. Data is sent and stored in real-time. The process of monitoring and setting the fish feeding schedule is done via a smartphone. The system will display the sensor readings every second. Feeding is carried out 2 times a day at 06.30 am and 17.00 pm with the weight of the feed that must be removed is 10 percent of the total weight of goldfish. In this study, there were three goldfish with a total weight of 200 grams. Thus, the weight of feed that must be removed by the fish feed control system is 10 grams.

Tests were carried out 10 times with an average weight of the feed that came out was 10.1 grams. The test results in Table 4 show that the automation of feeding has worked according to the set schedule and dose.

IV. CONCLUSIONS

Monitoring system and Fish feed control in aquaponics that have been designed and implemented can perform data storage, real-time monitoring, and perform scheduled fish feeding. The data taken is data from a pH sensor and a TDS analog sensor. Data will be sent continuously to the cloud server as long as the internet connection is good and the voltage supply to the microcontroller is not cut off. Automatic servo motor opens every 06.30 am and 17.00 pm to feed the fish according to the schedule with the relative weight according to the set dose. The pH and TDS sensor readings are relatively in accordance with real conditions. The pH sensor reading has an average pH difference of 0.66% with a pH meter, while the reading of the analog TDS sensor has an average difference of 2.558% when compared to the TDS meter.

ACKNOWLEDGMENT

On this occasion we would like to thank the Chairperson of LP2M and the Dean of the Faculty of Science and Technology of UIN SGD Bandung for their support in this research and publication.

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