Tools For Detecting and Control of Soil pH by Probe Sensor based on Android

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Abstract. Soil pH is very vital for all life on agriculture. For a farmer, knowing how much of soil pH (Potential of Hydrogen) is very important. By detecting of the soil pH, it will be easier for a farmer to decide for certain agriculture plants. This research aims at develop an automatic soil pH detecting system for Farmer to visualize the soil pH demand of smart farmer using the microcontroller and smartphone. The tool model is as an information for the farmer, which also includes the devices of suitable plants on the soil which could be used to decide the type of plants suitable for the soil. By detection results of this pH sensor will decide also whether or not to drain nutrients and whether to flush the air conditioner or not. We developed the tools model to detect pH in some of soil. We include a Google maps also in order to find out the pH value of the soil in a particular region. We have tested a number of soil samples area, namely humus soil, soil with a mixture of manure, fertilizer, compost, and soil mixed with sand. The research shows the soil pH based on android by online. Furthermore, the pH value and address of the coordinates tested are stored in the firebase database. In detecting of soil pH, the system only need about 2-5 seconds time during the processing to detect the pH of some soil.

1. Introduction

Soil is very vital for all life on earth, because the soil supports plant life by providing nutrients and water to support plant roots. For a farmer, knowing how much of soil pH (Potential of Hydrogen) is the most important to determine what type of agriculture plant is suitable for the soil. By monitoring the pH of soil, it will be easier for a farmer to decide the agriculture plants. The soil structure is not only a good for roots, but also for breathing for plants. Soil is also a habitat for various microorganisms, animals and life many people. The soil fertility can be known by the value of soil pH. Measurement of soil acidity and soil pH value is also as a parameter for determine soil fertility [1].

The value of pH is the acidity level used to determine the acidity of a soil. The pH value is defined as the quantity logarithm of hydrogen (H+) ion activity. The ion activity of hydrogen is difficult to measure experimentally, so the activity coefficient value is based on theoretical measurements. Therefore, the pH scale value is a relative value. This is a relative standard value as a solution of the pH value which is determined based on the international agreements [2].

The soil pH sometime is called a pH meter. Unfortunately, many farmers do not have this tool. Maybe because the price is quite expensive or lack of knowledge about the importance of knowing
soil pH. Though the knowledge of the degree of soil acidity is very instrumental in the success of an agriculture plants.

Plants will not grow and produce maximally if the soil pH is not right to the plants. By knowing soil pH, farmers can determine the ideal pH which is suitable for plants. To get maximum results of a plant to be optimal, the soil pH must be in accordance with these plants. For example, corn can grow well at place between 0-1300 m over sea level [3]. Corn plants will grow both on fertile soil, good drainage, warm temperatures of 21-32 °C, evenly distributed rainfall throughout the year, and monthly rainfall around 100-125 mm. A good soil for corn plants is soil with optimum pH 6.0-7.0.

Based on the description above, it is important thing to know the pH of some soils for farmers or other users. For this reason, we need a pH meter model as described in this study. This study proposes a model of pH sensor devices, to detect soil pH and plant references that are suitable for the position of the land. In addition to the soil pH, communication for sending of soil ph is also very necessary to find out the coordinates of the soil location correctly. It may need to involve sensor detection and communication media such as android for sending data in real time.

2. Related Work
Michael S [4] and colleagues conducted a sensor readings study to evaluate pH on agricultural land in Germany. Sensor reading is compared to standard value of soil pH values. In another study, Sachin Kumar [5] and colleagues described concepts and techniques for detecting soil pH. They said that soil pH is very important parameter to increase crop productivity, so it must be handled appropriately.

In another study, Gaytri Gupta and colleagues developed an experimental tool to measure pH in certain types of substances [6]. This tool is used to check pH on substances found in daily life. According to their research, pH is a hydrogen potential that most important as a basis to measure the acidity of soil. The pH value is to show a value of negative logarithm of hydrogen ion concentration in some soil [7].

In other studies, Sitompul et al [8] have developed the use of microprocessors for several fields of detection systems. Also, Sihombing P. et al [9] have developed of using of microcontroller for various purposes by connecting it to several sensors. Sihombing have developed a detection sensor whose results can be sent to the microcontroller and android smartphone [10]. Sihombing and colleagues have also developed a detection sensor that involves the location of an event and its results can be sent to the android smartphone in real time [11].

In other next studies, Deepa Ramane, et. al [12], wrote the integrated crop management systems have been designed to study spatial and temporal behavior of NPK and hydrogen ion concentration. Quantity of NPK and hydrogen ion concentration will determine the plant type and on plant growth fertility [13]. The soil pH condition will be the next benchmark for how much fertilizer will be added to the soil [14]. Also, in [15] Bachkar Yogesh Ramdas et al have proposed that to increase of crop productivity it needs to continuous monitoring not only of soil pH, but also moisture in automation in agricultural areas.

3. Description of research
Figure 1 below is a block diagram of detecting and control of soil pH that will be developed. In this study, soil pH was taken from several samples, including compost, soil given NPK fertilizer, humus soil, sand soil and soil that was given manure as we shown in the figure 1.
Description technique of the study is as follows:

a) Connect the smartphone with Arduino
b) Plug the pH probe sensor into the ground where the pH value will be measured.
c) Click the count button in the application that has been made to calculate the soil pH value.
d) Arduino will perform a calculation process based on the analog signal received from the sensor.
e) Arduino sends the calculation value in the form of soil pH to the smartphone
f) Click the save button on the application to save the soil pH value on the map with the appropriate coordinates at the checking location.

4. The Research Experimental and Result

Figure 2 below shows experimental setup of tools and materials needed in the experiment.

Figure 2. Experimental setup of tools and materials (compost soil, NPK Fertilizer, Top Soil, Sand Soil, Manure Soil).
4.1 Arduino Uno Software
Software of the Arduino is developed by using the C language and the Arduino C application as the compiler. The program file from the compiler has extension .ino which is then embedded on the Arduino board via an Arduino board-specific USB cable. Figure 3 below shows a portion of the Arduino IDE program.

![Source code in Arduino.](image)

4.2 The calculation results
The calculation results of soil pH calculation will be displayed in the form of soil pH carried out by the probe sensor. Besides displaying its pH value, it also has two buttons, namely the save button pH value and the map view button.

The save value button is an order to save the pH value to the database using the Google Firebase facility, where the data is stored in the coordinates location of the checkpoint along with the pH value. While the map view button is to open a map of the pH location has been detected, as is shown in figure 4.
In addition, the calculation results of soil pH have information in the form of what plants are suitable for planting according to the pH value that has been calculated. This display can be swiped, so users can see which plants are suitable for planting in this location. For example, figure 5 shows the results of the pH calculation and suitable plants to be planted.

Testing the soil pH sensor is detected by using an analog signal as the transmission. This range of analog signals consists of 10 bits in range of 0-1023. The sensor issues an ADC (Analog to Digital Converter) signal value which will be further processed by the Arduino. Table 1 below shows...
the results of soil pH testing which is given a pH acid-base buffer solution based on a soil pH sensor datasheet.

| Acid Soil | Base Soil |
|-----------|-----------|
| Acid Liquid (ml) | pH | AVO Meter (mV) | ADC | Base Liquid (ml) | pH | AVO Meter (mV) | ADC |
| 0 | 7 | 49.7 | 7 | 0 | 7 | 41.5 | 6 |
| 6 | 6 | 117.9 | 20 | 6 | 7 | 36 | 4 |
| 12 | 4.9 | 204 | 35 | 12 | 6.8 | 35 | 3.5 |
| 18 | 4.3 | 234 | 45 | 18 | 6.4 | 34 | 3.2 |

The results in table 1 are obtained by formulas $y = -0.0693x + 7.3855$. Where $y = \text{pH value}$, $x = \text{ADC value}$, constant value $= 7.3855$. For example, the ADC (Analog to Digital Converter) value is obtained after reading a compost soil sample is equal to 5. So, the pH value is: $y = -(0.0693 \times 5) + 7.3855 = -(0.0693 \times 5) + 7.3855 = 7.039$. So, the pH value obtained after passing the sensor process is 7.039.

### 4.3 Test Results on Soil Samples

Several soil samples have been tested, and the results are shown in table 2 and in figure 6.

| Soil Sample   | X1   | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | $\bar{x}$ |
|---------------|------|----|----|----|----|----|----|----|----|-----|----------|
| Manure Soil   | 3.99 | 4.89 | 4.41 | 4.47 | 4.34 | 4.27 | 4.20 | 4.13 | 4.13 | 4.06 | 4.28     |
| Compost Soil  | 5.39 | 5.38 | 4.82 | 5.10 | 5.03 | 4.96 | 4.68 | 4.82 | 4.82 | 4.06 | 4.9     |
| Sand Soil     | 4.13 | 4.89 | 4.13 | 3.99 | 4.20 | 4.13 | 3.99 | 4.13 | 3.99 | 4.13 | 4.17    |
| Humus         | 4.47 | 4.47 | 4.82 | 5.58 | 5.58 | 5.58 | 5.58 | 5.58 | 5.58 | 5.58 | 5.28    |
| NPK fertilizer| 1.77 | 2.12 | 1.84 | 1.77 | 1.98 | 2.12 | 2.26 | 1.98 | 2.19 | 2.12 | 2.01    |

Where $X_n = \text{pH value}$

Several experiments have been carried out with the detection results as shown in table 2 and figure 6. These results indicate that the pH value measured by the soil pH sensor is not much different from the
calculation of the soil pH manually. The voltage released by the sensor varies according to the pH level of some soil samples. The sensor takes about 2-5 seconds to calculate the pH value of the measured soil sample.

5. Conclusions

Microcontroller-based soil pH measuring instruments have been developed in this study. Measurements have been tested on several samples, such as soil fertilizer, compost, sand, humus, and NPK fertilizer. The output of the measurement resulted as follows: the pH value of Manure Soil is 4.28; the pH value of Compost Soil is 4.9; the pH value of Sand Soil is 4.17; the pH value of Humus is 5.28; and the pH value of NPK fertilizer is 2.01 as is shown in table-2. In addition to pH measurement, the types of plants are adjusted to the measurements that notified. Also, the measurement location is notified by this application. The calculation results of the soil pH application are relatively not much different when compared to the calculation of manual soil pH. The voltage released by the sensor varies, according to the pH level of some soil samples. The sensor takes about 2-5 seconds to calculate the pH value of a soil sample.

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