An Automatic PH Equipment for Hydroponic System Using ATMEGA328P Microcontroller

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***Abstract*— The equipment of automatic pH control system has been introduced on the hydroponic with microcontroller ATmega328p. The aim of this research is to create a pH control system to reins water pH on hydroponic. This control system consists of hardware such as pH sensor, microcontroller Atmega328p, servo motor, water pump, LCD and software such as program algorithm. Hardware components were control by program algorithm. The pH value of hydroponic was monitored by pH sensor. The pH value has been read by the sensor used to servo control on taps the acid and alkaline shelter. The pH control uses range of 5.50 to 6.50 as set point. The results showed that pH sensor has the calibration average error of 2.28%. The pH control system showed servo 2 "ON" and servo 1 "OFF" when pH value < 5.50. This resulted that addition of an alkaline that increasing pH of the liquid. And than servo 1 and servo 2 "OFF" when pH value on 5.50 to 6.50. This shows that the pH of the liquid on set point condition. While the servo 1 "on" and servo 2 "OFF" when pH value > 6.50 which resulted the addition of acid liquid that resulting decrease on pH of the liquid.**

Keywords*— *hydroponic, PH, sensor PH, microcontroller, control system

I. INTRODUCTION

Hydroponic is the correct cultivate method to produce a fresh vegetables with narrow field and fastly. Hydroponic do not use soil media but only use water or porous matter [1]. Hydroponic cultivation of plants has several advantages compared to conventional crop cultivation, namely plant growth can be controlled, plants can produce with high quality and quantity, plants are rarely attacked by pests of disease because they are protected, giving irrigation water and nutrient solutions more efficient and effective, can be cultivated continuously without being dependent on the season, and can be applied to narrow land [2]

Hydroponic plants obtain nutrients from nutrient solutions prepared specifically. Nutritional solutions can be given in the form of a puddle or in a flowing state. Nutrition is very important for success in hydroponic planting, because without plant nutrients it cannot grow optimally. Nutrients that must be present for plant growth are macro and micro nutrients. Adding acidic solutions is usually needed to maintain the pH of the solution between 5.5 - 6.5. If the water source has a high pH due to the presence of bicarbonant, the pH should be lowered before the fertilizer is dissolved to keep the deposition [3]. Decreasing and increasing pH can be done by adding acid base compounds such as HNO_3, H_3PO_4, or H_2SO_4 for acids and KOH compounds for base.

PH levels in water hydroponic nutrients affect the absorption of plant nutrients. So that plants cannot grow properly. Water conditions that are too acidic or too alkaline cause the plant to die.

Good acidity conditions for hydroponic plants are in the range of pH 5.5-6.5. Environmental conditions that tend to heat can affect the level of acidity in hydroponic nutrient water. Another factor that can affect changes in pH is the composition of organic matter. The composition of organic matter can increase or decrease the pH of water because in the process of decomposition of organic matter can produce acid [4]. Therefore, it is necessary to monitor and regulate pH automatically, so that it will make it easier for farmers to streamline their time and work.

II. METHODS

The equipment used in this study is a pH sensor, ATMega328P microcontroller, servo motor, water pump, and LCD. The pH sensor consists of a pH probe (sensor), and a signal conditioning module [5]. While LCD is a liquid crystal form that will emulsify when given a voltage [6]. The servo motor serves as a substitute for the hand to open the tap valve automatically [7]. The automatic pH control system algorithm can be seen in Fig. 1.

The following is an explanation of the program in Fig. 1.

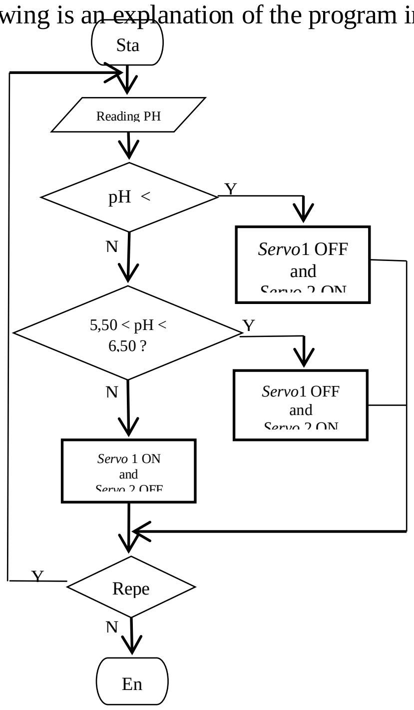

Fig. 1 Flowchart of a Microcontroller Program

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A. Main Program

The main program is in the void setup. Void setup is only called once when the program is first run. Void setup is used for defining pin mode or serial communication.

B. Reading PH

In this section the program contains the process of converting ADC values to pH values. The program is inside the void loop so the program will run continuously.

C. Servo Control

In this section, the servo motor is controlled by a microcontroller with a pH value limit.

III. RESULT AND DISCUSSION

A. Servo Motor Testing

The results of the comparison of angles in the arc with the angle produced by servo motor 1 and servo motor 2 can be seen in Table I.

From Table 1 it can be concluded that the servo motor can rotate according to the angle in the arc and can rotate from an angle of 0 ° to an angle of 180 °.

B. Results of Characterization and Calibration of pH Sensors

The purpose of this characterization is to obtain a relationship between the pH value of a standard measuring instrument and the output ADC value on a pH sensor that is read by a PC. The characterization of the pH value of the pH meter with the ADC value read by the microcontroller is shown in the following table 2.

The error value is a small. A data that has a smaller error value will show that the accuracy of the data is getting better. So it can be interpreted that the accuracy of the data is quite good [8].

TABLE I. THE SERVO 1 AND SERVO 2 TESTING RESULTS

Arc angle (°)	Servo 1 angle (°)	Servo 2 angle(°)
0	0	0
15	15	15
30	30	30
45	45	45
60	60	60
75	75	75
90	90	90
105	105	105
120	120	120
135	135	135
150	150	150
165	165	165
180	180	180

TABLE II. PH SENSOR CALIBRATION RESULTS

No	pH meter	Sensor pH
1	3.9	4.12
2	4.4	4.55
3	5.1	5.17
4	5.6	5.68
5	6.2	6.22
6	6.5	6.42
7	7	7.07
8	7.4	7.55
9	8	8.17
10	8,7	8.88
11	9,3	9.56
12	9,9	10.29
Average Error		2.28

TABLE III. TEST RESULTS OF AUTOMATIC PH SYSTEMS

PH values	Servo 1	Servo 1	Valve 1 (acid solution)	Valve 2 (alkaline solution)
pH < 5,50	OFF	ON	Close	Open
5,50 < pH < 6,50	OFF	OFF	Close	Close
pH > 6,5	ON	OFF	Open	Close

C. Testing of Automatic pH Control Systems

The test results of this system can be seen in Table 3.

In Table III it can be seen that when the pH value of water is in the range below 5.50 the servo motor 1 will still OFF. While the servo motor 2 will turn ON. These results in the water in the tub will get the addition of alkaline solutions from tap 2 until the pH value is more than the lower limit of 5.50. When the pH is in the range of 5.50 to 6.50, the two servo motors are in the same state, both of which remain OFF or not ON. This is because the pH value of the water is in the system set point range. When the pH is in the range above 6.50, the servo motor 1 will be active and the servo motor 2 remains in the OFF state. So that the water in the tub will get the addition of an acid solution from tap 1, until the pH value is less than the upper limit of 6.50. From the test results obtained that the system can run well.

In this test, the initial conditions are acidic and alkaline. Each condition was added with an acid-base solution with a concentration of 2.5%, 5% and 10%. So that obtained six times the test results can be seen in Fig. 2, Fig. 3, Fig. 4, Fig. 5, Fig. 6 and Fig. 7.

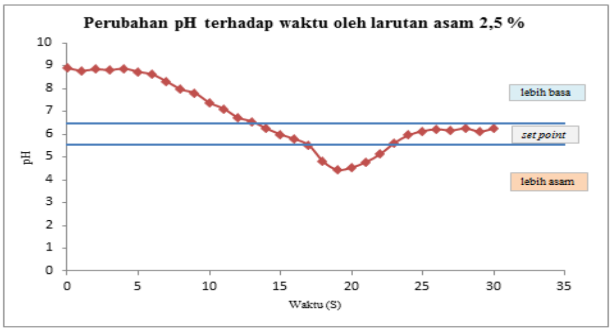

Fig. 2. Graph of changes in pH to time due to the addition of 2.5% acid solution

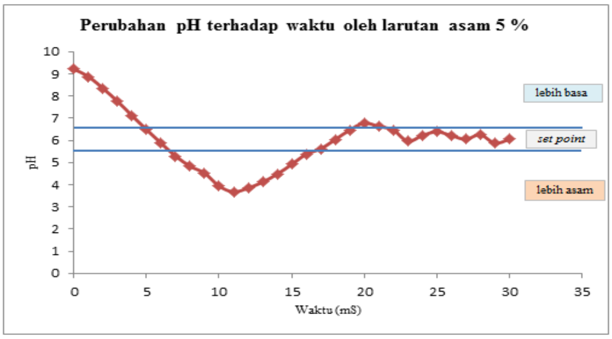

Fig. 3. Graph of changes in pH to time due to the addition of 5% acid solution

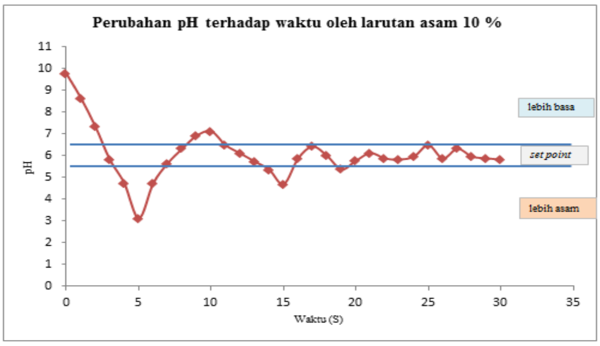

Fig. 4. Graph of changes in pH to time due to the addition of 10% acid solution

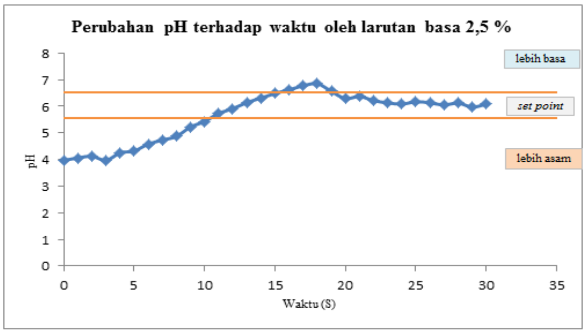

Fig. 5. Graph of changes in pH to time due to the addition of a 2.5% base solution

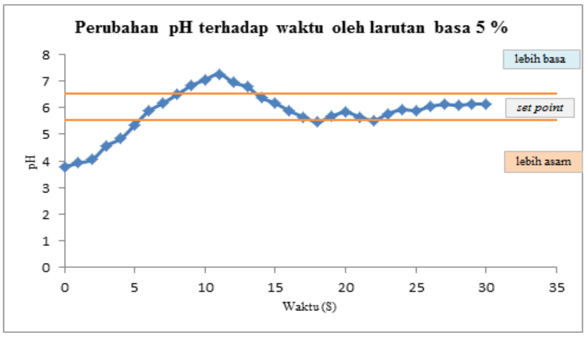

Fig. 6. Graph of changes in pH to time due to the addition of a 5% base solution

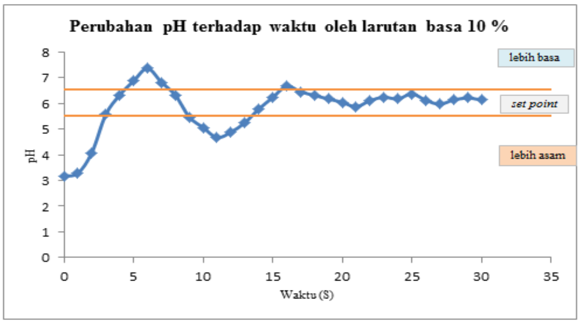

Fig. 7. Graph of changes in pH to time due to the addition of a 10% base solution

Testing with initial conditions are alkaline and the addition of acid solutions 2.5%, 5% and 10% give almost the same results. Where all three cross the lower limit before going to a stable pH condition. But the time to go to stability tends to be different. To achieve a neutral state on the addition of an acid solution with a large concentration will be faster than a small concentration, but with a large concentration will cause more fluctuations in acid and alkaline conditions. This situation shows that the concentration of acid solution is inversely proportional to its pH value. So the time needed to reduce pH by using an acid solution that concentrates 2.5% longer.

Testing with initial conditions are acidic and the addition of alkaline solutions 2.5%, 5% and 10% give almost the same results. The all three pass the upper limit of the set point before going to a stable pH condition. But the time to go to stability tends to be different. It will achieve a neutral state on the addition of alkaline solutions which it is with a large concentration will be faster than with a small concentration, but alkaline solutions with a large concentration will lead to more fluctuations in acid and base conditions. This experiment shows that the concentration of alkaline solution is directly proportional to its PH value. So the time needed to increase pH by using alkaline solutions that concentrate 2.5% is longer.

IV. CONCLUSION

Based on the results of the testing and analysis that have been carried out in this study, it can be concluded that the tools made are able to work optimally by maintaining a pH ranging from 5.50 to 6.50 with an error of 2.28%. The use of acidic solutions with concentrations of 2.5%, 5% and 10% requires 23, 22 and 20 seconds respectively to achieve neutral conditions. While the use of alkaline solutions with concentrations of 2.5%, 5% and 10% requires 20, 19 and 17 seconds to achieve neutral conditions.

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