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Fertilizer Optimization by an Smart Soil Analyzer with a Soil Tester for Agriculture Applications

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ABSTRACT

This paper presents the design and development of microcontroller based compact soil analyzer. Conventionally farmers are replenishing the soil by using the fertilizer. But all the crops not require same or with equal nutritive. Nutritive requirement for the fields depends on the crop and its age. The conventional soil test centres may not be more effective since they take more time to get the results and it is difficult to take the regular tests during the single crop life time. To minimize these problems and to get the better production, proposed a solution called "S*mart Soil Analyzer*" (SSA). The goal is to develop a portable kit to test the soil for the contents of NPK (Nitrogen, Phosphorus, and Potassium), pH value, salt content; moisture and temperature by using respective sensors and an electrode, the measured values are compared with the predetermined data base values then finally displays the fertilizer amount required. This paper provides a quantitative analysis for the proposed device and conventional soil tester. The analysis provides an evidence to use the proposed device to improve the crop production by more than 40%.

Key words: pH value, NPK, pH electrode, Soil Analyzer.

1. INTRODUCTION

The fields of agriculture have been the backbone of the Indian economy and it will continue for a longer time further. The country has existing Sustainable agriculture. It is defined as "an integrated system of plant and animal production practices having a site-specific application in same place". Physical aspects of the sustainability are partly understood. Usual practices that can cause long-term damages to soil include excessive tillage and irrigation without adequate drainage systems. There are long-term experiments which have provided some of the best data on how various regular practices affect the soil properties which are essential to sustainability. When the farmers grow and harvest crops, some of these nutrients from the soil will be removed. Without replenishment, the land suffers from the nutrient depletion and becomes either unusable from reduced yields in the longer time. Farmers are replenishing the soil with the help of fertilizer. All the crops do not require the same or equal amount nutritive. The nutritive requirement depends on the crop and its age.

It is observed that fertilizers increase the yields and the farmers are aware of this. By applying the right proportion of the proper fertilizers at the right time will increase the yield to a maximum. Without the fertilizer recommendation based upon a soil test, a farmer may apply more or less fertilizer that is needed for the plants actually, which is the principal factor in limiting the plant growth [1]. To minimize the unnecessary usage of fertilizers, government opens soil testing centers, but which are taking long time to get results and it is difficult to take the regular tests during the single crop life time. To avoid these problems and to improve the crop yield proposed a device which is called "*Smart Soil Analyzer*".

The proposed design provides a customized keypad to select the crop and its age. After selecting the crop and its age, the micro controller process the above specified parameters. Then it displays the quantity of N P K and pH value of the sample soil and also displays required proportion of N P K for the efficient growth of the plant in that age, So the farmer can provide proper quantity of fertilizer. This reduces the wastage of fertilizer and increases the production of the crops.

2. OBJECTIVES

a. For a given crop to provide a basis for fertilizer recommendations
b. Plan a nutrient management program to evaluate the fertility status of the soil
c. The purpose of soil analysis is to assess the adequacy, surplus or deficiency of available nutrients for crop growth and to monitor change brought about by farming practices.
d. To estimate the available nutrient status and reaction of a soil
e. The basic objective of this soil-testing is to provide farmers a low cost service which is leading to better and more economic use of fertilizers with better soil management practices for improving the agricultural production [2]

High crop yields which cannot be obtained without adding sufficient fertilizers to overcome the existing deficiencies for crops.

3. METHODOLOGY

- From the required agricultural land plunges the smart soil analyzer for soil test
- Moisture analysis and NPK of the soil [4]
- Collect the soil data through the relevant electrodes and produce the data for analyzing through Microcontroller
- Correlate the data with the predefined data available in the database
- Database available for different crops and their different growth stage requirements in the soil
- The results of correlation will be displayed and gives the required suggestions
- pH content analysis of the soil.
- Place the pH electrode in the mixture of distilled water and soil
- Display the pH content of the soil and give the required suggestions
- Calibrate the weather temperature and display along with that

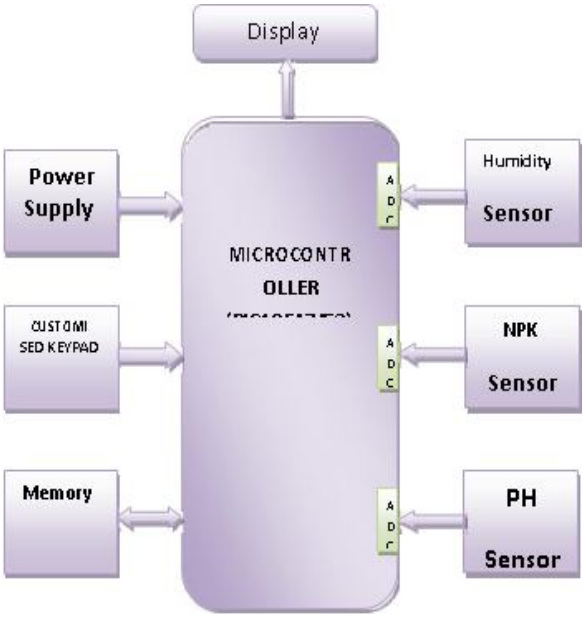


Figure 1: Block diagram of interfacing peripherals with microcontroller.

4. HARDWARE MODULE

4.1 Power supply

A power supply unit supplies direct current (DC) power to other components in a system/circuit such as microcontroller, display etc. it converts general purpose alternating current (230v/50Hz) to low voltage dc power for the internal components of the system. It consists of step-down Transformer, Rectifier, Filter and Regulator.

4.2 Microcontroller

Microcontroller [6,7] is main integral part in this project, a 8 bit PIC microcontroller (PIC18F47J53) [8] is used. It consists of processor, memory and I/O ports. It controls the overall activity of the system. Memory has divided into two parts i.e. Program memory and Data memory. The microcontroller has 128Kilo Bytes program memory and 3.2Kilo Bytes data memory and also has inbuilt RTCC module. Program is stored in program memory and required data base is stored in data memory. All peripherals are interfaced with the microcontroller such as Display, N-P-K Electrodes, pH Electrode and it has inbuilt temperature sensor.

4.3 N-P-K and pH Electrodes

N-P-K stands Nitrogen-Phosphorus- Potassium. Before knowing N-P-K and pH electrodes, an electrode is a conductor through which the current is passed. An electrode passes current between a metallic and a non- metallic part of a circuit. Frequently, conductors are metallic which carry electrical current. In few circuits, current is passed through a non-metallic conductor.

pH is the measure of acidity or alkalinity. Amount of hydrogen ions (H+) causes a liquid to be acidic or alkaline. And the pH range [3] is measured normally from 0 to 14 are possible. Most plants need pH value to be in between 4 and 6.5. The pH electrodes provide a voltage according to the concentration of Nitrogen ions in a given sample (Soil).

4.4 Display

A display device is an output device for presentation of information in visual or letter form. It is interfaced with microcontroller. It displays the measured values with the help of microcontroller such as NPK values, pH values and temperature etc. We are using 4x20 alpha numeric LCD display.

4.5 Customized Keypad

Key pad is an input device for provide information into the microcontroller or control the process flow of the microcontroller. Here the device is provided with only 3 keys one is selection key for select the particular option such as crop name or crop age etc. and 2 keys are used to scroll the display up and down.

4.6 ANALOG TO DIGITAL CONVERTER (ADC)

An analog to digital converter converts a continuous quantity to a discrete time representation. Normally, an ADC is a device that converts an input analog current or voltage to a digital number proportional with magnitude of the current or voltage. The accuracy of the system depends on an ADC. As the resolution of an ADC increases, the accuracy of the system increases. In the proposed design, microcontroller is having 13-channel, 10/12-bit inbuilt ADC. The Table 1 lists the hardware elements and its description used in the experimental setup.

Table 1: The Hardware Elements and its Description

Hardware	Family/ version
Microcontroller	PIC18F47J53
Liquid Crystal Display (LCD)	JHD204A series (20characters x 4 rows)
pH and NPK Electrodes	Ion Selective Electrodes(ISE)
Humidity sensor	STH21
Temperature sensors	LM35DZ

5. SOFTWARE MODULE

Basically the software module is divided into TEST, ANALYSIS and SETTINGS (date and time).Test program reads the values from the sample soil through sensors and ADC hardware and which are compared with the database and recommends the right NPK proportion, which is performed by the analysis module. Finally settings provide to update the date and time as per the specified format.

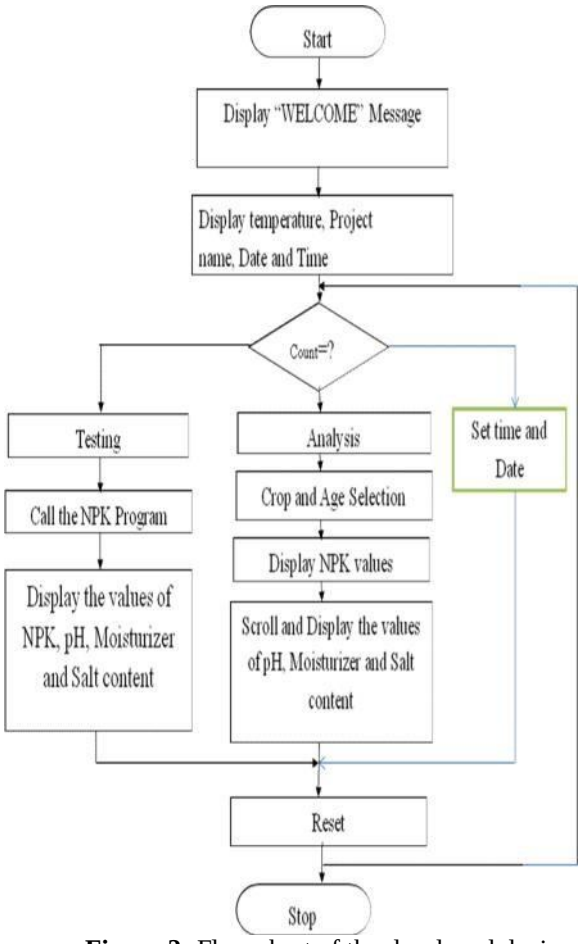
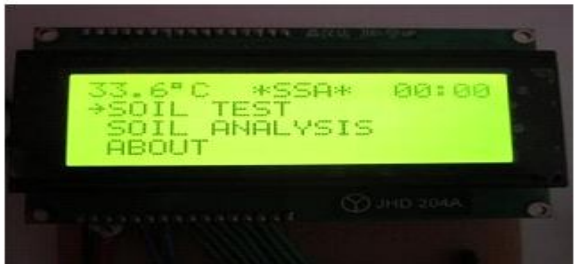


Figure 2: Flow chart of the developed device

6. RESULTS AND DISCUSSIONS

Displays the quantity(in terms of percentage) of NPK, Moisturizer and pH value in soil as well as weather temperature and also displays the required level of NPK, Moisturizer and pH value for the efficient growth of the crop in particular age. The figure 3 (a) shows the crystal display used in the proposed device and the figure 3 (b) shows the complete experimental setup cum portable device.



(a)

(b)

Figure 3: (a) Typical crystal display (b) an experimental setup of soil analyzer

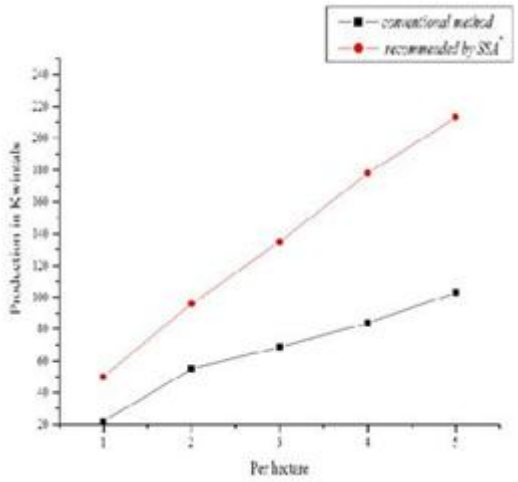


Figure 4(a): The plot of crop production by conventional method and by SSA for Paddy

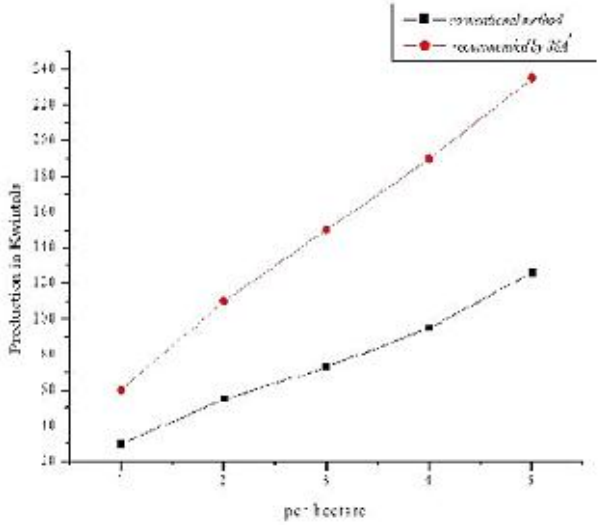


Figure 4(b): The plot of crop production by conventional method and by SSA for Maize.

From the two plots, the analysis can be made by taking figure 4(a) and 4(b) for two different (paddy and maize) crop

production data's, one is recommended by SSA and another from a traditional cultivation technique. This comparison notices there is an improvement in crop production by more than 40%. The overall analysis gives the evidence to state; there is an increase in the production rate by more than 40%.

7. ADVANTAGES

This system response time is less and it takes less time to get results (in terms of seconds). Single device is able to measure more than one parameter such as NPK values, pH values, Weather temperature and moisturizer. It gives accurate NPK and pH values. The developed device consumes Low power, handy in size and low cost. It is a portable and user friendly system. This can be used in Agriculture field, Nurseries and in Chemical industries.

8. CONCLUSION

The device is user friendly and very simple to operate. Farmer can have the device with low cost and analyse the soil at any time. Hence excess use of fertilizer is reduced; the method of testing is very simple which avoids the frequent visit to the soil testing centres whenever there is a need to test the soil. And the yield will be increased by more than 40% from the SSA recommendation that is more than the regular soil testers; also the time required to test the soil is very minimal.

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