MONITORING WATER QUALITY IN VEGETABLE HYDROPONICS USING ARDUINO MICROCONTROLLER

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ABSTRACT

pH stands for the power of Hydrogen, which is an important factor in hydroponic systems. The hydrogen ion concentration determines the value of the acidity in the solution. If the pH value of the solution is below 7.0, then it is called acidic, and if the pH value is above 7.0, it is called alkaline. The pH value can change, so it is necessary to pay attention to the acidity of the water so that the roots absorb nutrients properly that farmers often find it difficult to take measurements. Mustard plants have a pH range of 5.5 – 6.5. Based on the pH range, it is necessary to have a tool to monitor the quality of the pH in mustard plants. This monitoring is carried out by creating a hydroponic nutrient water disposal system by combining agriculture and mechatronics. Mechatronics will control the nutrient distribution system so that it can be monitored with a smartphone via wireless connectivity such as the GSM module (800L. The water quality monitoring system works by using ultrasonic sensors, sensor probes and TDS sensors, as well as the GSM 800L module. monitoring of water quality in hydroponic mustard plants) using an Arduino microcontroller and detecting pH conditions and solute content. As for the disposal of nutrient water, using a water pump connected to the microcontroller via a relay. Based on the prototype carried out on June 26, 2021, the condition of water quality has decreased in nutritional quality with the first data (pH 6.31 solute 529 ppm) and the latest data (pH 9.09 and solute 662 ppm). When the water quality is below the nutritional standard, the water pump turns on to remove the nutrient water. The results of the prototype that has been carried out have succeeded in monitoring water quality hydroponics and can be used by farmers.

Keywords*: Hydroponics, Microcontroller, Mustard Plants.*

I. INTRODUCTION

Hydroponic farming has been widely used by some people because of the hydroponic method of growing without using soil media [1]. *Hydroponic techniques based on growing media are divided into four, namely Deep Flow Technique, Floating System Hydroponics Technology, Aeroponics, and Nutrient Film Technique* [2]. The Deep Flow Technique hydroponic method is one of the widely used methods by the community.

Using the Deep Flow Technique (DFT) system, hydroponic cultivation can grow well and have better vegetable quality than conventional methods. The DFT method circulates the plant nutrient solution continuously while the pH of the nutrients is still available in the growing media so that plants get sufficient intake [2]. One of the plants using the DFT hydroponic system is mustard greens.

Mustard has high nutritional and also has economic value. It can grow in hot and cold places so it can be done in the lowlands and highlands. Suitable planting is from 5 meters to 1,200 meters above sea level [2]. Although it can grow in the highlands or lowlands, mustard greens require nutrient water to achieve plant fertility.

The DFT hydroponic method for mustard plants needs to know the pH range of nutrient water and the content of dissolved substances in the pipe to ensure plant fertility and regulate nutrient water disposal according to mustard plant parameters [2], [3]. Nutrient water for mustard growth should not be too acidic or too alkaline so that the fertility of the mustard plant can be maximized [3], [4]

From the background, we can conclude that the research on monitoring the hydroponic water quality of mustard plants uses the Arduino microcontroller. This system is made in the form of a prototype, namely making systems and tools that represent the actual system which is more complex. The system created helps monitor the pH levels of nutrient water and solutes in hydroponics so that the system can discharge nutrient water with fertility parameters, and farmers can monitor hydroponic growing media.

II. LITERATURE REVIEW

A. *Circulation*

Nutrient circulation in hydroponic installations is even out the distribution of nutrients in the water flow for all plants. Utilization of nutrient circulation also provides oxygen intake needed by plant roots and keeps the temperature of the nutrient solution incredible, so that nutrient solution absorption remains optimal [3], [5]

B. *Arduino*

Arduino is a microcontroller board based on the ATmega328. Arduino UNO contains everything needed to support the microcontroller; it is easy to connect it to a computer with a USB cable, supply it with an AC to DC adapter, or use a battery to get started. The ATmega328 on the Arduino Uno comes with a bootloader that allows us to upload new code to the ATmega328 without using an external hardware program [6], [7].

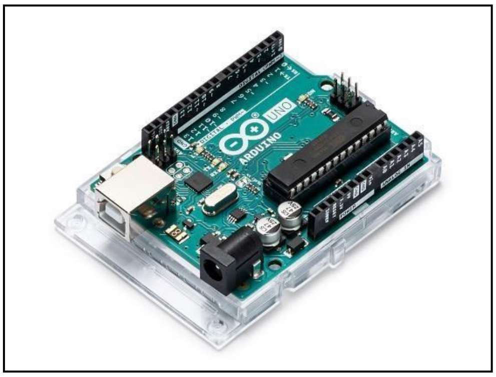

Figure. 1 Arduino

C. *Sensor pH air*

PH is a measure of the acidity or base of a solution on a scale of 0 to 14. A value of 0 indicates acid, a value of 7 indicates neutral, and a value of 14 indicates a base. The sensor can measure the solution by measuring the potential difference between two electrodes, namely the reference electrode and the glass electrode, sensitive to hydrogen ions. The two electrodes that make up the probe of the PH sensor [6], [7].

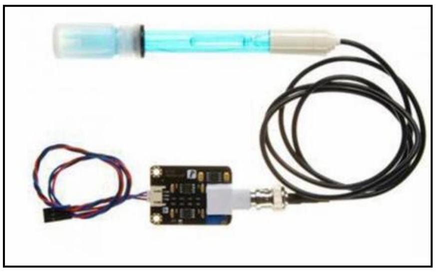

Figure. 2 Sensor pH

D. *Ultrasonic Sensor*

The ultrasonic sensor utilizes the ultrasonic wave reflection as the measurement medium. These sensors have analogue properties and can see changes in altitude to the smallest [8].

Figure. 3 Sensor Ultrasonic

E. TDS Sensor

The TDS (Total Dissolved Solids) sensor in water uses a conductivity sensor system with two probes made of stainless. In this sensor, the flow of direct current into the liquid becomes very susceptible to electrolysis and changes in the polarity of the ions. A constant AC voltage source is used on the probe so that the solution can flow current and convert the conductance value into volta [8], [9].

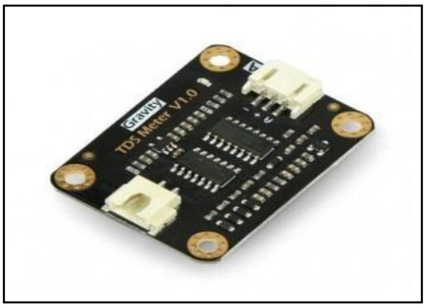

Figure. 4 Sensor TDS

F. Fertility Parameters

The nutrients in hydroponic nutrition are essential elements needed by plants for their growth and development. Treatment of nutrient concentration (K3) tends to produce the highest number of leaves caused in the process of forming leaf vegetative organs; plants need nitrogen nutrients in large quantities [3]–[6]. The following is a test table for the content of dissolved substances in mustard plants:

Table.1 Fertilitu Parameters[3], [11]

No	Consentrant	Average Nutrition Leaf		
1	1050 ppm (K1)	10,444	12,407	19,259
2	1150 ppm (K2)	11,704	13,296	20,852
3	1250 ppm (K3)	13,667	15,630	21,407

So from the above review, the mustard plant parameter used as a parameter in this study is the dissolved substance content of 1250 ppm.

G. Framework

The framework used as a reference for carrying out the steps used in this study is as follows :

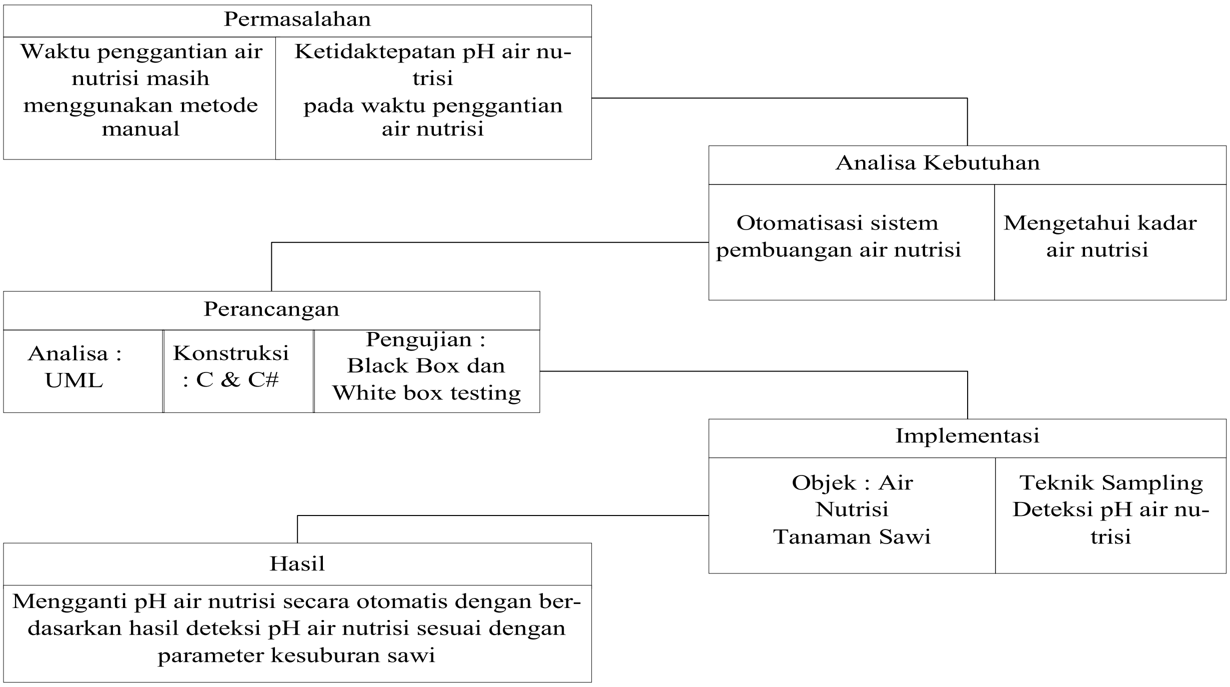

Figure. 5 Framework

III. RESEARCH METHOD

A. System Development Method

The system development method used is the waterfall method by detecting the pH of nutrient water and the content of dissolved substances in hydroponic growing media to automate nutrient water disposal. The steps used are as follows:

1. Analysis
   This stage is a process of analyzing the needs of hydroponic farmers. The problem with the DFT hydroponic planting method is the replacement time for nutrient water that is no longer suitable for plant nutrient intake. A system creates to overcome the delay in replacing nutrient water from these problems.
2. System Design
   In this research, we used a pH sensor, ultrasonic, and a microcontroller and made it connected to the web to display nutrient water replacement data.
3. System Coding
   This stage is the stage of coding the system from the tool that is designed and then coded using the programming language for web C# and C for Arduino IDE.
4. Experiment Process
   This stage is for testing the system by testing several sensors and then until the sensor data enters the database. The information displayed is nutrient water pH, solute content, and nutrient water disposal. As for the system, there are inputs, processes, and outputs using black-box testing and white box testing.
5. Implementation
   This stage is to implement the system. In monitoring the quality of nutrient water, if the water conditions are not following the pH parameters for the disposal of nutrient water in hydroponics using an Arduino microcontroller.

B. Need Analysis

There are several ways of collecting data, namely by using the following methods:

1. Observation
   Conducted by conducting a review of hydroponic farmers in the Griya Mustika Cindai Alus Martapura Complex, Banjar Regency, and analyzing the problems of hydroponic farmers, namely the accuracy of

nutrient water disposal and information about the quality of hydroponic nutrient water so that tools and information media are needed that display data on the condition of nutrient water quality on hydroponic growing media.

2. Literature Review

   It conducts a review of hydroponic farmers in the Griya Mustika Cindai Alus Martapura Complex, Banjar Regency, and analyzes the problems of hydroponic farmers, namely the accuracy of nutrient water disposal and information about the quality of hydroponic nutrient water so that tools and information media are needed that display data on the condition of nutrient water quality on hydroponic growing media.

3. Interview

   In this study, the authors conducted direct interviews with hydroponic farmers in the Griya Mustika Cindai Alus Martapura Complex, Banjar Regency, namely M. Hidayatullah. It is regarding the problems hydroponic farmers face, especially in mustard plants. The authors can carry out a needs analysis.

C. System Design

1) Equipment Flowchart

The flowchart of this tool serves to design a nutritional water quality monitoring tool for mustard plants in hydroponics. So that the grooves on the tool can run properly. The flowchart of the tool is as follows:

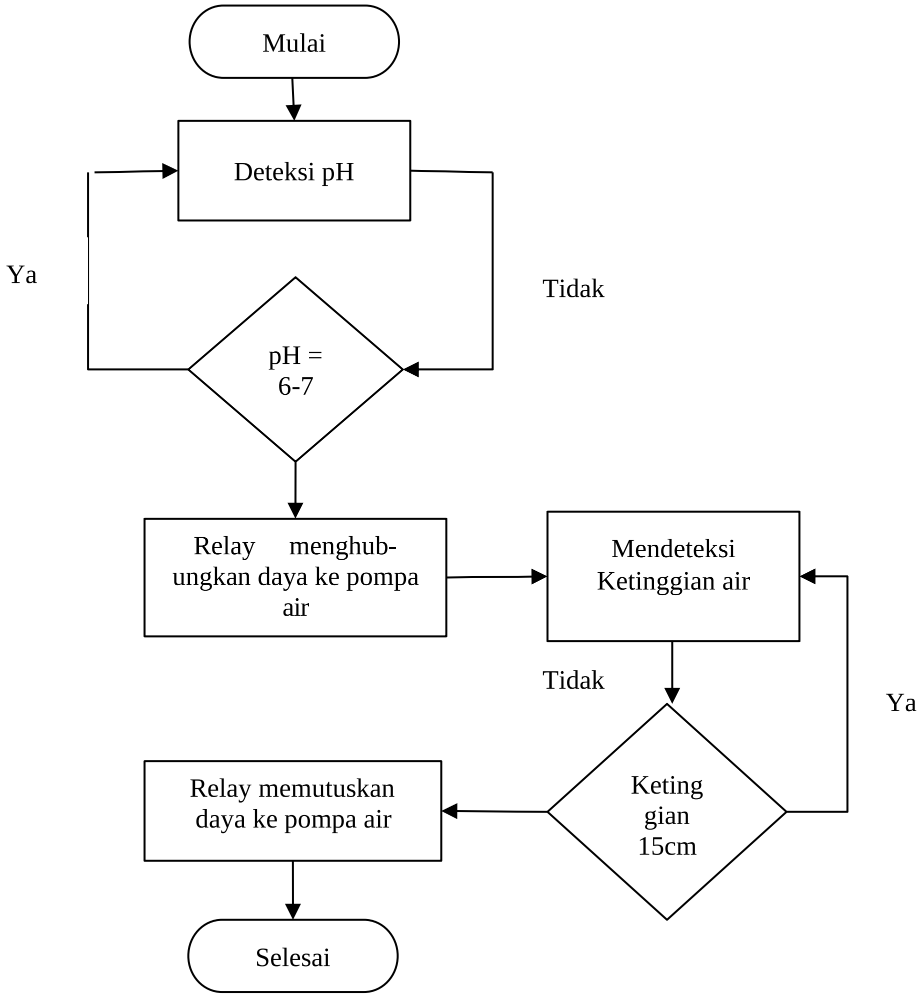

Figure. 6 Equipment Flowchart

The flow starts by detecting the pH of the nutrient water; if the pH condition is still in average condition. pH and solute detection will repeat until the pH condition does not match the 6-7 pH; the relay will connect the power to the water pump to dispose of the nutrient water. Then the water level will be detected; if the water level has reached 0-1 cm, which means the nutrient water has been wasted, the relay will cut off the power to the water pump.

2) *System Flowchart*

Application Flowchart is a flow for users on a hydroponic water quality monitoring system. Users can find out the design flow of the system. The application flowchart of this research is as follows *:*

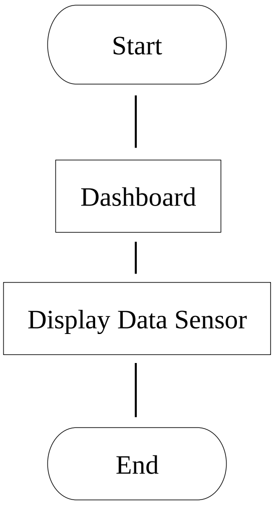

Figure. 7 Application Flowchart

IV. RESULT AND DISCUSSION

A. *Implementation*

In the series of hydroponic monitoring tools, ultrasonic sensors, sensor probes, and TDS sensors with relays help turn on the water pump and GSM module to send data to the hydroponic monitoring web application server. The sensor probe detects the pH conditions of the nutrients in the hydroponic pond. The probe sensor will continue to detect pH conditions until the pH level is below seven. If the pH is below 7, then the Probe Sensor will perform the function of turning on the relay connected to the water pump.

TDS Sensor detects dissolved substances in the hydroponic pond. The TDS Sensor will continue to detect the solute until the solute level is 1000 ppm. If the solute is above 1000 ppm, the TDS sensor will run the function on the Arduino to connect power to the water pump.

The ultrasonic sensor helps detect the water level to determine the water level in the hydroponic nutrient pool. If the air level has reached low due to exhaust, the sensor performs a function to turn off the relay connected to the water pump.

Fig. 8 Sensor Installation

B. *Basis Data Implementation*

The database in this study creates using LiteDb. The database implementation is as follows:

1) *Sensor Result*

The implementation of the sensor results database design is as follows:

Table.2 Sensor Result

No	Time	pH	pH Condition	Tds	Tds Condition	Water Level
1	**25/06/2021 00:25:43**	**7,0**	**Profer**	**1150,0**	**Improfer**	**6**

2) *pH Condition*

The implementation of the pH condition database design is as follows:

Table. 3 pH Condition

No	Upper Limit	Lower Limit	Description
1	7.0	6.0	Profer
2	7.0	14.0	Improver

3) *TDS Condition*

The implementation of the sensor results database design is as follows:

Table. 4 TDS Condition

No	Upper Limit	Lower Limit	Keterangan
1	1400.0	500.0	Profer
2	1500.0	1400.0	Improfer

C. *Interface Implementation*

The user interface implementation includes screen condition management, layout design, data handling, and user interaction to match the functions in the application. The following is a page that displays sensor data sent from Arduino using the 800L SIM module. Sensor results filter according to the date the sensor data was sent. In the sensor results interface, the date filter functions to view the sensor results on the date of the input data. There is also a timetable to display the sensor result time. A pH table to display sensor data from the sensor probe, a TDS table to display sensor results data from the TDS sensor, and an ultrasonic display of the results of water level detection so that the altitude can be known. Water in a hydroponic pond.

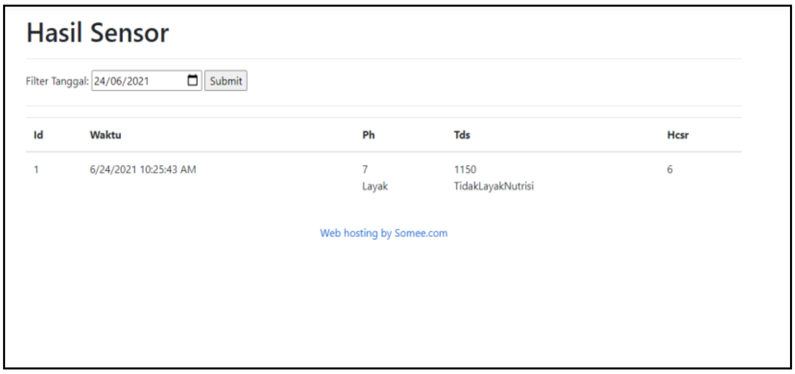

Figure. 9 Sensor Data

D. Testing

In this study, testing tools help know the accuracy of the sensor data so that the assembly of the tool already shows valid data. Testing tools in this study are as follows:

1) Probe Sensor

In this step, a sensor probe detects the pH of a nutrient whose pH is already known using a pH measuring device. In the test, it is known that the pH value of nutrients is 7, as shown in the following figure:

Fig. 10 Nutrition pH Sensor Test

After using a sensor probe, it is known that the nutritional pH value is 6.67, as shown in the following figure:

```
21:55:37.135 ->     pH:6.67
21:55:38.059 ->     pH:6.67
21:55:38.963 ->     pH:6.67
21:55:39.851 ->     pH:6.67
21:55:40.741 ->     pH:6.67
21:55:41.633 ->     pH:6.67
21:55:42.572 ->     pH:6.67
```

Figure. 11 Nutrition pH Result

2) TDS Sensor

The TDS sensor test determines the dissolved content so that it can be defined and used according to its content. Tests for detection of dissolved substances in nutrient water. This solute test detects nutrient water whose solute value is known, namely ppm, as shown in the following figure:

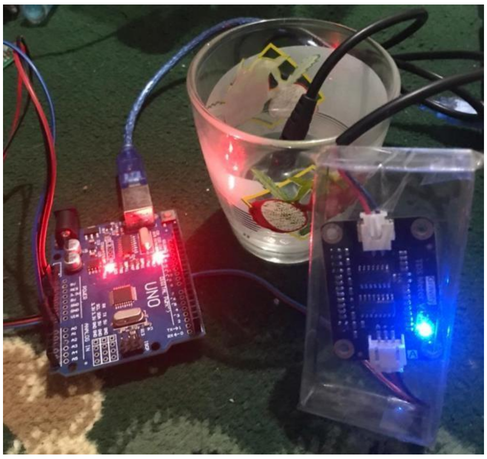

Figure. 12 Dissolved Substance Test

After using the TDS Sensor and obtaining the value of the mineral water is ppm as shown in the image below:

```
22:45:41.290 -> TDS Value:195ppm
22:45:42.087 -> TDS Value:195ppm
22:45:42.931 -> TDS Value:195ppm
22:45:43.726 -> TDS Value:195ppm
22:45:44.520 -> TDS Value:195ppm
22:45:45.316 -> TDS Value:195ppm
22:45:46.112 -> TDS Value:195ppm
22:45:46.909 -> TDS Value:195ppm
22:45:47.702 -> TDS Value:195ppm
22:45:48.496 -> TDS Value:195ppm
22:45:49.294 -> TDS Value:195ppm
22:45:50.133 -> TDS Value:195ppm
22:45:50.930 -> TDS Value:195ppm
22:45:51.722 -> TDS Value:195ppm
22:45:52.516 -> TDS Value:195ppm
```

Figure. 13 Dissolved Substance Result

3) Ultrasonik Sensor

The water level test uses a ruler at a water depth in one container, and the ultrasonic sensor detects the water level. The ultrasonic sensor is placed above the water surface, so if the sensor value is high, the water will recede.

Fig. 14 Testing Process of Water Level Detetion

Figure 14 is an ultrasonic sensor test that detects the water surface. If the ultrasonic sensor detection results show an increase, then the water level shows a decrease.

```
COM6

01:06:53.680 -> Distance: 8
01:06:54.714 -> Distance: 8
01:06:55.686 -> Distance: 8
01:06:56.720 -> Distance: 8
01:06:57.707 -> Distance: 8
01:06:58.704 -> Distance: 8
01:06:59.679 -> Distance: 8
01:07:00.710 -> Distance: 8
```

Fig. 15 Water Level Result

4) GSM Module

The GSM module is tested by sending data to a hydroponic web database server as shown in the following image:

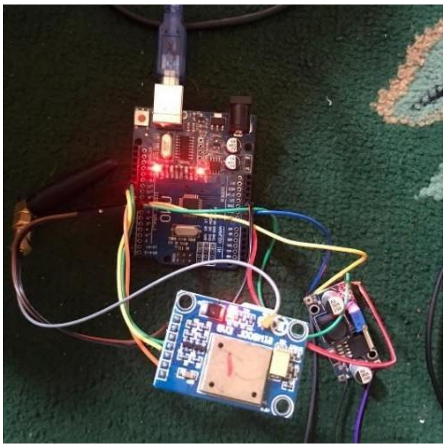

Fig. 16 Modul GSM

In testing the GSM module, it is done by programming to send sensor data that has not been calibrated to the program on the Arduino IDE.

Table. 4 Send Data

No	Time	pH	Tds	Level
1	24/06/2021	30.0	10.0	10.0

E. Experiment Process

The sensor probe will detect the pH. The TDS sensor detects dissolved substances in the nutrient water reservoir; if the detection results show the data is below the parameter, the relay connects the power to the water pump and removes the nutrients. When the water pump has drained the nutrient water, the relay will wait for the results of the ultrasonic sensor to detect the water level; if the water has shown low tide, the relay will cut off power to the water pump.

F. Discussion

The manufacturer of this hydroponic water quality monitoring tool uses three sensors, namely ultrasonic sensors, probe sensors, and TDS sensors. The module used is the gsm 800l module, which sends sensor data to the webserver. The manufacture of this tool begins by testing or calibrating the sensors and modules used. The next step is to combine sensors, modules, and Arduino microcontrollers, as shown in the picture.

Monitoring water quality in hydroponic mustard plants using an Arduino microcontroller and detecting pH conditions and solute content. As for the disposal of nutrient water, using a water pump connected to the microcontroller via a relay.

On June 26, 2021, We experienced a decrease in nutritional quality with the first data (pH 6.31 solute 529 ppm) and the last data (pH 9.09 and solute 662 ppm). When the water quality is below the nutritional standard, the water pump turns on to discharge the nutrient water. With the results of monitoring water quality in hydroponics, it can be concluded that this research has been achieved. This system expects to be used by hydroponic farmers, especially in monitoring the condition of mustard plants.

V. CONCLUSION

The design of a hydroponic plant nutrition monitoring system is by detecting the pH; the dissolved substances will be displayed on the application to make it easier for farmers to monitor the quality of hydroponic nutrient water.

The condition of water quality on June 26, 2021, for 3 hours, experienced a decrease in nutritional quality with the first data (pH 6.31 and solute 529 ppm) and the last data (pH 9.09 and solute 662 ppm) where the pH conditions showed basicity and lead to a decrease in the nutritional quality of the air. The pH sensor and TDS sensor data are sent to a web server with a GSM module. It is displayed in the form of a table of sensor results. Based on the data obtained, the water condition has decreased so that the water pump connected to the relay turns on to dispose of water in the hydroponic pool.

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