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The Application of Quality Monitoring System of Water in IoT-Based Aquaponics Technology

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Abstract:

The sector of fisheries plays an important role in driving the economy in Indonesia. However, lately the supply of fish has started to decrease due to the cost of fishing and uncertain weather changes. This affects the need for freshwater fish to increase so as to increase the potential for freshwater aquaculture. On the other hand, getting the right air source and cultivation land for fish is seems difficult. Aquaponics is a sustainable agriculture system in a symbiotic environment by combining aquaculture and hydroponics. This water system should flow on the planting medium periodically to ensure the plants get the nutrients, while the water can be filtered properly by the medium. This research designed a smart Aquaponics system that could monitor water quality such us the degree of acidity, dissolved oxygen, water temperature, and ammonia that were integrated with internet-based mobile application. In this system, there was a sensor installed to retrieve data, which was then transmitted to Blynk IoT Cloud server that could be accessed in real time through the internet network. Thus, the quality and water circulation were well- preserved. Results showed that the accuracy of the pH sensor for acidic water is 1.52% of error and temperature sensor had an average error of 0.238%, and the monitoring system proceeded as expected

Keywords **—Monitoring, Iot, Aquaponics.**

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I. INTRODUCTION

Indonesia is the biggest marine thus the sector of fisheries became driving the economy. The fishery sector is one of the main sources of livelihood for the population [1].Thus, the fishery sector plays an important role the economy in Indonesia [2, 3, 4]. Lately, fish supply is reduced due to high fishing costs and unpredictable weather changes [5].This has resulted in the need for freshwater fish to increase so that this can increase the potential for freswater of aquaculture [6]. This potential has many problems as the availability of land in urban areas. The increase in population causes clearing land which results in incerasing land conversion for the settlements [7, 8, 9].This problem is a challenge to provide solutions in limited land cultivation technology and good water quality to produce high productivity.

Aquaponics is one solution to the limited land and water. Aquaponics can be defined as the integration of hydroponics into a recirculating fish farming system (RWS) [10]. The system of Aquaponics use waste from fish farming as a nutrients for plant growth [11]. Thus, plants have nutrification bacteria which provide a natural filter to remove dissolved nitrogen and phosphorus [10, 12, 13].

Monitoring of water quality in Aquaponics activities is really important. Water is a medium that is really influential on the productivity of aquatic animals so that it is necessary to pay attention to its quality [14, 15]. Therefore, monitoring must be carried out to maintain water quality.

Monitoring that is currently being carried out still manual. This activity is less effective and takes a long time because cultivators must know the current conditions of the cultivation environment directly by going to the field [16]. In the 4.0 era, cultivators can monitor remotly via the internet in real time [17]. This is the background for the author to conduct research by building a monitoring system that uses the ESP8266 module as a delivery module.ESP8266will transmit data that is obtained from the sensor. Transmission data can be monitored through the mobile application and notifications will be carried out directly according to a predetermined treshold.

II. METHODOLOGY

The stages of research carried out are identification of problem, literature study, system architecture design, program implement, integration, testing, and evaluation. This stages can be seen in figure 1.

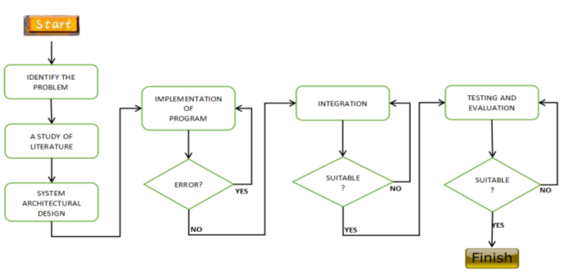

Fig. 1 Block Diagram of steps study

In this stage,the author identifies on cultivation of Aquaponics. The identification that is carried out such us how to cultivate of Aquaponics, what the factors that affect Aquaponics cultivation are and what the problem that are being faced by farmers are. The identification of problem is carried out so that this research can be useful and making problem solve that exists in the field.

Literature study is carried out to obtain additional information as a complement to the existing data. Researchers make observations on similar system that has similarities in the object of study. This stage which is used to develop system and understand the system that will be created more deeply.

Design of architecture design developed by author in this research includes how to build a good system started by forming a system built in a cultivation area, a system for placing sensors, and also a system used for monitoring processes.

In the stage of implementation program is determining the language of program that will be used to compile the program and doing the assembly on the hardware. The compiled program will be uploaded via the microcontroller. On the other hand, this stage includes the creation of the interface from the mobile application.

Integration is a merging process between the assembled hardware and the mobile application interface. The thing to note at this stage is using library that must be in accordance with the needs of the system created and also the size of the program code does not exceed the capacity of the microcontroller.

In this last stage is determining process of testing carried out on the monitoring system. The process of testing has three parts, namely calibration, functional, and monitoring test. Calibration test is the first procedure to validate tools developed with calibrated laboratory equipment. Fuctional test is carried out to determine the performance of the monitoring system from hardware to notification system whether it can work properly or not. Monitoring test is seeing the stage whether the monitoring process of the mobile application can run well, namely a data visualization displayed directly in the system.

III. RESULT

A. Design of Architecture System

This research will design an architecture of IoT used to monitor the water quality on Aquaponics.

Design of architecture system that will be made on this study can be seen in the figure 2 and 3.

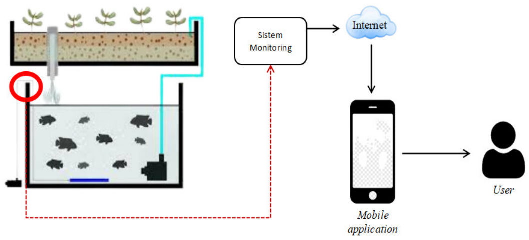

Fig. 2 Architecture of System in Aquaponics

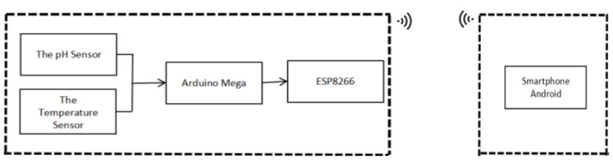

Fig. 3 Architecure of System Monitoring

B. Implementation of Program

The Stage is carried out in the implementation of program assembling of hardware and merging of program code for respective hardware. The Hardware consists of sensor, Wi-Fi module and microcontrollers. The sensors and Wi-Fi module are assembled using jumper cables and are connected to the arduino microcontrollers. The prototype assembly on the pH and temperature sensor can be seen in the figure 4 and 5.

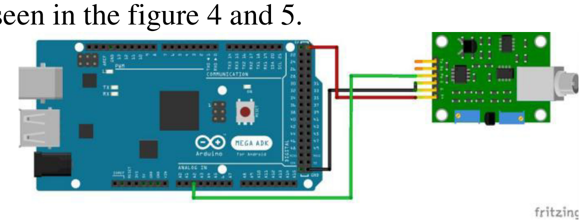

Fig. 4 Prototype of The pH Sensor

Sensor of pH used in this study takes data via the A2 of analog pin. The data obtained are in the form of voltage data stored in the variable of voltage.Then, the voltage value is converted into value of pH and stored in the variable of pH-read having been getting the value of pH. And then, doing calculation uses the regression equation from the calibration process so that the data obtained are more accurate. The value will be stored into variable of *nilai_pH*.

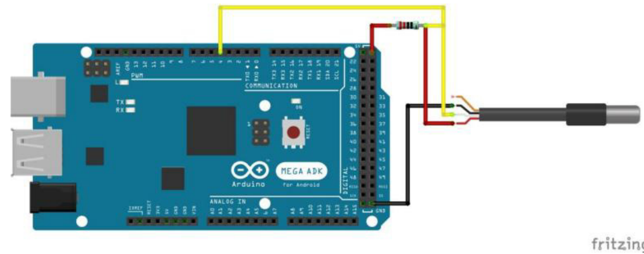

Fig. 5 Prototype of The Temperature Sensor

Thetemperature sensor used in this study is the sensor of digital. The reading of sensor is the pin of digital 4. Calculation of temperature sensor value taken in the cultivation media uses the library so that the calculation is carried out in the library.The value obtained by sensor is stored into variable of temperature.The program obtains the value of temperature carried out the calculation using the regression equation from the calibration process so that, thedata obtained are more accurate. The value will be stored into variable of *nilai_suhu*.

C. Integration

Delivering the data to the server will be cerried out when the sensor has obtained the parameter value used. The data obtained from sensor will be processed by Arduino. The Data will be sent to Blynk using ESP8266 module every fifteen minutes. Blynk saves the data stored in database having been provided. After that, mobile application gets the data delivered in Blynk and visualized in the system of monitoring. The GET data format is JSON data. The schematic of the data transmission process carried out by the ESP8266 module can be seen in the figure 13.

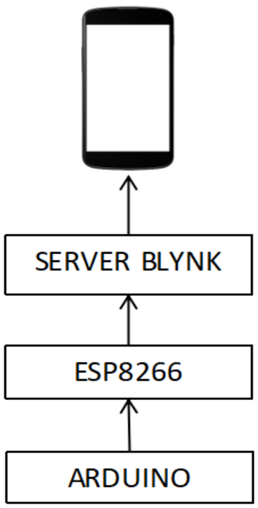

Fig. 6 Steps deliver The ESP8266 Data

D. Testing and evaluation

The results of test from sensors and laboratory equipment that have been standardized are described in the table 1 and 2. The results of the comparison test between the sensors and laboratory equipment can be shown the level of sensitivity of the tool to the media. Meanwhile, tolerance limit of the sensor with standard-laboratory equipment were tested using the regression test. The results of the regression test for each sensors can be seen in the figures 7 and 8.

Sensor	Laboratory Equipment	Results of Calibration	Error Percent
3,28	5,92	5,77	0,44
4,53	6,02	6,35	0,24
5,67	7,34	7,29	0,22
6,43	7,89	7,92	0,18
7,69	8,47	8,96	0,09
8,32	9,68	9,48	0,14
9,68	10,35	10,61	0,06
10,51	11,09	11,29	0,05
11,98	12,56	12,51	0,04
12,94	13,31	13,29	0,02
13,46	14,13	13,73	0,04

Table 1. The Calibration Test of pH Sensor

The table5 is the results of the calibration test of pH sensors. The results of calibration test have the value of error below 5%. The value of the calibration results has a value that is not different from the value taken usinglaboratory equipment. This shows that the pH sensor can be used properly. The results of calibration are calculated by equation 1.

$$y = 0{,}993243243x + 0{,}000223649 \quad (1)$$

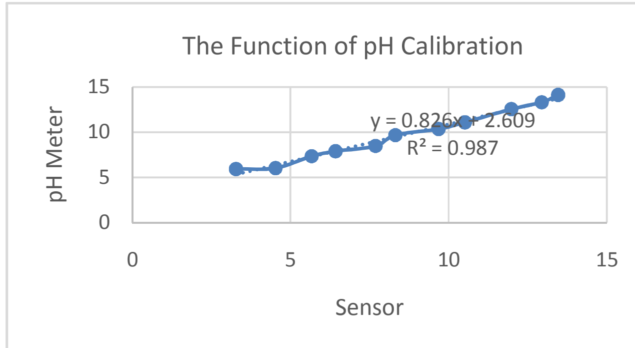

Fig. 7 Testing Regression of pH Sensor

The results of testing regression from pH sensor are shown in figure 8. The graph shows the results of measuring pH values using a sensor compared to standard-laboratory equipement. The value of 'X' is the value of the sensors and the value of 'Y' is the value of the pH sensor (laboratory equpment). The regression test shows how accurate the sensor is when compared to standard-laboratory equipment.

Sensor	Laboratory Equipment	Results of Calibration	Error Percent
21,3	22,8	22,2	0,066
23,6	24,1	24,5	0,02
25,1	25,7	25,9	0,023
25,9	26,3	26,6	0,015
26,8	27,6	27,5	0,029
27,7	28,5	28,3	0,028
29,2	29,6	29,7	0,013
29,8	30,4	30,3	0,019
30,9	31,7	31,4	0,025

Table 2. The Calibration Test of Temperature Sensor

The table 2 is the results of calibration test of temperature sensor. They show that the temperature sensor has the error value under 5%. they have a value which is not so different as the value which uses laboratory equipment. they show that the temperature sensor can be used properly. Results are calculated by the equation 2.

$$y = 0.9499x + 2.0482 \quad (2)$$

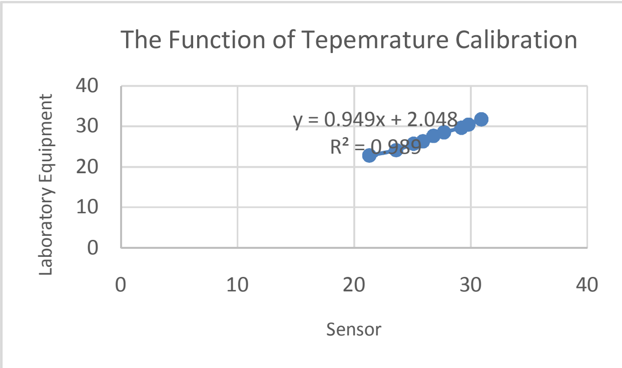

Fig. 8 Testing Regression of Temperature Sensor

The results of testing regression from the temperature sensor are shown in the figure 8. The graph shows the results of accounting value of temperature using sensor on default laboratory equipment. The variable of 'X' is the value of sensor when the variable of 'Y' is the value of temperature (laboratory equipment). The regression test shows the how accurate the sensor is when used to the default laboratory equipment.

Evaluation is carried out to know the return of the data from the sensor used and see the data collected. The collected data illustrated in the form of the graph in figure 9 and 10.

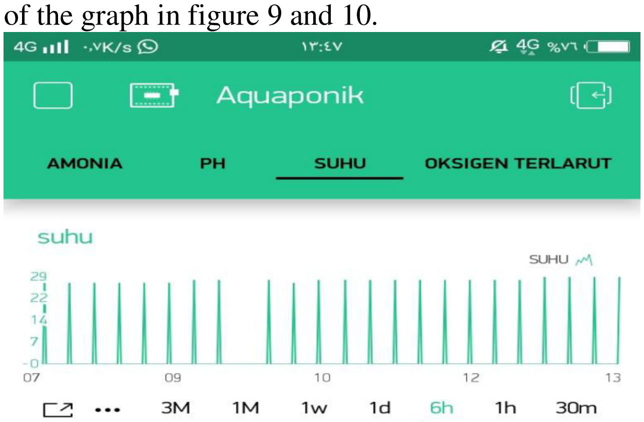

Fig. 9 Monitoring of Temperature Sensor

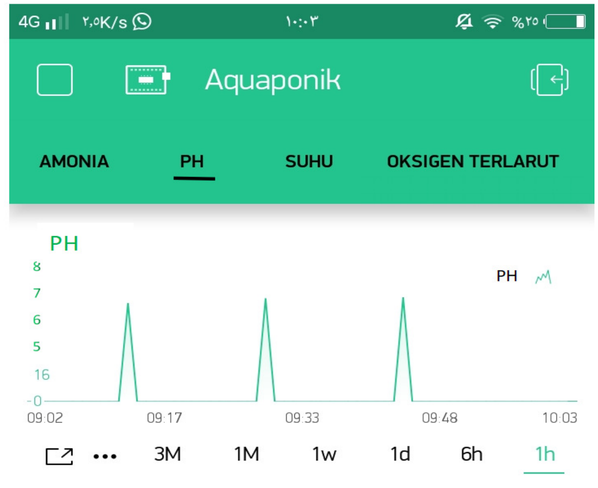

Fig. 10 Monitoring of pH Sensor

Before doing the data restore, the sensor used is calibrated by the default laboratory equipment. The pH and temperature sensor have R2 of approximately 0.9874 and 0.9897 respectively. The results of calibration show the accuration of good value so that the precision of reading the data is accurate. The pH data has data minimum approximately 5.8 which explains that the pH of the water is too low. Meanwhile, data minimum of 8.3 which explains that the pH of the water is standard. The temperature data has minimum and maximum data of approximately 25.8^{0}C and 27.8^{0}C. The temperature data explain that the temperature has a value in ideal condition.

The minimum and maximum data are to determine the lower and upper limit of the threshold respectively that will be used alert notification.

IV. CONCLUSIONS

This study succeeded in developing an android-based mobile application used for a cultivation of Aquaponics monitoring. The sensor used to take the data are pH and temperature sensor. Each sensor has been calibrated with a good accuracy value. The process delivering the data from arduino to blynk uses ESP8266 module. The data is *GET* from blynk for the alert notification process in the mobile application which does every 15 minutes.The mobile application is successful in displaying data, representing detailed data in the form of graph and notification.

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