Automated Soil Macro-Nutrient Analyzer using Embedded Systems

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***Abstract*— Nutrient is a substance which provides essential nourishment for the growth of plant. Nutrients are classified as Micronutrients & Macronutrients. Nutrients those are needed in small amount are known Micronutrient while those are needed in large amount for growth of plant is known as Macronutrients. NPK are Primary Macronutrients. In this Paper, Soil Macro-Nutrient analyzer is designed which measures amount of NPK available in soil sample using color sensor, also soil pH using pH Sensor. Microcontroller controls the operation and displays the contents. This method will reduce human efforts, time and reduces errors in measurement.**

Keywords—NPK, Soil pH, Color Sensor, pH Sensor

I. INTRODUCTION

Proper nutrition is essential for growth and production of plant. The use of Soil Nutrient and Soil pH analyzer can help to determine the status of nutrients available in plant to develop fertilizer recommendation and also to achieve an optimum production. The primary goal of Soil Macro-Nutrient Analyzer is to ensure efficient and effective management of fertilizers based on the available macronutrients present in soil sample. The presence of nutrients is determined by chemical processes and quantified using sensors. Plants extract nutrients that they need for their growth from the soil.

The measurement of substances those are present in soil like NPK is done by colorimetry. Colorimetry technique is commonly used to determine the concentration of colored compounds present in soil solution. To analyze soil Macronutrients NPK Color sensor is used to quantify the results. It detects the color and sends the value of the color detected to Microcontroller. Soil pH (Potential of Hydrogen) is an indicator of soil acidity & basicity. The scale of pH is from 0 to 14. pH of a particular soil reflects a certain chemical and mineralogical environment in the soil, and thus pH has a great importance for plant roots. To measure soil pH, pH sensor is designed. It has pH electrode followed with signal conditioning circuit is interfaced with microcontroller.

Automatic soil nutrient detection for analyzing nutrients (NPK) present in soil sample is discussed in [1] it consists of color sensor and Microcontroller Unit, there are 3 different color sensors are used for soil nutrient detection. Results in increase in cost of system also make it bulky. Whereas we have used only one color sensor for analyzing all 3 macronutrient which reduces cost of analyzer also makes it simple.

Color sensor TCS-3471 light-to-digital converter having color detection range of 1M, is used in [2]. The color sensor TAOS TCS3200 programmable color light-to-frequency converter having high resolution conversion of Light Intensity to Frequency is used in proposed system; it has nearly limitless range for Measurement of Color.

Analog pH meter is used in [3] which is designed for field testing and also increases cost of system. We have designed pH meter which can be suitable for pH testing of Water based solution of soil sample. It is user friendly and less expensive.

The overall study utilizes the AVR Microcontroller based Soil Macronutrient analyzer, It consists Color Sensor for Measurement of Soil Macronutrients (NPK), pH sensor for measurement of soil pH, Microcontroller to analyze and process the output.

This device is a big help in providing standard recommendations to farmers about availability of soil macronutrients NPK in soil sample. Also it lessens human errors and saving of time for soil testing by Traditional method.

II. SOIL NUTRIENTS AND SOIL PH

A. Soil Nutrients

The chemical elements which are essential for the growth of plant are soil nutrients. The three main macro-nutrients are Nitrogen, Phosphorous and Potassium (NPK).

a) Nitrogen: Nitrogen is a very important nutrient to ensure proper plant growth. Atmospheric nitrogen is a source of soil nitrogen. It is present in the soil as either nitrate ion (NO_3^-) or as Ammonium ion (NH_4^+).

b) Phosphorous: Phosphorous helps to transfer energy from sunlight to plant, stimulates early root and plant growth, and hastens maturity.. Present in the soil as Phosphate.

c) Potassium: Potassium is absorbed in large quantity by plants and is present as cat-ion K^+. Potassium increases strength and disease resistance of plants, helps form and move starches, sugars and oils in plants.

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B. Soil pH

pH (Potential of Hydrogen) is measure of acidity & alkalinity of a water based solution. pH is the negative algorithm of Hydrogen ion concentration:

$$pH = -\log_{10}[H^+] \quad (1)$$

A neutral solution has a pH of 7, while solutions with pH<7 are acidic and pH>7 are alkaline.

III. Proposed System

The Soil Macronutrient consists: Soil Sample, Color Sensor followed by Frequency Interface, pH Sensor Electrode followed by Signal Conditioning Circuit, Microcontroller and Output. Block Diagram of the same is shown below.

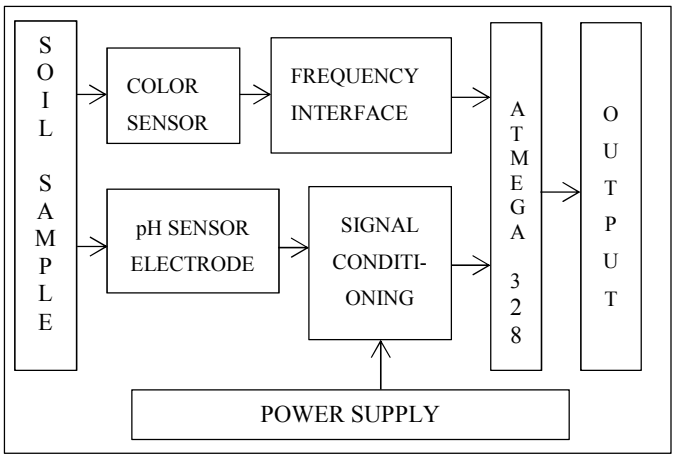

FIGURE I. Block Diagram

A. Soil Sample

Soil sample is a mixture of soil sample and distilled water to make it water based solution.

B. Color Sensor with Frequency Interface

It is a Programmable color light to frequency converter combines configurable silicon photodiodes and a current to frequency converter, Interfaced with Microcontroller AVR ATMEGA 328.

TAOS TCS3200 programmable color light-to-frequency converter is used.

C. pH Sensor Electrode with Signal Conditioning Circuit

pH sensor electrode is a combined electrode consists of glass and reference electrode in single entity. Therefore a separate electrode need not be used along with this electrode. pH signal conditioning circuit is needed to interface pH sensor electrode with Microcontroller. Output voltage obtained at signal conditioning is given to Analog to Digital Converter of Microcontroller.

We have designed pH Sensor which includes pH electrode and Signal conditioning circuit.

D. Microcontroller

The Atmel AT mega is a powerful microcontroller that provides a highly flexible and cost effective solution to many embedded control applications. AT mega 328 is used to take inputs from sensors, process and control the same and produces desired output.

E. Output

LCD can be used as an output. It will show respective values of Soil Macro – Nutrients.

F. Power Supply

It is a DC power supply to fulfill requirements of system.

IV. Analyzing Process

A. Soil Sample Preparation

Soil sample obtained from Agricultural land, Preparation of soil sample extract solution is done by mixing soil with distilled water to obtain 1:2 soils to water ratio in volume and mixing it thoroughly.

B. Soil Macro – Nutrients

Analyzing of Soil Macro- Nutrients NPK is based on Qualitative method of Soil Analysis. Reagents are added into 4ml of prepared soil sample for respective nutrient. Mixing it gently until the chemical is dissolved, waiting for color to develop. Change in color is detected by color sensor and result is analyzed by microcontroller, observed on Display.

C. Soil pH

Calibration of pH meter is done by using pH buffer solutions of pH 6, pH meter is dipped into 4ml of water based solution of soil sample, result observed on Display.

V. Results

There are three soil samples obtained from agricultural land, soil testing is done in laboratories of University. Same soil samples are analyzed by proposed system and values are compared as shown in table 1. All values are in kg/hectare.

TABLE I. Results of NPK Analysis

Soil Sample / Macro Nutrients		1	2	3
Nitrogen	Actual Value	279	166	198
	Observed Value	>16	>16	>16
Phosphorous	Actual Value	21	6	14
	Observed Value	>16	<12	12-16
Potassium	Actual Value	683	670	56
	Observed Value	>36-49	>36-49	>36-49

VI. Conclusion

In this paper we have discussed the "Automated Soil Macro- Nutrients Analyzer Using Embedded Systems", which will indicate the value of available Macro-Nutrient (NPK) present in respective soil sample. This system indicates NPK value in lesser amount of time compared to soil testing by traditional methods done in laboratories. It reduces the human efforts and errors occur while measuring as well as user friendly & Time saver.

Analysis of Soil Macro-Nutrients is done by using proposed system; Values are observed and compared with soil testing done in MPKV laboratories by using traditional methods. Those are nearly matches as shown in Table 1. It is qualitative 3 tier method of analyzing soil Macro-Nutrients.

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