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Design of Automatic pH Level Prototype Using Microcontrol Nodemcu Esp8266 Based on IoT Technology

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Abstract:- In the process of controlling the pH level of water manually there is a risk of controlling pH levels directly in contact with hazardous chemicals such as HCl and NaOH. The two chemicals are chemicals that can be used to regulate the pH level of water, but both of these chemicals are included in corrosive materials which can cause damage to the skin or eyes if there is direct contact with the two materials. This study aims to design a system to control the pH of water in the form of a tool that can monitor and control the pH level of water automatically in order to reduce the risk of exposure to hazardous chemicals and facilitate the work of officers. This system uses a NodeMCU ESP8266 microcontroller controller which has an input in the form of a pH sensor and a water level sensor. The system output is in the form of 3 water pumps and 2 diaphragm pumps. NodeMCU will adjust the diaphragm pump speed by using the Sugeno Fuzzy logic method. By utilizing the Internet of Things (IoT) technology, the condition of the pH value of water and pumps can be monitored online via a smartphone making it easier to monitor at any time. The application used is the Blynk application based on the Android Operating System. The quality of the internet network connection connected to NodeMCU is very influential on sending data to CloudBlynk. Testing the diaphragm pump speed value is regulated by Sugeno fuzzy logic based on the readable pH value. Based on testing the pH of water, this system successfully controlled the pH of water with a capacity of 8 liters with a submersible pump speed of 1.31l / min, the highest pH value of the experiment 11.14 with a duration of 213 seconds, and the lowest pH value of 2.01 with a duration of 260 seconds

Keywords:- *pH, Internet of Things (IoT), Fuzzy Logic, NodeMcu ESP8266, Smartphone.*

I. INTRODUCTION

Business actors who have disposal waste in the form of water are expected to be able to maintain the pH level of water in accordance with standards determined through Minister of Health Regulation Number: 416 / MEN.KES / PER / IX / 1990 concerning Requirements and Supervision of Water Quality, namely pH 6.5 to 8.5, (Permenkes, 1990). Water pH levels that do not meet the standards will pollute the community's environment. Therefore, business operators must have a water disposal treatment system that can maintain the pH level of the water according to the standards set by the government.

This automatic water pH control system uses the chemicals HCL and NaOH to maintain the water pH level to comply with government regulations. This system can also reduce the risk of pH control agents from hazardous chemicals such as HCl and NaOH, because both of these chemicals are included in corrosive materials which can cause damage when in contact with living tissue. (Utomo S. 2012)

II. LITERATURE REVIEW

In this study a system was designed to monitor and control the pH level so that it remained in the pH range of 6.5 to 8.5. Prototype or miniature controller of water pH using NodeMCU as a central controller that has a pH sensor input and level switch sensor and output in the form of a motor driver IC to drive the diaphragm pump and immersion pump. Then the results of monitoring the pH level will be displayed on a smartphone that has the Blynk application installed.

Research that has been published in several journals shows differences in both the objectives and the methods used. There is a research that regulates the acidity level aimed at maintaining water quality so that the life of ornamental fish Chefs continues (Bayu, Sugito Slamet, 2017) Other studies design the control of pH in the acid-base titration process (Mukhlish KI, Hendra C. 2010) and there are also pH control studies that use the Self Tuning PID method with Adaptive Control (Achmad DC, Hendra C. 2012).

III. METHODOLOGY

Besides having the ability to monitor the pH value of water, this automatic pH control system also aims to keep the pH level in the range of 6.5 to 8.5. The monitoring results will be forwarded to Cloud Blynk so that it can be viewed via a smartphone via the Blynk Android application. This system uses a pH sensor to find out the pH level of the water and a level switch sensor to find out the height of the water. This prototype includes chemicals using a diaphragm pump, while in the process of transferring and stirring the water a submersible pump is used. The switch is used to start and stop system processes. This block diagram system is shown in Figure 1.

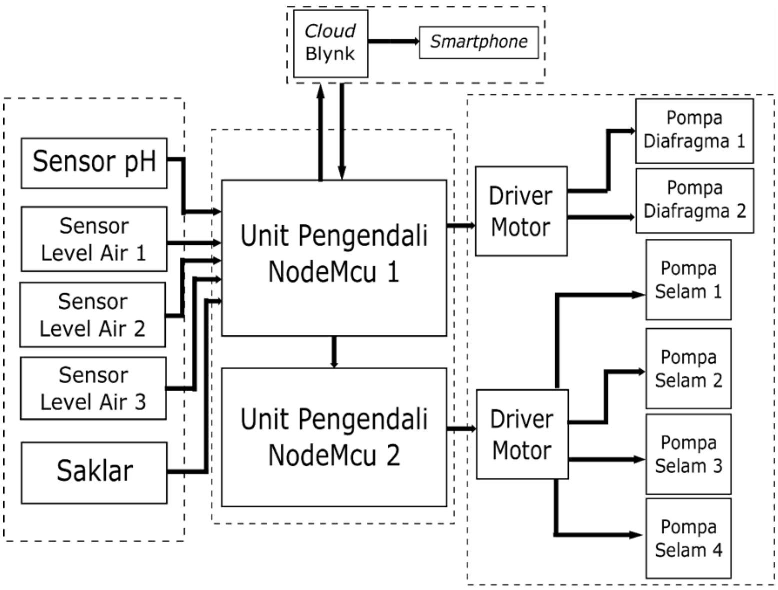

Fig 1:- Block Diagram of Monitoring pH Water Control System

➢ *Hardware Designing*

In the hardware design section, the system uses NodeMCU V2 which has input in the form of two sensors namely a pH sensor and a level switch sensor, while the output consists of an L298 IC driver, a 12 V diaphragm pump and a 5 V dip pump. know the pH level of water in the containers. The signal modifier functions as a voltage signal modifier on the pH sensor probe from 414.12 mV to -414.12 mV to a voltage range that can be read by NodeMCU analog inputs, from 0 V to 3.3 V. Level sensor switches are used to determine the water level in the water reservoir containers. The end result of this process is to find out whether the desired water level to start controlling the pH level of the water has reached the minimum limit. In this circuit the Water Level sensor output is connected to pins D2, D6 and D7 on NodeMCU. The workings of this sensor are as follows: when the floating sensor section is lifted by water or water in a full containers, the magnet in the float will deactivate or disconnect the reedswitch connection in the sensor rod.

Prototype of the pH Water Control System will be made using a glass containers measuring length, width and height of 60 cm x 25 cm x 20 cm which is divided into three parts, namely the water reservoir containers, controlling the pH level and the end result of the process with a capacity of 8 liters each. Figure 3 shows the prototype design of a water pH control system.

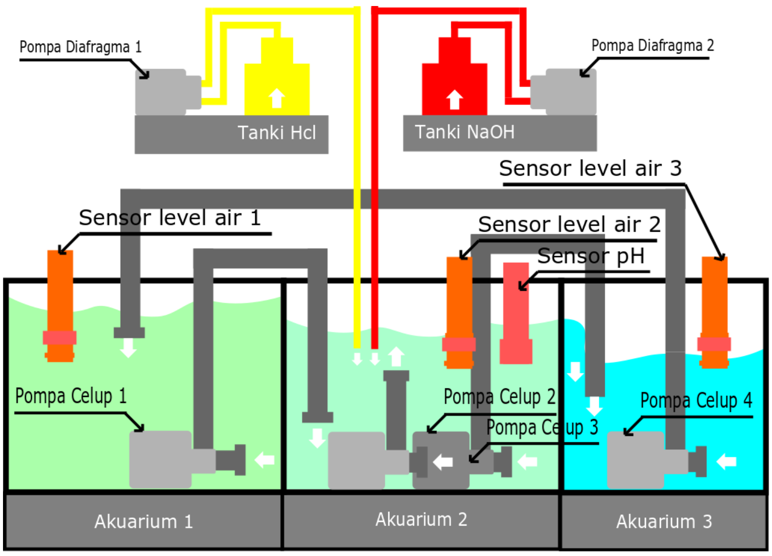

Fig 2:- Description of Prototype of Water pH Control System.

➢ *Software Design*

The software design uses the Arduino IDE program to compile a series of program commands on NodeMcu and Blynk applications so that the system is able to display data that will be forwarded by NodeMCU.

The program flow begins by connecting NodeMCU to WiFi connected to the internet so that it can communicate with Cloud Blynk. Furthermore, the system will start operating when the switch is On. The water reservoir pump will activate if the water level in the water tank is full and the containers controlling the pH level has not been reached. If this has been achieved, the water stirring pump inside the containers that controls the pH level will be active. The pH level data from the sensor collected 30 samples will be calculated the average value and converted to a pH value. If the pH is 6.5 to 8.5, the water reservoir pump is On. The diaphragm pump speed used to increase or decrease the pH level will be processed using the Sugeno Fuzzy Logic method based on the pH value. Information on the pH level and condition of all pump motors will be sent to Cloud Blynk so that the results of pH control can be monitored via a Smartphone. Meanwhile, the final pump will be active if the water level in the containers is final.

In this design the Arduino program was made to process data from the PH sensor, Water Level sensor, switch, and a program to control the speed of the Diaphragm Pump and the Submersible Pump.Implementasi Rancangan Pada Aplikasi Blynk

The design of Blynk application uses 1 notification facility, email and virtual LCD as much as 1 piece. The design requires a SuperChart which is used to find out information on pH levels and the processes that are taking place from NodeMCU processing. Virtual pins V0 and V1 are used for LCD input. Virtual pins V2, V3, and V4 are used for SuperChart input.

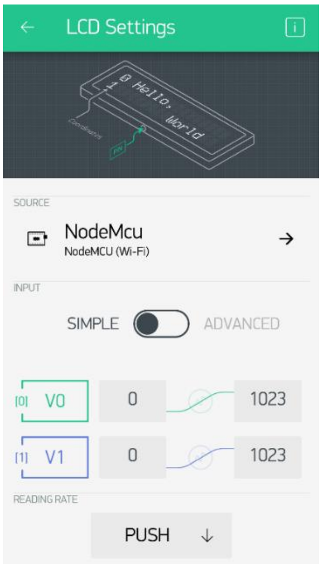

Fig 3:- Pin Settings on the Virtual LCD

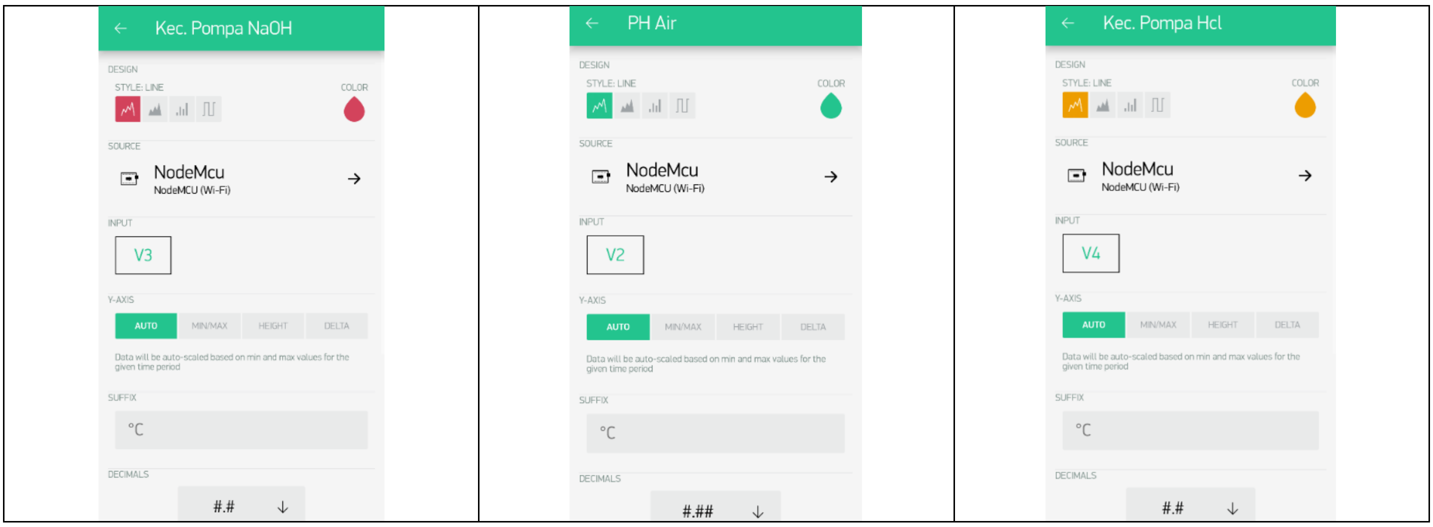

Fig 4:- Pin Settings on SuperChart

➢ *Fuzzy Logic Design*

Fuzzy Logic Design consists of 2 input variables namely Water pH Level and Diaphragm Pump Speed. The pH level variable consists of 5 fuzzy sets, namely Lower Limit 2, Lower Limit 1, Safe Limit, Upper Limit 1, Upper Limit 2. The diaphragm pump speed variable has 4 fuzzy sets, namely a maximum speed of 100% and a minimum of 0% in NodeMCU ie "stop "With a value of 0%," slow "with a value of 50%," medium "with a value of 75%, and" fast "with a value of 100%.

Diaphragm Pump 1 rule to reduce pH levels as follows:

- If the pH of the water is in the safe zone, the pump stops (0)
- If the pH of the water is at the upper limit 1 then the pump speed is moderate (75%)
- If the pH of the Water is at the Upper Limit 2 then the pump speed is Fast (100%)

No.	Input Variable	Output Variable
	pH of water	Diaphragm Pump Speed 1 (%)
1	Safety limit	0
2	Upper Limit 1	75
3	Upper Limit 2	100

Table 1:- Fuzzy Rules of Diaphragm Pumps 1

Whereas Diaphragm Pump 2 Rule to raise the pH level as follows:

- If the pH of the water is in the safe zone, the pump stops (0%)
- If the pH of the water is at Lower 1, the pump speed is moderate (75%)
- If the pH of the Water is at the Lower Limit 2 then the pump speed is Fast (100%)

	Input Variable	Output Variable
	pH of water	Diaphragm Pump Speed 2 (%)
1	Safety limit	0
2	Lower Limit 1	75
3	Lower Limit 2	100

Table 2:- Fuzzy Rules of Diaphragm Pumps 2

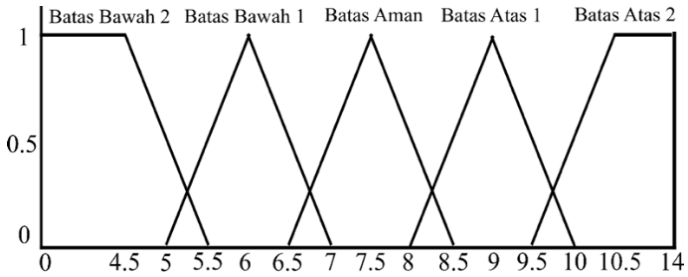

Fig 5:- Input Data Fuzzification

- *Diaphragm Pump Speed*

No	pH of Water	Pump Speed (%)	
		Diaphragm Pump 1 (M1)	Diaphragm Pump 2 (M2)
1	4.36	0	100
2	5.4	0	80
3	5.96	0	75
4	6.54	0	69
5	6.70	0	45
6	7.56	0	0
7	7.90	0	0
8	8.02	3	0
9	8.46	69	0
10	8.92	75	0
11	9.8	90	0
12	10.36	100	0

Table 3:- Diaphragm Pump Speed Settings

This prototype uses the Sugeno fuzzy logic method to regulate the motor speed of the diaphragm pump 1 (M1) and 2 (M2) based on the pH level read by the DF Robot pH sensor. Pump speed regulation is done by simulating using MatLab software to obtain pump speed values. Subsequently carried out experiments of several conditions of pH levels from 4 to 11. The results obtained are shown in Table 3.

IV. DISCUSSION / ANALYSIS

The results of the prototype design of a water pH control system are shown in Figure 6.

Fig 6:- Photograph of Prototype Design Results

➢ *Water Level Reading Test*

This prototype uses 3 water level sensors installed in the water reservoir containers, the PH level control containers **and the** final containers as shown in Figure 7.

Fig 7:- Water Level testing

The way this sensor works is to read the water level in each containers, if the water level has been reached (sensor floats lifted by the water) then the connection to the sensor will be lost. Briefly the results of the water reading test are shown in Table 4.

No	**Condition**	**Connection**
1	Reached Water Level	Break
2	Water Level Not Achieved	Connected

Table 4:- Test Results for Water Level Readings

➢ *Water Filling in Containers Controlling pH*

The process of moving water from the Water Reservoir container to the pH Controlling container uses a Submersible pump 1 (M3) which has 2 conditions where if the water level Sensor 1 ON (the float lifts by water) indicates the presence of water in the Water Storage container then the Submersible Pump 1 (M1) will be ON as in Table 5.

No	Sensor Level Air 1	Pompa Celup 1(M1)
1	ON	ON
2	OFF	OFF

Table 5:- Experiment of Water Level Sensor 1 with Submersible Pump 1.

➢ *Fill the water in the Final Containers*

The process of moving water from the pH control container to the finished product has 2 conditions to regulate the Submersible Pump 2 (M4) where if the water level sensor 2 is ON (a float lifted by water) that indicates the presence of water in the container and the pH level read by the sensor pH is 6.5 to 8.5, Submersible Pump 2 (M4) will be ON as shown in Table 6.

No	Water Level Sensor 2	PH 6.5 – 8.5	Submersible Pump 2 (M4)
1	ON	YA	ON
2	ON	TIDAK	OFF
3	OFF	YA	OFF
3	OFF	TIDAK	OFF

Table 6:- Experiment of Water Level Sensor 2 with Submersible Pump 2.

➢ *Water Filling Container Water Testing*

The process of moving water from the Final Results container to the Water Collection container uses a Submersible Pump 4 (M6) if the water level Sensor 3 is ON (the buoy is raised by water) which indicates the presence of water in the container, the Pump will be ON. Table 7 shows the results of Water Level 3 and Submersible Pump 4 Tests.

No	Water Level Sensor 3	Submersible Pump 4 (M6)
1	ON	ON
2	OFF	OFF

Table 7:- Testing of Water Level Sensor 3 and Submersible Pump 4

➢ *Water pH Reading Testing*

The Water pH reading system uses a DF Robot pH sensor found in the pH control container as shown in Figure 8. Testing the pH Sensor

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Fig 8:- pH sensor

Testing is done by comparing the results of the value of the DF Robot pH sensor with litmus paper, the object being tested is mineral water, buffer pH 4, 7, a mixture of HCL and NaOH. The results of reading the object as shown in the table shows that the pH sensor works in accordance with a range that can be tolerated.

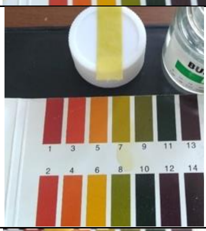
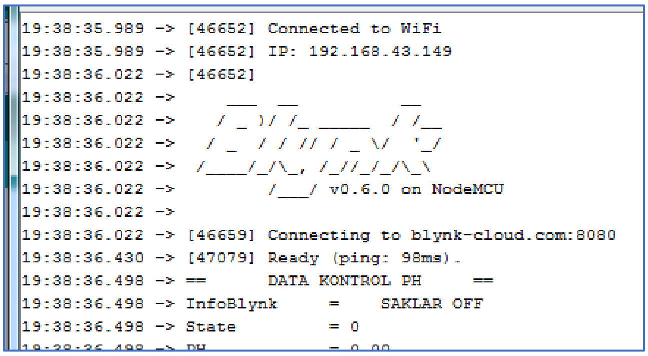
No	The object	Litmus Paper	pH Sensor Reading
1	Buffer pH 4		3.9
2	Buffer pH 7		7.1
3	Air		5.6
4	1500 ml of Water and 100 ml of 48% NaOH		13.31
5	1500 ml of Water and 100 ml of 32% HCL		2.21

Table 8:- Testing pH values

➢ *Blynk Connectivity Testing*

This prototype requires an internet connection to connect NodeMCU with the blynk cloud in order to communicate with each other. In testing the NodeMCU connection with Cloud Blynk through the internet network (wifi), the results show that the quality of the network greatly affects the speed of data transmission.


```
19:38:35.989 -> [46652] Connected to WiFi
19:38:35.989 -> [46652] IP: 192.168.43.149
19:38:36.022 -> [46652]
19:38:36.022 ->     ___  __          __
19:38:36.022 ->    / _ )/ /_ _____  / /__
19:38:36.022 ->   / _  / / // / _ \/  '_/
19:38:36.022 ->  /____/_/\_, /_//_/_/\_\
19:38:36.022 ->         /___/ v0.6.0 on NodeMCU
19:38:36.022 ->
19:38:36.022 -> [46659] Connecting to blynk-cloud.com:8080
19:38:36.430 -> [47079] Ready (ping: 98ms).
19:38:36.498 -> ==      DATA KONTROL PH     ==
19:38:36.498 -> InfoBlynk     =    SAKLAR OFF
19:38:36.498 -> State         = 0
```
Fig 9:- Pengujian Konektivitas

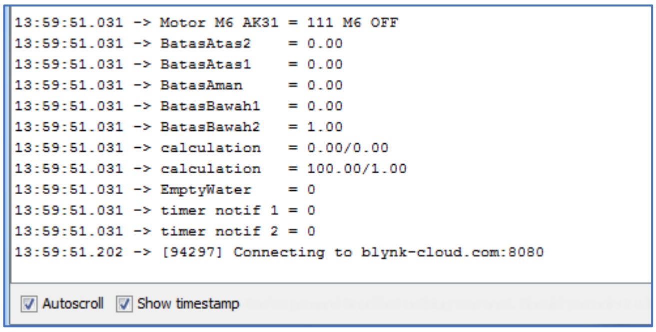

```
13:59:51.031 -> Motor M6 AK31 = 111 M6 OFF
13:59:51.031 -> BatasAtas2    = 0.00
13:59:51.031 -> BatasAtas1    = 0.00
13:59:51.031 -> BatasAman     = 0.00
13:59:51.031 -> BatasBawah1   = 0.00
13:59:51.031 -> BatasBawah2   = 1.00
13:59:51.031 -> calculation   = 0.00/0.00
13:59:51.031 -> calculation   = 100.00/1.00
13:59:51.031 -> EmptyWater    = 0
13:59:51.031 -> timer notif 1 = 0
13:59:51.031 -> timer notif 2 = 0
13:59:51.202 -> [94297] Connecting to blynk-cloud.com:8080
```

Fig 10:- Testing of poor Internet connectivity

➢ *Testing Data Transmission from NodeMCU to Blynk and Display Data at Blynk*

This prototype uses Blynk to monitor Water pH, system conditions and speed of Diaphragm 1 (M1) and 2 (M2) pumps, then the data transmission test from NodeMCU to Blynk is shown in Figure 11 of the Blynk Test.

Fig 11:- Blynk Testing

From the above Blynk test, it can be concluded that NodeMCU successfully sent Water pH value data of 6.78, Diaphragm 1 (M1) pump speed of 33%, Diaphragm 2 (M2) pump speed of 0, and sent information that the system was in the process of controlling Water pH.

➢ *Blynk Notification*

This prototype uses notification in the form of reporting water pH data every hour as a result of monitoring the pH level of the water that will be sent from NodeMCU to Blynk and email. Figure 12 shows the results of the Blynk Notification Test. After testing the prototype for 1 hour, it can be concluded that the results of monitoring the pH of the water were successfully sent to Blynk and email.Prototipe ini menggunakan notifikasi berupa pelaporan data air pH setiap jam sebagai hasil monitoring kadar pH Air yang akan dikirimkan dari NodeMCU ke Blynk dan email. Gambar 12 menunjukkan hasil Pengujian Notifikasi Blynk. Setelah dilakukan pengujian terhadap prototipe selama 1 jam, dapat disimpulkan bahwa hasil monitoring kadar pH Air berhasil dikirimkan ke Blynk dan email.

Fig 12:- Testing of Blynk Notifications

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Analysis of the test: from the results of the connectivity test above it can be concluded that NodeMCU successfully connected to the internet network via wifi and connected with Blynk, and when the quality of the internet connection is poor the transmission of NodeMCU data to blynk is disrupted.

➤ *Water pH Control Testing*

One of the goals of making this prototype is to find out the length of time needed to reach the pH level of water according to the specified standards. The test is carried out by determining the pH level of the water first, then the time needed to obtain the pH standard that has been determined is the pH of water 6.5 to 8.5. The active motor time is set for 25 milliseconds and stops 1 second. Table 9 shows the results of the Water pH control test.

No	Initial pH	The time it takes to reach pH 6.5-8.5 (seconds)
1	2.01	260
2	3.34	184
3	4.42	111
4	5.12	41
5	5.53	27
6	6.04	13
7	9.17	23
8	9.68	76
9	10.01	121
9	10.34	169
10	11.14	213

Table 9:- Testing of pH Control of Water

V. CONCLUSION

Based on the results of tests that have been carried out on the prototype design of the pH water control system, the following conclusions can be made:

- ➤ Based on testing the pH reading, the pH sensor of the DF Robot has a difference of 0.1 when measuring pH Buffer 4.0 and 7.0.
- ➤ Quality of Internet connection connected to NodeMCU 1 is very influential in sending data to CloudBlynk.
- ➤ Based on testing the diaphragm pump speed value, the pump was successfully adjusted according to the value of the processing of the pH value which is read using the fuzzy logic of the Sugeno method.
- ➤ Based on the Water pH control test, the prototype of the water pH control system succeeded in controlling the Water pH of a capacity of 8 liters with a submersible pump speed of 1.31l / min, the highest pH reading of 11.14 with a length of 213 seconds, and the lowest pH value of 2.01 with a duration of 260 seconds

LIMITATION AND STUDY FORWARD

Some suggestions for the development of a prototype of this water pH control system are as follows:

- ➤ A water level reading system can be developed by replacing the water level sensor with an ultrasonic sensor so that it can read the water level with varying values.
- ➤ A water stirring pump can be developed by using a faster pump motor or adding a pump so that the time process of mixing chemicals with water can be done more quickly.

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