IoT-based for Monitoring and Control System of Composter to Accelerate Production Time of Liquid Organic Fertilizer

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***Abstract*—The composter is a method to produce liquid organic fertilizer. The manual process certainly takes a long time. Thus, the automatic composter proposed in this research is equipped with a monitoring and control system. In producing liquid organic fertilizer using a composter, several things can affect the maturity of the fertilizer, including pH and temperature factors. The reference temperature for producing liquid organic fertilizer in the composting process ranges from 30-40 ºC, while the pH in the composter must be in the range of 4.5-6.5. This composter is designed to be able to carry out automatic mixing equipped with a temperature control system that serves to maintain temperature stability in the compost media according to the reference temperature. The composter design is equipped with a DHT 11 sensor as a temperature sensor, a pH sensor and the ESP 32 as the controller. The internet of Things (IoT) makes this system easy to control using android. Producing liquid organic fertilizer compared between the automatic and manual processes. The results show that liquid organic fertilizer can be produced faster, has a better quantity and quality than the manual process.**

***Keywords*—Composter, Liquid organic fertilizer, pH monitoring, Temperature control**

INTRODUCTION

Indonesia has strong potential in the agricultural sector [1]. Indonesia has always focused on national agricultural development since the Dutch colonial era. This increase in agricultural development is an effort to overcome the community's need for food which will continue to be carried out with various efforts, ranging from fertilization, pest eradication or the use of superior seeds. These efforts are socialized, especially in outreach activities. Counselling to farmers is often carried out, especially regarding the use of fertilizers.

The factor of low farmer knowledge is also one of the biggest factors causing this to happen because farmers are often given the wrong dose of fertilizer so that the impact is the production of chemical residues from the fertilizer that is given so that in the long term it causes damage or criticality the land [2]. The use of appropriate fertilizers can increase crop productivity. Fertilizers can fertilize infertile soil quickly [3]. However, if the application of fertilizer is used inappropriately, it can make the soil harden and lose its nutrients. Due to improper application of fertilizers, many agricultural lands in Indonesia are in very poor condition, due to damage and poor nutrients.

The cause of inappropriate use of fertilizers is also influenced by the use of inorganic fertilizers, known as chemical fertilizers, which do not pay attention to the dose or are excessive [4]. The negative impact of using inorganic fertilizers or chemical fertilizers, among others, is marked by a decrease in production and a decline in soil fertility. Overcome the condition of agricultural land that has been damaged, it can be done by using organic fertilizers. Organic fertilizers can increase the productivity of existing dry land, food production can also be increased through the expansion of the planting area on dry land because it does not use chemical or synthetic elements. Soil fertility management is not limited to increasing chemical fertility, but also physical and biological soil fertility [5].

Organic fertilizers are fertilizers composed of weathered plant, animal and human residues in solid or liquid form, which can be sourced from organic waste, green and dry leaves, harvest residues such as straw and rice husks and livestock waste. The form of organic fertilizers can be grouped into 2 forms, namely; liquid organic fertilizer and solid organic fertilizer. Liquid organic fertilizer is an easily soluble solution, containing one or more carriers of elements needed by plants. Solid organic fertilizers are organic fertilizers that are solid, crumbly, and odorless when dissolved in water and do not dissolve easily. Liquid organic fertilizer is a solution from the decomposition of organic materials originating from plant residues, animal, and human wastes which contain more than one nutrient element. The advantages of this organic fertilizer are that it can quickly overcome nutrient deficiencies, is not problematic in nutrient leaching, and can provide nutrients quickly [6].

The process of making liquid fertilizer can be done by using the help of bacteria to speed up and help the decomposition process. Fertilizer can be for one week to a maximum of one month. However, the obstacle in making this organic liquid fertilizer manually is that the temperature conditions are not always monitored by the makers and the makers are not always at the place of fertilizer manufacture [7]. Because the essence of the process of making fertilizer is in the bacteria and the

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bacteria that play a role in making liquid fertilizer also cannot live in hot places, usually decomposing bacteria live at temperatures of 30°C– 40°C [8].

Previous research that was used as a reference in making this tool, among others, the Design of Organic Waste Processing Equipment into Liquid Fertilizer [9] which carried out the design of the tool by analyzing the elements in the material using X-Ray FlourFluorescence) [10]. The working principle of XRF is the collision of atoms on the surface of the sample (material) by X-rays. So, the system using X-Ray Fluorescence (XRF) gets the elements that are read in liquid fertilizer, namely Magnesium (Mg), Potassium (K), Sulfur (S), Calcium (Ca), Argon (Ar), Ferum (Fe), Argentum (Ag), and Rhodium (Rh) [11]. However, this system is considered complicated and cannot be understood by farmers so it can only be analyzed by researchers who understand how XRF works [12]. Another way to produce liquid organic fertilizer with

of a combined motor as a stirrer and a picture of a composter tube as a place for the process of making liquid organic fertilizer and a picture of a panel box as a place for components needed to design an automatic control and monitoring system. The dimension of this composter consists of length = 100 cm, width = 60 cm, and height = 130 cm. The detailed design of the equipment for making liquid organic fertilizer can be seen in Figure 1.

B. The Design of Temperature Control System

In addition to designing the fertilizer tool for making liquid organic fertilizer, it is also necessary to design a system. Before designing the actual system, it is necessary to do some preparation. The preparations made include making user and interface designs. The block diagram of the monitoring system designed in the implementation of this Research can be seen in Figure 2 as follows.

Figure 2 shows that the workflow begins with a sensing

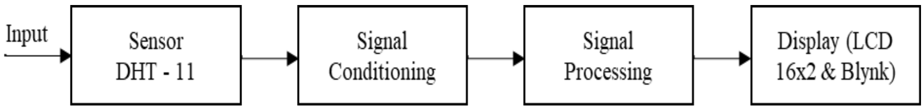

Figure 2. Block Diagram of Temperature Measurement

maintaining the condition of the composter according to reference conditions, such as the reference temperature that was stated before [10]. Therefore, the role of control is indispensable to maintain temperature [13]. Departing from the above problems, therefore it is necessary to develop a composter to produce the Liquid Organic Fertilizer with the temperature control system and pH monitoring system which accelerate the production time of liquid organic fertilizer. Internet of Things (IoT) is added to this system to make it easier for users to control composters from anywhere because they are connected to android. This method will compare with the manual method and will analyze the production time, the quality and the quantity of Liquid Organic Fertilizer.

METHOD

A. The Design of Composter

Design a system is an important thing to do first. Starting from the mechanical design and automatic system design and to the design stage of the whole tool. There is a picture

element in the form of a DHT-11 sensor as a temperature sensor that will detect a sample in the form of an analog signal. Then the signal will be streamed to the conditioning element, at this stage the analog signal will be converted into a digital signal so that it can be read by the next element. After that the signal will be transmitted to the processing element in the form of a controller to be processed so that it can be transmitted to the display component. At this stage the measurement data will be displayed in the form of current, voltage, and measured temperature.

The open loop control system is a control system in which the output quantity does not affect the input quantity, so that the controlled variable cannot be compared to the desired value as in the temperature control system in Figure 3.

Based on the open loop control system, the microcontroller set the upper and lower limit for temperature variables. If the process variable as an output shows the value outset the upper and lower limit, the microcontroller will ask the actuator to heat the process. Thus, the temperature in the process will adjust the

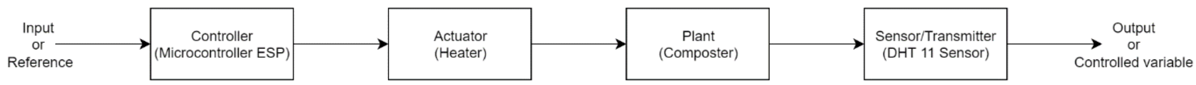

Figure 3. The Open Loop Control System

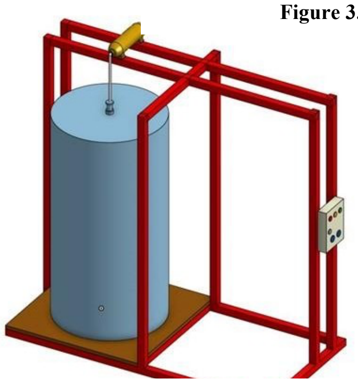

Figure 1. The composter design

reference value and be measured by DHT 11 sensor.

C. The Design of the pH Monitoring System

The composter is also equipped with pH monitoring because pH is an important variable that affects the quality of liquid organic fertilizer. The block diagram of the pH monitoring system shows in Figure 4.

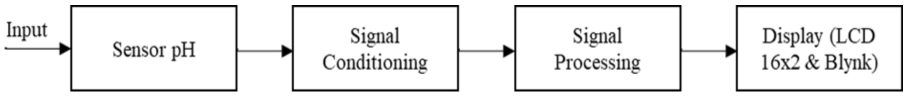

Figure 4. Block Diagram pH Sensor Monitoring

The monitoring system starts with a pH sensor to measure the pH value as a signal. The signal will be conditioned and controlled before displaying on LCD.

D. The Component Selections

In the selection of components in the manufacture of this liquid organic fertilizer. The design of this system is a combination of Arduino Uno and ESP microcontrollers, LCD circuits, push button circuits, Real Time Clock (RTC) circuits, pH sensors and DHT-11 temperature sensors, and Solid-State Relay (SSR) circuits and contactors on motor control. The whole series works as an automatic mixing system based on temperature control on the composter machine.

Journal results in Machine tools for making liquid organic fertilizer will be useful for monitoring temperature, humidity and pH, as well as controlling compost mixing. Thus, it will produce liquid organic fertilizer that is mature and of good quality. In the selection of components in the manufacture of this liquid organic fertilizer, I will use the technology that can be seen in Table 1 as follows.

TABLE 1.

COMPONENTS USED

No	Form	Function
1	pH Sensor	as a measure of the pH content of liquid organic fertilizer, which serves to determine the maturity of a liquid organic fertilizer
2	DHT 11 Sensor	As a temperature and humidity detector in the process of making compost
3	Composer Tube	As a place for fertilizer decomposition
4	Panel Box	As a place for electronic component
5	Microcontroller	Microcontroller Whole system controller
6	Motor	As a driving tool in the stirring process
7	Heater	As a heater for the process of making liquid organic fertilizer
8	Blynk application	To display the value of monitoring results

E. The Component Specification

The specifications of the components used are:

1. DHT-11

Selection of soil moisture and temperature sensors using DHT-11 which has high accuracy and precision in measurement. As a detector of temperature and humidity in the process of making compost. The DHT-11 is a temperature and humidity sensor, this sensor outputs a digital signal with conversion and calculations performed by the integrated 8-bit MCU. This sensor has accurate calibration with adjustment chamber temperature compensation with coefficient values stored in the integrated OTP memory. The specification of DHT-11 is in Table 2.

TABLE 2.

SPESIFICATION OF DHT 11

No	Specification	Description
1	Temperature Measurement	0-50 °C
2	Temperature Accuracy	2 °C
3	Humidity Measurement	20%-80%
4	Humidity Accuracy	5%
5	Data Update Speed	1 once per second (1Hz)

2. pH Sensor

pH sensor is an electronic device used to measure the pH (acidity or alkalinity) or base of a solution (though special probes are sometimes used to measure the pH of semisolids). A typical pH sensor consists of a pH measuring probe (glass electrode) connected to a reading meter that measures and displays the measured pH. The working principle of this tool is that the more electrons in the sample, the more acidic it will be and vice versa, because the rod on the pH meter contains a weak electrolyte solution.

The pH sensor that will be used is a pH sensor using a 4502C module. The 4502C pH Sensor Module is a sensor module made in China. This module is included in the price category which is relatively cheap with an accurate and quite a good level of accuracy. The pH 4502C analog pH meter is specially designed for Arduino controllers and has simple, convenient and practical connections and features. It has an LED that functions as a power indicator and over-range indicator, and is equipped with a BNC connector. To use it, simply connect the pH probe with the BNC connector, and connect the pH 4502C interface to the analog input port of each controller. The pH sensor specifications can be seen in Table 3 as follows.

TABLE 3.

SPESIFICATION OF PH SENSOR

No	Specification	Description
1	Heating Voltage	5 0.2V (AC DC)
2	Working Current	5 – 10 Ma
3	Detectable Temperature Range	pH 0-14
4	Response Time	5 s
5	Component Power	0.5 W
6	Working Temperature	10 – 50
7	Humidity	95 %

F. The Electric Wiring

This Liquid Organic Fertilizer Making Tool will be equipped with a Composter Tube as a storage medium and a place for the process to run, equipped with an LCD and a smartphone as a direct viewer of sensor readings. Performance testing is a large test of temperature, pH and humidity of the motor rotation speed in the appropriate stirring process to produce good quality liquid organic fertilizer.

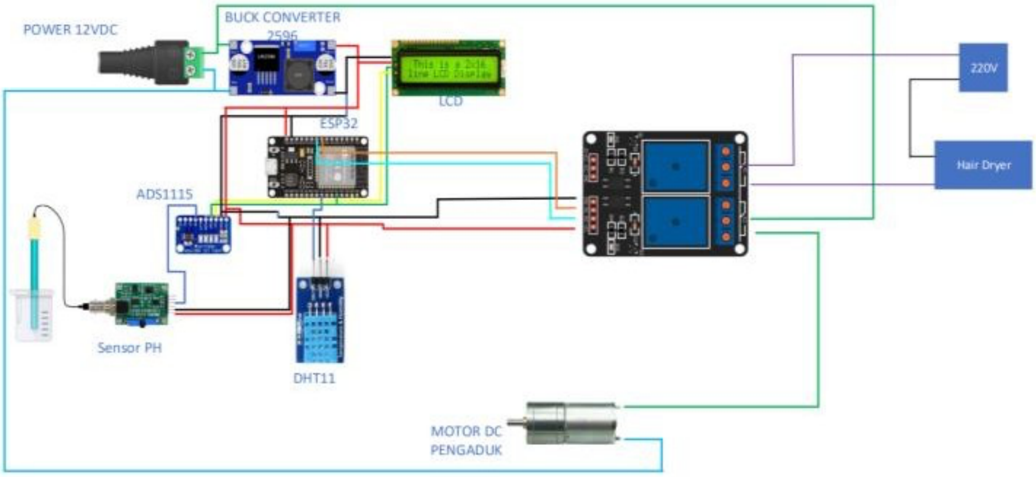

Figure 5. The Electric Wiring of Composter

Temperature sensor readings will be displayed on the LCD. Users can see the temperature and pH in real-time. The system schema shown in Figure 5 is the result of the designs that have been carried out in the Journal (Putra, 2019). The development focuses on resource systems that use 3-phase motors with temperature monitoring, as well as control of the use of motors and lights. The electric wiring of the composter shows in Figure 5.

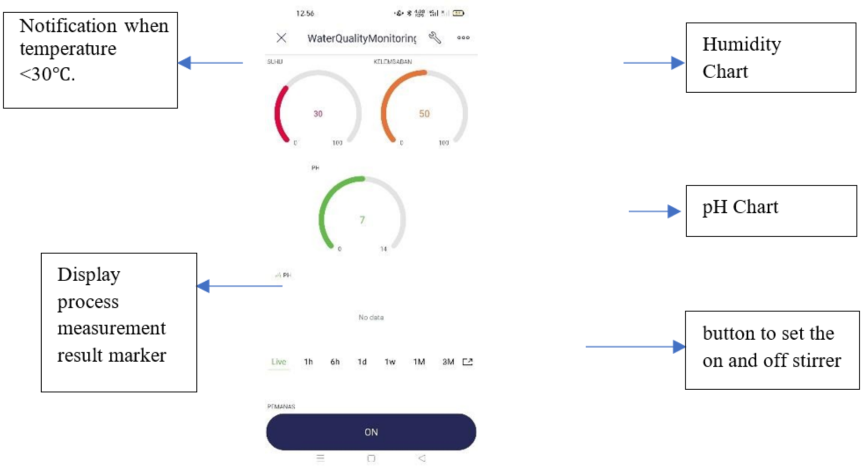

Figure 6. Design of User Interface on Blynk App

G. Connecting with the Internet of Things

Making the monitoring system design is one step before making the system. To reduce the risk of failure due to the wrong location of a component or other factor, the design phase of the monitoring system and application interface is very important.

The temperature sensor will detect and send a signal to the controller to be able to display the results of the temperature reading that is read. The optimal temperature for the mixing process in Liquid Organic Fertilizer is 30-40°C. When the temperature is less than 30°C or more than 40°C, there is a reminder/notification on the blink app to remind you that the temperature has been less than 30°C and more than 40°C. The reminder will stop when the tube temperature is optimal. Furthermore, the motor will turn on at a speed that can be adjusted as desired. The speed sensor will detect and send a signal to the controller to be able to display the speed results to the display and blink app. The user interface design of the Blynk App shows in Figure 6 below.

RESULTS AND DISCUSSION

A. The Prototype of Fertilizer

The realized composter design can be seen in Figure 7 as follows the dimension of this composter consisting of length = 100 cm, width = 60 cm, and height = 130 cm.

Figure 7. The Realization of Composter Design

Figure 7 above is equipped with an ON/OFF control system for the electromotor heater and stirrer. This machine is equipped with parts of components consisting of a motor, stirrer, heater, tube and filter. Figure 1 above, it shows that the design of the Liquid Organic Fertilizer making machine has succeeded in being able to be used as a fertilizer tool for making liquid organic fertilizer that moves automatically through the Blynk application.

B. The Temperature Sensor Validation Test Results

Testing the DHT11 Sensor is done by connecting the DHT11 sensor to the Arduino Uno. Through Arduino Ide is programmed to read temperature and humidity then displayed on the PC screen via a serial monitor. Followed by observing the readings on the serial monitor with a thermometer. By analyzing the reading of the measured value obtained through the DHT 11 sensor and the value measured with a standard measuring instrument, namely a thermometer, the difference between the results of the DHT 11 reading and standard measuring instruments will be assumed as the error value that will occur. The data to be taken is room temperature data which is taken 8 times and is carried out every minute, as seen in Figure 8.

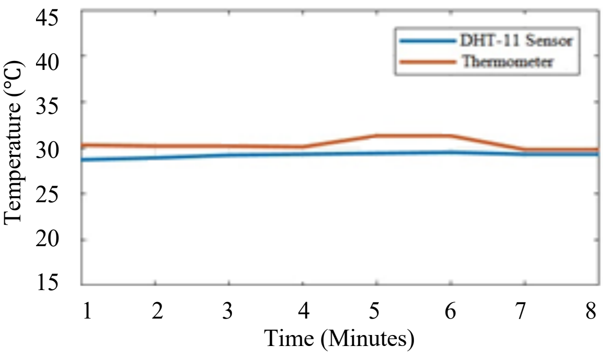

Figure 8. Chart of Validation of DHT-11

By analyzing the reading of the measured value obtained through the DHT 11 sensor and the value measured by a standard measuring instrument, namely the Thermometer, the difference between the results of the DHT 11 reading and the standard measuring instrument will be assumed as the error value that will occur. The data to be taken is room temperature data taken 8 times and carried out per minute. From these tests, it can be seen the results of the DHT Sensor testing with a standard measuring instrument thermometer at room temperature which is shown in Table 4.

TABLE 4.
THE RESULTS OF TEMPERATURE SENSOR VALIDATION

No	Form	Value
1	Accurate	99.54%
2	*Error*	0.46%

Based on the data that has been obtained from testing the instrument, it is known that the measured value can be said to be close to the standard measuring instrument. By getting an accuracy value of 99.54% and an error value of 0.0046, it can be said that the DHT-11 sensor is worthy of being used as a measuring instrument in my research

C. The pH Sensor Validation Test Results

The results of the pH meter sensor which were made in this research and the standard pH meter at the validation value of ten experiments with a time per 10 seconds using a powder solution of pH 9.18. Obtained the results of the test results of pH Sensor with a standard measuring instrument pH Meter in a 9.18 powder solution. Figure 9 is a graph of the measurement results of the pH sensor with a validator, namely the pH Meter.

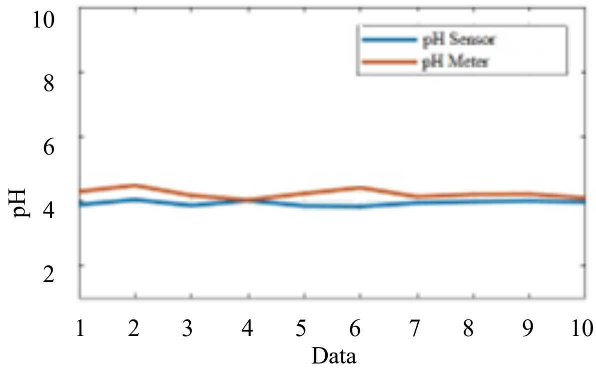

Figure 9. Chart of Validation pH Sensor

Based on the data that has been obtained from testing the tool, it can be obtained the characteristics of the pH sensor measuring instrument in Table 5

TABLE 5.
THE RESULTS OF pH SENSOR VALIDATION

No	Form	Value
1	Accurate	99.68%
2	Error	0.32%

From Figure 9, it can be seen that the readings of the instrument are close to the standard. By getting an accuracy value of 99.68% and an error value of 0.32%, it is said that this pH sensor is worthy of being used as a measuring instrument in my research

D. The Control System Testing Result

In testing the composter was applied with an automatic stirring system during the composting process. This test serves to maintain temperature stability in the composting media in the composter room. The control system conditions shown in Table 6.

TABLE 6.
CONTROL SYSTEM RESPONSE

No	Form	Control System Response
1	Temperature below 35 °C	Stirrer and heater on
2	Temperature between 35-50 °C	Stirrer and heater on
3	Temperature above 35 °C	Stirrer and heater off

The components used in this temperature control process are the DHT-11 sensor as a temperature sensor, pH sensor, Arduino as a controller, and heater as an actuator. The working principle of controlling the temperature of the liquid organic fertilizer is that the DHT-11 sensor will sense the temperature input contained in the fertilizer and then transmit a signal to the controller, namely Arduino to select which actuator will work.

In testing the control system on the heater, it is carried out with the tool in the off state, which was initially controlled by the heater off to a hot temperature level. The results of the control system testing of the blynk application on the heater are in Table 7 below.

TABLE 7.
HEATING TEST RESULTS

Minute	Temperature
0	24
1	25
2	27
3	30
4	33
5	35
6	36
7	36
8	36
9	36
10	36

A dynamic response graph can be made to determine the change from the initial temperature conditions in the tube until it reaches the highest temperature achieved by the heater. The graph of the dynamic response of the control system of the heater shows in Figure 10 below.

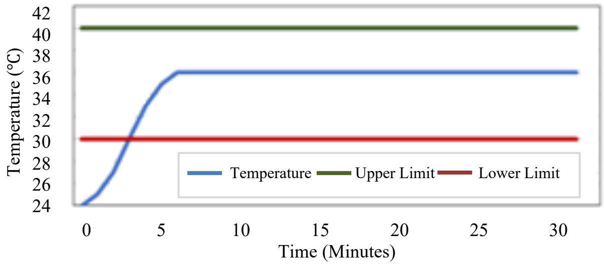

Figure 10. The Dynamic Response of Control System

Figure 10 shows the response of the system when it was initially operated. The results show that the control system can maintain a state between the upper limit and the lower limit

E. The Result of IoT Testing

In addition to the above tests, there is a test of sending Blynk data to the Tool which aims to find out how long the delay is and how much packet loss is lost when sending data to the Blynk application. Testing the serial communication system using the wi-fi module is done by connecting the Node MCU microcontroller with the ESP 32 Module. This test requires an internet connection so that the system is connected to the Blynk application. The ultrasonic sensor will read the distance between the sensor and the reflector.

The temperature and time readings have been successfully displayed on the Blynk App plus humidity but it does not have much effect on the manufacture of liquid organic fertilizer. The button for monitoring the maturity process of liquid organic fertilizer has been successfully executed. In testing the delay of the ESP32 wi-fi module, the average delay value of the ESP 32 module is 4 seconds. Meanwhile, in the packet loss test of the ESP 32 wi-fi module, all data was successfully sent and the packet loss value of the ESP 32 module was 0%.

F. Optimization Results of Liquid Organic Fertilizer

In testing the composter machine was applied with an automatic stirring system during the composting process. This test serves to maintain temperature stability in the composting media in the composter room. The test is carried out in 2 ways of making, making liquid organic fertilizer normally for 14 days and making liquid organic fertilizer with a Research tool in the Instrumentation Engineering measurement laboratory for 10 days in real-time. The result of the quantity and quality of liquid organic fertilizer is shown in Table 8.

TABLE 8.
PHYSICAL FORM OF LIQUID ORGANIC FERTILIZER RESULTS

Form	Sample with the machine	Sample without the machine
Color	dark turbid yellow	bright turbid yellow
Odor	Fermentation smell	Fermentation smell
Volume	100 mL	10 mL
pH	4.5	5.6

CONCLUSION

In writing this journal, entitled as for the conclusions obtained on the Design of Temperature Control Systems for Fertilizers and Monitoring the pH of Products as an Efforts to Optimize the Making of Liquid Organic Fertilizers, it can be concluded that this fertilizer tool for making liquid organic fertilizers can work well by combining elements in this research.

The elements in question are the DHT-11 sensor and the pH sensor on the device. The use of the DHT-11 Sensor is considered good because it can read the temperature in the tube in real time, showing an accuracy value of 99.54% and an error value of 0.0046. Followed by the use of a pH sensor that can read well on the results of liquid organic fertilizer products, which is indicated by an accuracy value of 99.68% and an error value of 0.32%

The results of the Design of the Temperature Control System on the Fertilizer and Monitoring the pH of the Product as an Effort to Optimize the Making of Liquid Organic Fertilizer were declared successful with the results of Organic Fertilizers being made shorter in 10 days compared to the manufacture of normal liquid organic fertilizers which produced higher yields of organic fertilizers. and reach the desired pH.

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