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Design and Development of Smart Soil Analyser

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Abstract
This paper presents the design and development of microcontroller based compact soil analyser. Conventionally fertilizers are used to restock the soil by the farmers, depending on the soil restock level crops will require nutritive intensity. Conventionally soil test methods are time consuming and ineffective predicting the results which this makes it difficult to analyse during the lifetime of the single crop. To minimize the impediments and to increase the crop yield a smart device to test the soil components is being proposed. The objective of the proposed project goal is to develop a portable kit to test the soil for the contents such as of NPK (Nitrogen, Phosphorus, and Potassium), salt content, pH value, temperature and moisture are measured through sensors and electrodes. The captured values of the soil contents are then compared with the existing data set and the accurate findings are displayed which reveals the quantity of fertilizers required for that particular crop. This paper provides a quantitative analysis of the nature of soil for the proposed device and the conventional soil tester. The analysis provides an evidence to use the proposed device to improve the crop production by more than 40%.

Keywords: pH value, NPK, pH electrode, Embedded System, Smart Soil Analyzer

INTRODUCTION

In Indian economy largely depends on agriculture and will continue to for a longer period [11]. This Sustainable agriculture has been defined as; “an integrated system of plant and animal production practices having a site-specific application in same place”. The physical parameters of sustainability are partially known here.

The conventional method in agriculture leads to gradual decrease in fertility of the soil, also in turn the erosion of the surface layer and causes improper drainage in the irrigation system. Many practices have proven to have an effect on the soil properties in order to maintain the sustainability as per the known standard dataset. In general the nutrients in the soil tend to get eliminated during the crop harvesting carried out by the traditional farming method. The yield of a crop reduces gradually and subsides overtime, due to insufficient nutrients or regular replenishment. So the fertilizers are used to replenish and enrich the soil. Commonly, the crops require varied amount of nutrients depending on ingrained contents of the soil and also on the age of the crop [12, 13, 14].

Fertilizers are used to increase the productivity of the crop, which the farmers unscientifically misuse. The acceptable proportion of fertilizers provided at the right time to the right crop, will enhance the yield of the crop to the maximum level, if supervised through a meticulously conducted soil test [1, 14]. The plant growth is curtailed due to both excessive and inadequate addition of fertilizers to the soil, which greatly affects the productivity. The government has provided a facility to test any soil type, but the method involves a cumbersome process and takes considerable time to give the results which makes it formidable for the fertility of the soil to be maintained well at regular intervals during a certain crop lifecycle. In order to reduce the above mentioned problems and to achieve a quality crop yield, a device called “smart soil analyser” is been proposed. The proposed design provides a customized keypad to select the crop and its age. After which the micro controller processes the above specified parameters and then displays data such as the quantity of N P K and pH value of the sample soil and also the essential proportion of N P K for the efficient growth of the plant for that particular crop age. This would greatly aid the farmer to administer just the right amount of fertilizer, thereby reducing the wastage of fertilizer and also increases the crop production significantly.

Objectives

1. To able to suggest fertilizer recommendations for a given crop in the detected soil type.
2. To diagnose the soil fertility and plan a

suitable nutrient substitute.

3. The purpose of soil analysis is to assess accurately whether the nutrients present in the soil are excessive or deficient for crop growth and to monitor the change brought about by farming practices being followed.
4. To calculate the pH value of the soil.
5. The main objective [2] of the soil test is to provide the farmers with a low cost service to administer efficient use of fertilizers to carry out better soil management practices in order to increase the crop production.

METHODOLOGY

The proposed smart device is placed on an agriculture land where soil test to be conducted. A moisture and NPK level of the soil is analyzed by inserting respective electrodes into the soil and captured the data for further evaluation. The measured data is compared with the standard predefined data set, which consists of different crops and growth levels at different stages to analyze the soil insufficient nutrients. The comparison result will be displayed on the device monitor and recommends the necessary suggestions to a particular crop.

In pH analysis is carried out to measure acidity or alkaline nature of the soil. The measured data is compared with an available standard data set and recommends the necessary suggestions to a particular crop. Calibrate the weather temperature and display

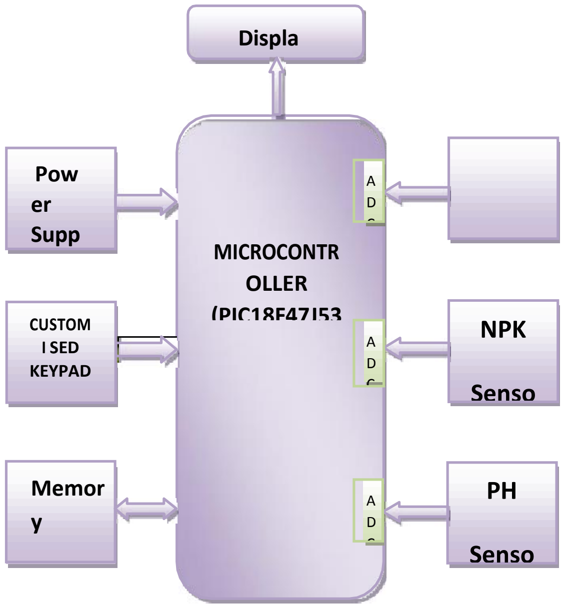

Figure 1: Block diagram of interfacing peripherals with microcontroller

HARDWARE MODULE

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.

Microcontroller

Microcontroller [6, 7] is the main integral part in this project, a 8 bit PIC microcontroller (PIC18F47J53) [8, 9] is used. It consists of processor, memory and I/O ports. It controls the overall activity of the system. Memory is divided into two parts: 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.

N-P-K and pH Electrodes

N-P-K stands Nitrogen-Phosphorus- Potassium, these soil essentials are measured using NPK sensor. An electrode is used to pass a current through a conductor to convert physical parameter into electrical signal. A current is passed between non-metallic and metallic part of the circuit in electrode. Here, conductors are mainly used to pass the current.

Acidity or alkalinity is measured through pH analysis. Low hydrogen ion concentration refers to liquid is alkaline and for high hydrogen ion (H^+) leads to become acidic. The possible pH value range [3] is varied from 0 to 14. 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 and the measured value is compared with standard database of soil parameters, accordingly suggestion is displayed.

Display

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

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.

Analog to Digital Converter (ADC)

A continuous signal is converted to discrete digital representation through a Analog to Digital Converter (ADC). Here the input current or voltage quantities are proportionally converted to digital number in typical ADC device. 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

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 is as shown in figure [2].

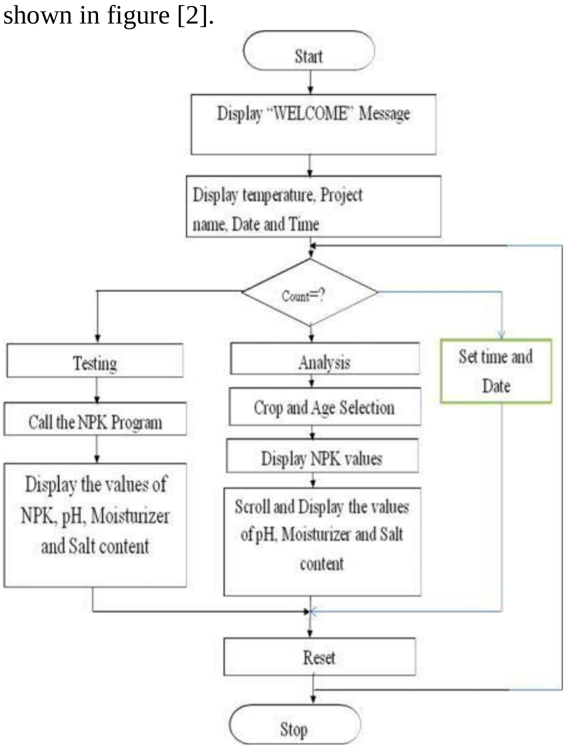

Figure 2: Flow chart of the developed device

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 (a) shows the crystal display used in the proposed device, and the figure (b) shows the complete experimental setup cum portable device.

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

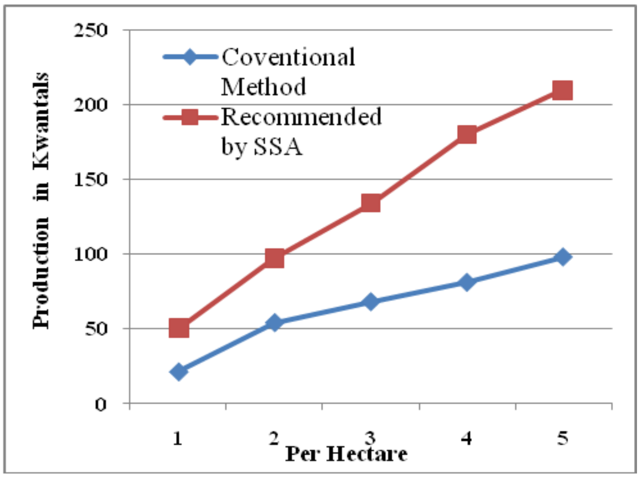

Figure 4(a): The plot of crop production by conventional method and by SSA for Paddy

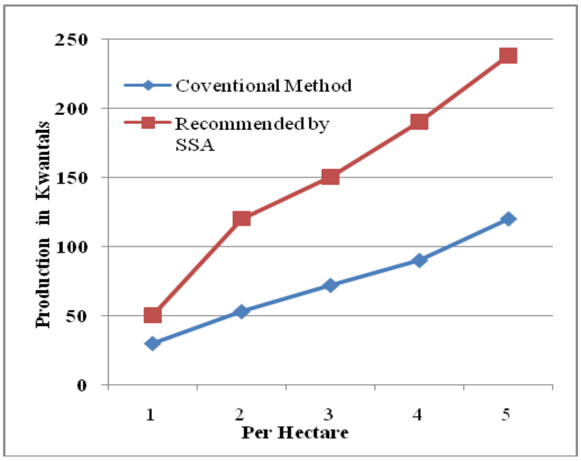

Figure 4(b): The plot of crop production by conventional method and by SSA for Maize

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. From the comparative study 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%.

CONCLUSION

The device is user friendly and very simple to operate. Farmer can have the device with low cost and analyse the soil condition at any time. Hence excess use of fertilizer is reduced. The proposed method is simple procedure and quick also reduces frequent visit to the soil test centers to test the soil fertility. The outcome product is an embedded design with a suitable microcontroller makes the device portable and user friendly for farmers to operate in fields. Analysis shows that, there is an increased yield about more than 40% for the crops Maize and Paddy with reference to Smart Soil Analyzer recommendations, which is much higher than the traditional soil testers.

CONFLICT OF INTEREST

I declare that author(s) have no conflict of interest with this manuscript.

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