pH ANALYZER DEVICE WITH MICROCONTROLLER-BASED WATER NEUTRALIZATION SYSTEM FOR PECHAY CULTIVATION

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ABSTRACT

There are many different factors that contribute to the growth and development of a plant, one of which is the power of hydrogen or commonly called as pH level. Due to extreme changes in the climate and the decreasing area of agricultural lands, it is important to maximize every possible harvest. With this being said, this study focuses on providing plants such as Pechay the right pH level that it requires. The group will be using a microcontroller based system that will analyze the pH level of water and would proceed according to the needed action to neutralize the water. By using the suitable reagent, the desired pH level of water for the plant will be provided. With this, a faster growth and healthier plant is expected.

Key Words – acidity, alkalinity, microcontroller, Pechay, pH,

I. Introduction

Having the right pH level is important because lacking or exceeding the needed level can be harmful to every individual. If the pH level of a solution is below 7, it is considered acidic. If it is the other way around, the solution is called alkaline. The acidity and alkalinity level of a substance can be determined with the help of a pH scale. This scale ranges from 0 to 14 with 7 considered as neutral. [1] It is important to monitor the pH level of plants because it is a significant factor in the development and growth of it. If the pH level is too low or too high, it is possible that the plant will not get its required nutrient or might have been exposed in the presence of high concentration of minerals which might be damaging to plants. Several micronutrients such as copper and zinc will be absent in plants if the soil is too alkaline. On the other hand, micronutrients like phosphorous, calcium, and magnesium will not be absorbed or worse might have reach toxic levels if the soil is very acidic. [2]

This study aims to create and design a pH meter that will be used for monitoring the pH level of irrigation water. At the same time, this study also aims to neutralize irrigation water using a microcontroller-based system that would detect unwanted increase in pH level that is detrimental to the growth and development of quality crops. The group used Pechay as a plant sample.

The system used a pH analyzer device with a probe that reads the pH and temperature level. The said pH analyzer device triggers the microcontroller based system with PID to controller to release an

accurate amount of neutralizing agent that is proportional to the amount of water being tested in the system once an increase or decrease of pH level is detected. The neutralized water should have a pH level around 5.4-6.7 because it is the ideal range in growing a Pechay. [3]

II. Equation

A. Nernst Equation

In using a pH electrode, one will obtain a voltage (typically in millivolts) value that will later be converted into a pH value. In doing so, anything that affects the voltage values taken by the probe will affect the end result. Following the Nernst Equation, voltage is affected by temperature by decreasing the total potential taken by the electrode. The second term of the right side of the equation where temperature is included is taken as the Nernst slope. An ideal electrode will project that increasing the temperature will also increase the Nernst slope. This will then lower the total potential where pH is to be taken.

$$E = E^0 - 2.3\left(\frac{RT}{nF}\right)\log a_H{}^+ \quad (1)$$

The electrode membrane, which is in direct contact with the sampling water, is also affected by temperature. This is the physical effect of temperature to the pH electrode. It was found out that as the temperature increases, the surrounding membrane of the glass portion of the electrode decreases. This results to a slower response once the temperature is brought back to an ideal or preferred room temperature. Knowing this effect, the electrode may be rendered unusable when introduced to extreme temperatures. It is ideal, similar with the application done in this project, that the water sample would be around room temperature.

B. Steinhart-Hart Equation

$$\frac{1}{T} = A + B\ln R + C[\ln R]^3 \ldots \quad (2)$$

The Steinhart-Hart is a method for modeling thermistor temperatures easily and more precisely. The T stands for temperature in Kelvin while the R stands for resistance in Ohms. To get the resistance, this formula is used: $R = 10K\left[\left(\frac{2V}{V_{out}}\right) - 1\right]$.On the other hand, A,B, and C are the Steinhart-Hart coefficients that vary depending on the type of temperature range being tested and the kind of thermistor, usually the model, is being used. This equation is used to calculate the resistance of a thermistor as a function of temperature with high accuracy. The narrower the temperature range, the more accurate the resistance calculation will be. [4]

III. Block Diagram of the System

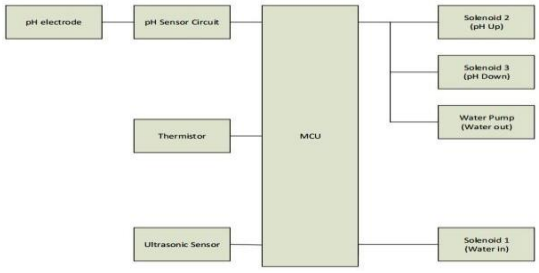

Figure 1 General Block Diagram of the Water Treatment System

The proposed project, a water treatment system, involves manipulating different variables present in a water sample. In doing so, there will be a setup that includes a tank that will hold the water sample, a probe that will determine the pH level of the water sample, and a digital meter that can display the probe's findings in numeric figures.

The project revolves around the microcontroller to be used that will do the chemical content regulating. A pH level sensitive probe will determine and indicate the amount of certain compounds present in the water. With the reading taken by the probe, the microcontroller allows selected chemical agents to be released into the water sample. This will make sure that the pH level of the water is favorable in agricultural conditions.

The water tank features an inflow and an outflow valve which will regulate the amount of water to be treated at a given instance. Although the valves will not be a main component of the project, this is to be noted as a means of making sure that a certain amount of water can be sampled taken from an open source such as a river.

IV. Flowchart

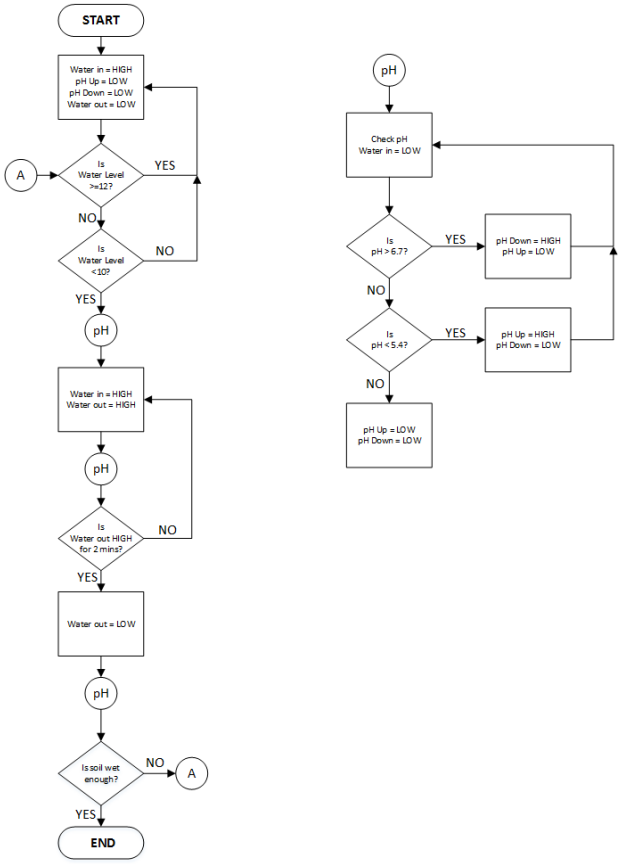

Figure 2 Flowchart of the Water Treatment System

The system begins with water filling up the tank. While in this stage, the pH up, pH down, and water out are expected to be turned off. Water in will remain on until the water level reaches the range of 10 to 12 cm. Once the water level inside the tank is sufficient already and water in is already low, the pH adjustment will take place. If the pH level is greater than 6.7, pH down will turn high. Otherwise, the system will check if the pH is less than 5.4. The pH up will turn high if the pH level is below 4.5. The system will repeat the steps in pH adjustment until it reaches the desired pH level. The pH up and pH down will eventually

be low and the water out will be high once it met the said conditions. If the water out is high for 2 minutes, it will stop for a while and will again proceed to pH adjustment to check if the water inside the tank is still within the desired pH level. The process will only end if the soil inside the plant box obtains its required soil moisture.

V. Results and Discussion

A. Water Out

Table 1 Summary of Water Out Testing

	WATER OUT	FLOW RATE
TIME (secs)	mL	L/min
5	150	1.8
10	300	1.8
15	480	1.92
20	600	1.8
25	700	1.68
30	800	1.6
35	920	1.577142857
AVERAGE		1.739591837

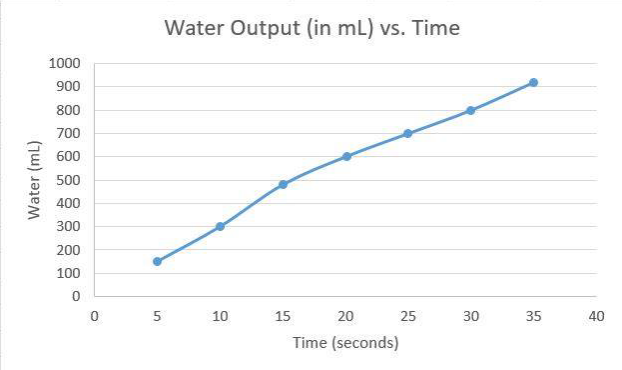

Figure 3 Water Output vs. Time

Based on the data gathered after testing, the group observed that the water output is about 100-150 for every five seconds. The group got an average flowrate of 1.74 liter per minute.

B. Temperature Accuracy Checking

Table 2 Summary of Temperature Accuracy Testing

DATA SAMPLE	OAKTON	Thermistor	% error
Tap water from faucet	23	23	0
Boiled water for 1 min	45	42	6.666666667
Boiled water 1 min 30 secs	62.4	58	7.051282051
Boiled water 1 min 50 secs	84.5	76	10.0591716
Boiled water 30 secs	81	72	11.11111111
Boiled water + tap water	27.9	28	0.358422939

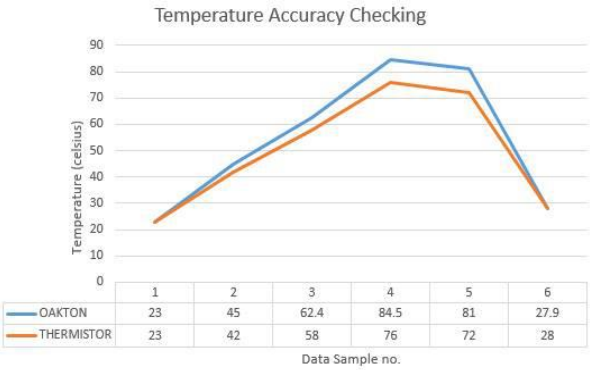

Figure 4 Thermistor vs. Oakton Device Reading

When comparing the temperature reading of Oakton device and pH analyzer device, the group recognized that the percent error between the two devices increases as the temperature increases. The group got an almost the same temperature when both devices were tested with tap water.

C. Temperature Reading

Table 3 Summary of Temperature Reading of Thermometer and pH Analyzer Device

Test No.	Time Water Heater is Submerged (sec.)	Thermistor Reading	Thermometer Reading (reference)
1	5	36	38
2	10	36	38
3	15	38	39
4	20	39	40
5	25	40	41
6	30	42	42
7	35	45	46
8	40	48	48
9	45	50	51
10	50	52	52

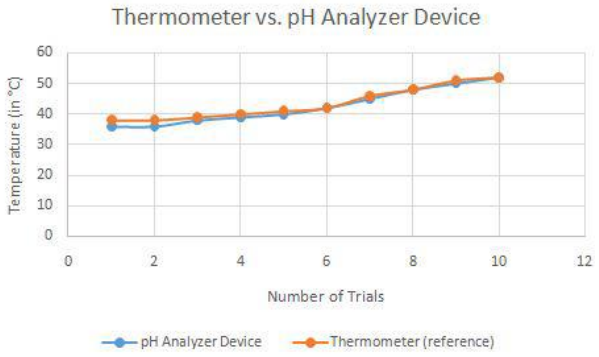

Figure 5 Thermometer vs. pH Analyzer Device

The table shows that the thermistor reading and thermometer reading have a small dissimilarity with each other. It is also shown in the diagram that the error between the two decreases as the temperature increases.

D. Data for pH Up and pH Down Effect on Plant Samples

The group used a mixture of 1250 mL of water and 30 cc vinegar to increase the pH of water and a mixture of 1250 mL of water and 30 cc soda otherwise. The pH reading of the former is 8.04 while the reading of the latter is 4. Both of these solutions are then applied to separate plant samples for 4 consecutive days and pictures of data are shown below

Day 1

Both of the pot shows no sign of Pechay growing in it the pot with the blue flag represents the pot that used basic solution and pot with the red flag represents the pot that uses acidic solution

Figure 6 Pechay at Day 1

Day 4

The pot with acidic solution as its water sample shows a lot of pechay plants that are growing in its pot compared to the pot with basic solution. During the other day the difference between the pechay plants that are growing on both pots are slim to none but during the 4th day it is very noticeable that the pot with acidic solution have greater seeds that have already grown when compared to the other pot sample.

Figure 7 Pechay at Day 4

The length of the sprouts for both pots are also measured and it is confirmed that pechay plants grow well with water samples that are treated in the range of a more acidic pH

Figure 8 Acidic Solution vs. Basic Solution

At the end of testing the group was able to confirm that pechay based from its ideal pH range of 5.4 – 6.7 which Is on the acidic state is more likely to grow faster if the water to be used for watering it is on the more acidic side compared to a water sample that is on it basic state. The data shown beforehand could fully support the observations.

E. State Test

In this state test, the water pump should only be high when the pH value reading is around 5.4-6.7.

Table 4 State Diagram Using pH Value of 7.8

			STATE			
Water Level	Temp.	pH Value	Solenoid 1	Solenoid 2	Solenoid 3	Water Pump
25	23	7.8	HIGH	LOW	HIGH	LOW
24	23	7.82	HIGH	LOW	HIGH	LOW
23	23	7.82	HIGH	LOW	HIGH	LOW
22	23	7.81	LOW	LOW	HIGH	LOW
21	23	7.82	HIGH	LOW	HIGH	LOW
20	23	7.82	HIGH	LOW	HIGH	LOW
19	23	7.82	LOW	LOW	HIGH	LOW
18	23	7.82	LOW	LOW	HIGH	LOW
17	23	7.81	LOW	HIGH	HIGH	LOW
16	23	7.81	LOW	LOW	HIGH	LOW
15	23	7.81	LOW	LOW	HIGH	LOW

Solenoid 1	Water In
Solenoid 2	pH Up
Solenoid 3	pH Down
Pump	Water Out

As expected, solenoid 3 and water pump would be high and low respectively because the pH value is higher than the threshold set. There were a couple of deviations for solenoids 1 and 2 where error lies in water level measurement and pH value sudden change.

F. pH Accuracy

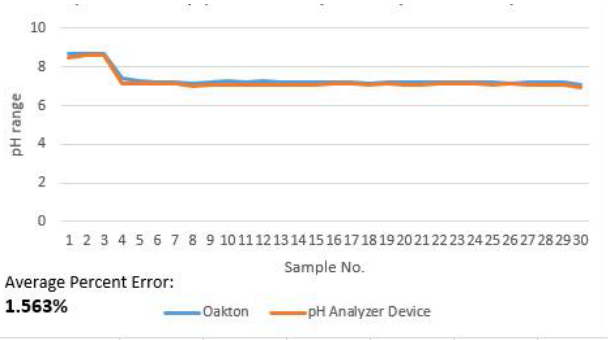

Figure 9 Oakton vs. pH Analyzer Device

Table 5 Summary of pH Accuracy Testing

Sample No.	pH Value of Oakton (reference)	pH Value (Device)	Percent Error
1	8.68	8.49	2.188940092
2	8.69	8.61	0.920598389
3	8.7	8.6	1.149425287
4	7.43	7.13	4.037685061
5	7.25	7.12	1.793103448
6	7.24	7.14	1.38121547
7	7.24	7.13	1.519337017
8	7.12	7.04	1.123595506
9	7.18	7.1	1.114206128
10	7.26	7.09	2.341597796
11	7.21	7.08	1.803051318
12	7.25	7.09	2.206896552
13	7.22	7.06	2.216066482
14	7.21	7.08	1.803051318
15	7.21	7.06	2.080443828
16	7.21	7.12	1.248266297
17	7.21	7.13	1.109570042
18	7.16	7.05	1.536312849
19	7.18	7.11	0.974930362
20	7.19	7.1	1.251738526
21	7.2	7.09	1.527777778
22	7.19	7.13	0.83449235
23	7.2	7.12	1.111111111
24	7.2	7.12	1.111111111
25	7.21	7.08	1.803051318
26	7.14	7.11	0.420168067
27	7.19	7.1	1.251738526
28	7.2	7.05	2.083333333
29	7.2	7.09	1.527777778
30	7.05	6.95	1.418439716
	Average Percent Error		1.562967762

G. Settling Time with Mixer

Table 6 Summary of Testing with Mixer

Target pH range = 5 -6.5

Test No.	Reagent	Amt. of Reagent	Starting pH	Ave. Settling Time	Final pH
1	Vinegar	15mL	8.67	30 seconds	7.65
2	Vinegar	15mL	7.65	30 seconds	5.86
3	Vinegar	15mL	5.86	30 seconds	4.74
4	Baking Soda	15mL	4.74	30 seconds	5.47
5	Baking Soda	15mL	5.47	30 seconds	6.15
6	Baking Soda	15mL	6.15	30 seconds	6.64

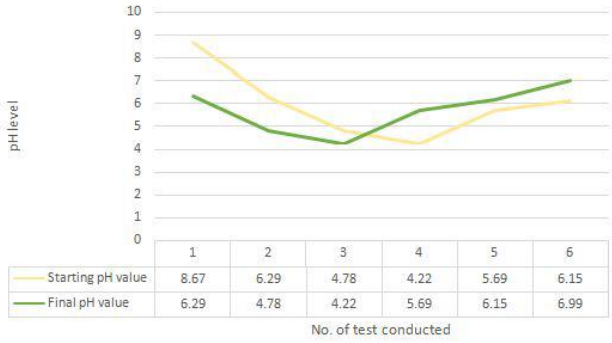

Figure 10 Settling Time with Mixer

Table 7 Summary of Comparison of Final pH Reading

Test No.	Final pH reading with mixer	Final pH reading without mixer
1	6.29	7.65
2	4.78	5.86
3	4.22	4.74
4	5.69	5.47
5	6.15	6.15
6	6.99	6.64

Figure 11 Comparison of Mixer Implementation

The tests conducted proved that the mixer circuit designed by the group helped in the dispersion of the reagent. It is shown in the graph that the desired pH level of water is obtained more rapidly when the mixer is present at the system.

H. Pechay Cultivation

The Pechay seeds were planted 4cm away from each other. The sticks serve as the marker of where the seeds were planted.

Figure 13 Planting of Pechay Seeds

The group originally planted 11 Pechay seedlings but only 9 were able to grow properly. The group thinks that lack of enough space is the reason why some of the seedlings died.

Figure 14 Cultivated Pechay Leaves

III. Conclusion

After conducting various tests, the objectives of this study were met. The group successfully made a pH Analyzer Device which is able to control the pH level of a certain amount of water sample. Three solenoid valves and a pump allows the flow of liquid by means of signals sent by the pH Analyzer Device. The right amount of neutralizing agent is dispensed whenever there is a sudden change in the pH level of the water under test. A conclusive average accuracy rate of 98.473% was taken from the above mentioned tests.

The water neutralizing system features a water level regulation system where the level of water is maintained at a distance of 20cm ultrasonic sensor used. The use of sending ping, rather than the conventional digital control, proved to be reliable in terms of response time and measurement accuracy. Originally, the group was to use PID control in maintaining the water level. But after careful planning and several trial-and-error scenarios, the group decided to have a different approach of matching the inflow and outflow accompanied by a set of fail-safe parameters that are reflected in the codes.

The pH level of the water under test is determined by introducing a pH probe to the liquid storage. The group made use of a budget-friendly probe which yields a relatively conclusive measurements. After subjecting the water under test to numerous changes in pH level, the group checked the accuracy by using a pH meter that can be purchased in the market for reliability purposes. After which, the group was able to display the pH level, water level, and the temperature in a 16x2 LCD display for user convenience.

IV. Recommendations

To be able to execute the project and study with more accuracy the group suggests that the timeframe for the study of reagents to be used should be longer to be able to study carefully its behavior and effect on the Pechay plants. Proper tubing system should also be implemented specially on the water storage system because if not leakage of reagents would occur causing interference on the whole operation of the system. Enough time for Pechay cultivation should also be utilized to be able to come up with data that would include the taste and appearance of Pechay plants given the pH level of water sample used for it to grow.

V. References

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