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Electronic devices monitoring water pH, humidity and temperature controllers in Agro-Hydroponic Business

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ABSTRACT

Increasing the cultivation of hydroponic plants presents challenges, particularly in monitoring water pH and controlling temperature and humidity in hydroponic farming, which are often neglected. The lack of proper monitoring can significantly impact hydroponic plant growth. This issue arises due to the reliance on manual checks, which prevents real-time and efficient monitoring. This research employs a comparative method to analyze water pH levels using both a water pH sensor and a pH meter. For temperature and humidity monitoring in the hydroponic plant area, the study compares the readings of the DHT22 sensor with online weather data, both monitored in anytime via a web server. Temperature and humidity data can be accessed at any time, but the focus of comparison is on daytime, as temperature and humidity fluctuations are more drastic, with temperatures exceeding 30°C.The purpose of this test is to determine the water pH level as well as the temperature and humidity conditions suitable for hydroponic farming. Based on observations, the developed system enables real-time monitoring via a web server, demonstrating good performance and meeting efficiency objectives in automated temperature and humidity control. The implementation of this system is expected to be expanded in the future, providing a viable solution for users and enhancing process efficiency in related fields.

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1. INTRODUCTION

At this time, technology has developed in various fields of equipment that have reached a level where each tool can be done automatically, both on a home scale and on an industrial scale [1]. In the field of automation, electronic devices play a bigger role in various types of industry and daily life, both in the social and environmental fields [2]-[4]. The environmental field needs to be improved, both in permanent agriculture and permanent non-agriculture. And the use of permanent non-agriculture must be improved by applying hydroponic engineering methods, which are planting methods that do not require soil as a planting medium, such as vegetable plants [5]-[7]. Hydroponics has several advantages, including ease of management, efficiency of the amount of plant nutrients, the amount of water, no need for soil, fertilization, and savings on land used [8]-[10].

Conditioning the pH of the water used will have a big impact on hydroponic plants so that the pH required by these plants ranges from 5.5 to 7.5, especially during the rainy season, which contains quite acidic water which can affect the pH of hydroponic plant water [11]-[13]. Temperature and humidity in the hydroponic plant environment also have an impact on the quality of hydroponic plants which experience a decrease in the quality and growth of hydroponic plants [14]. The temperature required in this hydroponic plant area ranges from 180-300 Celsius, but this temperature also varies depending on the location of the area, such as lowland areas ranging from 210-300 Celsius. If the temperature is not met, it can cause

Dissolved Oxygen (DO) in the water absorbed by plants [15]. Humidity also affects hydroponic plants, which is optimal for plant cultivation. Hydroponics should not be too far from 70% to above 80% RH.

These hydroponic plants require a tool that can detect water pH, temperature and humidity in the hydroponic plant environment area [16]-[18]. This tool uses a Raspberry Pi microcontroller which is used as a monitoring and control system for the tool [19]-[21]. This tool uses water that will be channeled through a hose and sprayed into water droplets by a sprayer nozzle to lower the temperature and increase humidity in the hydroponic plant area.

2. METHOD

Tool design aims to overcome errors in the manufacturing process so that the resulting tool is in accordance with the plan. This research method includes the design and manufacture of hardware and software. The hardware design was made using the SketchUp application, an application used to create 3D designs for the components used. Meanwhile, the software design used the Fritzing application to create a schematic diagram of the tool and the use of VNC, PuTTY and Arduino IDE to create a programming sketch of the tool. Block diagrams are the foundation in designing a tool. By designing a good block diagram, we can ensure that the circuit we create will function as expected. Figure 1 below shows a block diagram of the system in the tool used..

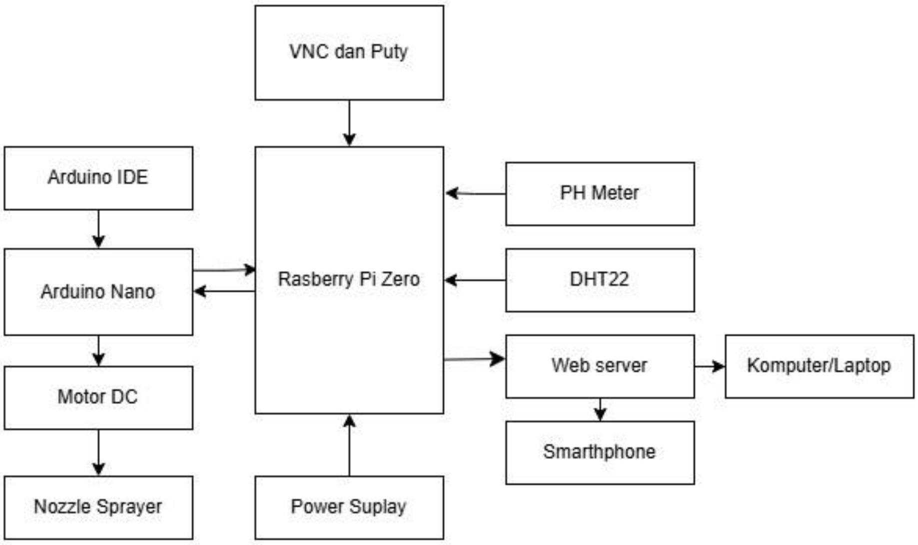

Figure 1. Block diagram of the proposed hydroponic system

Based on the block diagram above, the design of each block diagram has the following functions: 1) Raspberry Pi Zero is the main component in this system which has a function as a brain / controller [18]. Which uses a web server as a medium to convey data information sent by the tool can be accessed via PC/Computer or Smartphone [22]. 2) VNC and PuTTY are software used to make it easier to replace and change the program used on the Raspberry Pi Zero as a data sender regarding the information to be displayed, and the programming used in designing the information display uses C ++ programming [23]. 3) Arduino Nano is a compact and open-source microcontroller board designed to facilitate the development of various electronic projects [24]. Arduino nano functions as a control center for the control system on the tool. 4) Arduino IDE is used to develop applications such as compiling into binary code and uploading into microcontroller memory, programming, and as a hardware programming interface [25]. Arduino IDE software is used as a medium for programming tools that will be tested on hardware. 5) Power Supply as a power supply provider used to raspberry pi zero, arduino nano and to turn on the DC motor. 6) The pH meter sensor functions as a sensor used to measure the degree of acidity (pH) in a solution/water to be tested. 7) The DHT22 sensor functions as a temperature and humidity reader and sends data used as a temperature detector in the hydroponic plant greenhouse room. 8) The webserver functions as a medium to inform the data obtained and received by the raspberry pi zero.

The working principle of this tool is to provide information about the pH value of plant water, temperature and humidity used by the hydroponic plant area. With the presence of this temperature and humidity sensor is also used to control the temperature and humidity of the hydroponic plant area. The microcontroller used is raspberry pi zero which is used to process data from these two sensors to provide data about water pH, temperature and humidity and arduino nano as a microcontroller that controls the dc motor as a temperature and humidity controller output. This tool makes it easy for users to control temperature and humidity automatically and can monitor water pH, temperature and humidity through a web server. The general working principle in the process of this tool is done automatically through interaction between hardware and software.

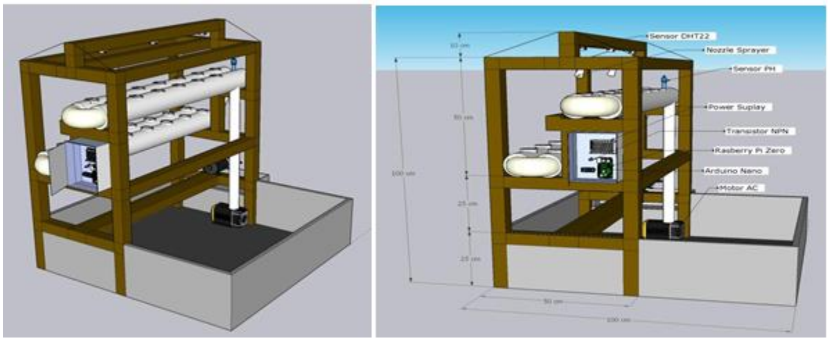

Figure 2. Design of hydroponic equipment

Figure 2 is the hardware design of the tool which includes the design of the components that will be used in 3D form so as to create a realistic visual model and simplify and reduce the level of errors when creating hardware so as to achieve optimal results. The components used are raspberry pi zero, arduino nano, power supply, DHT22 sensor, pH sensor, NPN transistor, DC motor and sprayer nozzle. Figure 3 is the overall design of the tool, there is a circuit schematic which aims to determine the connection of each pin on the component used in this research.

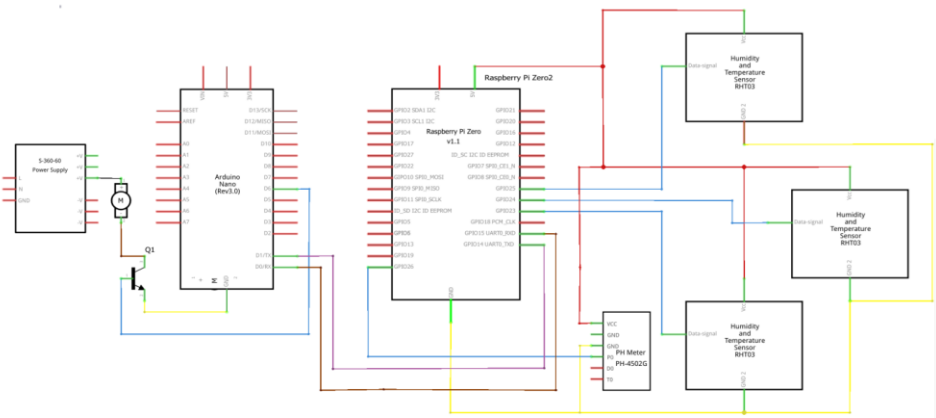

Figure 3. Circuit schematic.

After the hardware assembly stage is complete, the next process is software development. This stage includes writing program code, testing to identify and correct errors, and integrating the program with the hardware to ensure the system operates as a whole. Software design in the form of a flowchart is defined as a diagram with graphic symbols that shows a process flow, displaying several symbolized steps or a graphical depiction of the steps or sequence of a program procedure that performs a specific function. Figure 4 shows the primary design for each sensor, namely the water pH sensor and the temperature and humidity sensors. The water pH sensor begins by measuring the water's pH level. If the sensor does not detect the pH level, it will re-measure, and if detected, the data will be displayed on the webserver. Then, the temperature and humidity sensors begin measuring the temperature and humidity in the hydroponic plant area. If the temperature and humidity are not detected, the sensors will re-measure. Once the temperature and humidity sensors have been read and the temperature has reached the specified range, the information will be sent to the webserver. However, if the temperature and humidity are detected to be not within the specified range, the DC motor will be activated to spray water, where the sprayer nozzle will change the water into water droplets which will be used to lower the temperature and increase the humidity, after which the data will be sent to the web server.

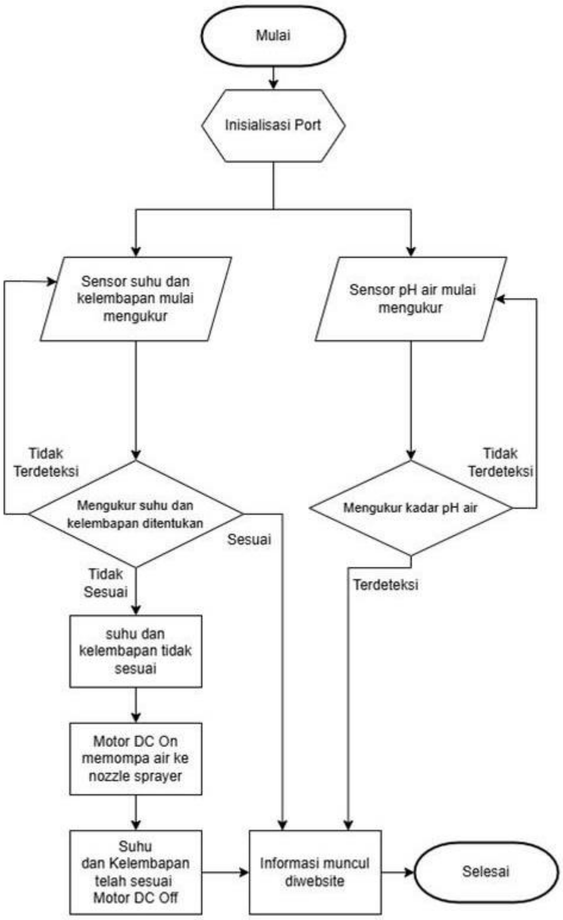

Figure 4. Software design flowchart

3. RESULTS AND DISCUSSION

This tool was tested to clearly demonstrate that the hardware and software worked together effectively. The hardware design included the mechanical and electronic components of the entire tool, including the Raspberry Pi Zero, Arduino Nano, NPN transistor, DC motor, water pH sensor, temperature and humidity sensor. The electronic design in this study used a box-shaped casing to protect the connected electronic components. The hardware design results can be seen in Figure 5.

Figure 5. Results of making hardware of a hydroponic system

This software design consists of a web server connected to several sensors, including a water pH sensor, temperature, and humidity sensors, using a mini PC as a monitoring medium to send the data to a web server using a Raspberry Pi Zero. The data obtained includes monitoring of the plant water pH, temperature, and humidity in the hydroponic plant area. The results of this software design can be seen in Figure 6.

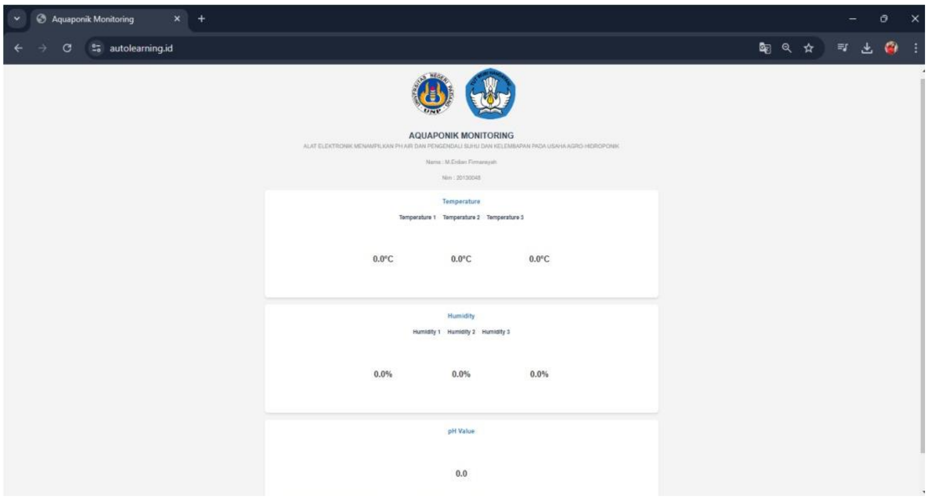

Figure 6. Software Design Results in the form of a Webserver

Testing of this device began with temperature and humidity measurements using a DHT22 sensor to determine the temperature and humidity in the area around the hydroponic plants. Three DHT22 sensors were placed on the right, middle, and left sides of the device to detect temperature and humidity. The test was conducted over four days at three different times: morning, afternoon, and evening. The results of this test can be seen in Table 1, which records temperature and humidity.

Table 1. Temperature and humidity testing

No	Day / Hour	DHT22 Sensor (Temperature (^{O}))			Weather Online	DHT22 Sensor (Humadity)			Weather Online
		1	2	3		1	2	3	
1	Day-1 (07.00)	28.4	28.4	28.4	29.8	70%	70%	70%	70%
2	Day -1 (13.00)	31.7	31.4	31.4	32.8	69%	69%	69%	69%
3	Day -1 (18.00)	27.5	27.5	27.5	28.9	72%	72%	72%	72%
4	Day -2 (07.00)	28.7	28.7	28.7	29.8	71%	71%	71%	71%
5	Day -2 (13.00)	32.5	32.3	32.1	33.5	60%	60%	60%	63%
6	Day -2 (18.00)	28.9	28.9	28.9	30.1	67%	67%	67%	67%
7	Day -3 (07.00)	28.2	28.2	28.2	28.9	67%	67%	67%	68%
8	Day -3 (13.00)	29.5	29.5	29.5	30.6	66%	66%	66%	67%
9	Day -3 (18.00)	28.3	28.3	28.3	28.2	67%	67%	67%	68%
10	Day -4 (07.00)	28.7	28.7	28.7	27.6	69%	69%	69%	70%
11	Day -4 (13.30)	34.8	34.8	34.8	33	66%	66%	66%	67%
12	Hari-4 (18.00)	28.4	28.4	28.4	30.2	67%	67%	67%	67%

Table 1 shows that the accuracy of the DHT22 sensor test for temperature and humidity differences with online weather showed a difference of no more than 20°C over the four-day test. The next test, which examined the pH of the water used for hydroponic plants, was conducted on several types of water with varying pH values. The results are shown in Table 2.

Table 2. Water pH testing

No	Water Type	pH meter	pH sensor	Error	% Error
1	1	4,12	4,20	0,08	1,94%
2	2	5,36	5,26	0,10	1,86%
3	3	,23	6,29	0,06	0,96%
4	4	7,34	7,22	0,12	1,63%
5	5	9,08	8,94	0,12	1,54%

This can be seen in the five types of water pH used as the pH test media for the pH meter sensor and the pH meter that will be applied to the water used in hydroponic plants. The results of the water pH testing showed that the error rate of the pH sensor and pH meter was no more than 2%. The next test was the temperature and humidity control system, which was carried out three times a day, preferably during the day between 12:30 and 14:00 WIB, when the temperature fluctuates drastically. This test can be seen in Table 3.

Table 3. Temperature and humidity control system testing

Day	Time	Temperature (^{0})	DC motor
1	07.00-08.00	27.4	Off
	12.30-14.00	32.3	On
	17.30-18.30	29.6	Off
2	07.00-08.00	28.4	Off
	12.30-14.00	26.8	Off
	17.30-18.30	26.4	Off
3	07.00-08.00	28.3	Off
	12.30-14.00	34.8	On
	17.30-18.30	29.5	Off

This test demonstrated that the temperature and humidity control system operated smoothly. When the temperature exceeded 300°C, the DC motor was activated. When the DC motor was activated, the temperature dropped and humidity increased in the hydroponic plant area. The next test, which involved water pressure, was used to lower the temperature and increase humidity in the hydroponic plant area. This was conducted in seven trials under various conditions, as shown in Table 4.

Table 4. Water pressure testing from the sprayer nozzle spray distance

Testing	Distance of Nozzle Sprayer
1	12 cm
2	13 cm
3	15 cm
4	14 cm
5	15 cm
6	15 cm
7	15 cm

In this test, it can be seen that the sprayer nozzle's spray power can be adjusted and the maximum distance is 15 cm. In the fourth experiment, there was a decrease in spray distance due to the difference in the length of the hose used to channel the water from the reservoir to the sprayer nozzle.

4. CONCLUSION

The results of the testing and analysis conducted in this study showed that the use of this tool is able to work according to the design that has been made. In addition, the use of a web server as a monitoring of water pH, temperature and humidity in hydroponic plants can be monitored in real time. Also, the use of a mini PC as a control and monitoring system has proven to be able to work effectively and efficiently to regulate and monitor temperature and humidity in the hydroponic plant area. It can be concluded based on existing testing and observations, the system has demonstrated decent tool performance and can monitor water pH levels, temperature and humidity in real time, which can be seen from the test results that the error rate/difference with the comparison is not much different. The use of this tool is successful in being able to control temperature and humidity from the existing comparison level. Based on existing observations, the results of the system created can be monitored in real time on the web server, and shows good performance results and meets the goal of efficiency in monitoring and controlling temperature and humidity automatically.

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