International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 07, July-2018

A Quantitative Analysis of an Advance Smart Soil Analyser with a Soil Tester: A Comprehensive Survey

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***Abstract*-- Agriculture is the main cause for the food supply of all countries in the world. It is important for the economic growth of the country. Agriculture is the art or science involved in production of crop and livestock on the farm. Fertilizers are used by farmers for restoring the soil contents. But all crops do not require same or equal nutritive. Nutritive requirement depends on the crop and its age. It is important to test the properties of the soil and to provide information about the nutrients required for the agriculture.**

The main aim of this paper is to review different methods of detection soil contents such as NPK (Nitrogen, Phosphorus, and Potassium), pH value, salt content, temperature and moisture in the Agricultural field. In "Smart Soil Analyser" (SSA), we can measure these soil contents using respective electrodes and sensors. Then the measured values are compared with the predefined values in the database and finally display the required amount of fertilizer to be supplied to the agricultural field. The conventional soil test centers are not more effective because they take more time to get results and difficult to take regular tests during single crop lifetime. The Smart Soil Analyser provides a solution to these problems.

Keywords— pH value, NPK, pH electrode.

I. INTRODUCTION

India is agriculture back boned country. Agriculture plays an important role in the economic growth of country. The Agricultural land is damaged due to de- nitrification, erosion, and irrigation without proper drainage. On harvesting the crops, some of these nutrients get removed from the agricultural soil. This leads to nutrient depletion, without restoring the land becomes either unusable from reduced yields. So farmers are restoring the soil contents by using fertilizer. But all crops do not require same or equal nutritive. Nutritive requirement depends on the crop and its age.

The NPK elements play an important role in plant growth in three different ways. Nitrogen (N) helps for the vegetation and growth of leaves. Phosphorus (P) stimulates the growth of shoot and root. The Potassium (K) helps for the fruiting, general hardiness, and flowering. The pH is useful in the measurement of soil the acidity. Low productivity is caused due to water mismanagement, growing crops without proper knowledge, and heavy use of fertilizers. Now we have to follow knowledge-based agricultural technology instead of resource-based agricultural technology.

Fertilizers are used to increase the soil fertility and yields. By applying aright proportion of required fertilizers at the right time will increase the yield maximum. Farmers may be applying excess or insufficient fertilizer without a fertilizer recommendation based upon a soil test, which is actually the prime factor in limiting the plant growth. The government opens soil testing centers to stop unnecessary use of fertilizers. Soil testing centers are not more effective because they take long (more) time to get results and is difficult to take regular tests during single crop lifetime. To reduce these problems and to get good crop yield proposed a device called "Smart Soil Analyser".

II. LITERATURE SURVEY

Smartphone Irrigation Sensor [1] uses a Smartphone to capture images of the soil. The Wi-Fi network and Camera operations are controlled by an Android App. The use of the Android App is that it wakes up the smart phone and activates the device with the help of user-defined parameters. RGB to gray transformation is performed on the image captured by the camera. This is required to determine the dry to wet ratio of the capture image.

The ratio between the dry and wet area of the image is transmitted to a gateway once the Wi-Fi connection is enabled which needed to handle the irrigation pump. Finally, the smart phone is put into the sleep mode by an Android App to save its energy. Photovoltaic panel is used to charge the irrigation sensor which has rechargeable batteries. Thus Smartphone irrigation sensor can be used as a practical tool only for irrigation.

The irrigation sensor used in Smartphone Irrigation Sensor [1] has many advantages over other soil moisture sensor. The results of the other sensors depend on the soil properties such as compaction, density, and mixture of their components among others. The irrigation sensor is a low power consumption device, functioned using water saturated and dry soil image.

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Detection of N, P, K using Fiber Optic Sensor and PIC Controller [2] investigates the soil nutrients such as Nitrogen (N), Phosphorous (P) and Potassium (K) contents temperature, and humidity in the soil. It is an essential factor to decide the proper percentage of nutrients required for the soil to maximize the crop quality. Here NPK contents present in the soil are decided using fiber optic based color senor. Absorption of color by the solution is the working principle of color sensor.

For the test, the soil is mixed with the distilled water which illuminates different colors of light. Optic fiber collects the light reflected from the aqueous solution of soil. The reflection of light is mainly based on the absorbent coefficient of soil. Then which further converted into electrical signal. The NPK levels are determined by using threshold values stored in the database of the microcontroller. This is useful in identifying the deficient component of the soil. Thus the deterioration of soil can be reduced by preventing the undesired dispensing of the fertilizers. It helps for measurement of Agricultural Parameters using sensor. Thus helps to increase the productivity of crops and the quality of the product is also improved through the efficient use of fertilizer.

NPK Measurement in Soil and Automatic Soil Fertilizer Dispensing Robot [3] used to measure and provide the nutritive contents which are necessary for the soil based on the test result. This helps to determine the macronutrients which are the nutrients required for a large amount and micronutrients these are the nutrients required in smaller quantities. This root is helpful to estimate the NPK nutrients required in the soil. This also distributes the needed deficient nutrient.

The Nitrogen, Phosphorous and Nitrogen contents in the fertilizers are measured by using NPK measurement kit. The color of the solution changes which mainly depends on the amount of component present in fertilizer. This change in the color is send to microcontroller by color sensor. Microcontroller compares this signal with the stored reference. Then it passes the command to actuator drive which instructs the solenoid valves to release the specified amount of fertilizer required for the agricultural field. The solenoid valve converts the electrical signal from actuator drive into mechanical energy and helps to distribute the fertilizer. NPK Dispensing Robot saves labor time because there is no need of dispenses of fertilizer annually. We can also get better results with the minimum amount of fertilizers.

Review on sensing the fertility characteristics of agriculture soil [4] provides correct information about the nutrients required in the soil to get optimized production. The nutrients application rates mainly depends on the requirement. Soil fertility defined as the ability of the soil to give required water and nutrients in proper amounts for the plant growth. Soil fertility can be determined by measuring soil components like percentage of Potassium, Nitrogen, Phosphorus, moisture, PH level, oxygen, and temperature.

The electrochemical sensor is useful in the measurement of temperature, NPK, and pH values of the soil. Thus the device is made with combination all the electrochemical sensors to determine the soil components essential for the growth of the plant. Here the soil sample is tested and observed by using sensors array. The nutrients present in the sample soils are sensed with the aid of electrochemical sensor. This senses the outputs in terms of mV. These signals are further processed by using Analog to Digital converter. The main controller will compare or match the output mV values with the look-up table values. The lookup has percentage (%) values. The matched are used to determine the fertility of the soil. Finally, the output is displayed on the LCD display. Thus, this method is useful in the determination of soil nutrients.

NPK nutrients detection with the help of Fiber Optic Sensor [5] provides accurate information about the extra nutrient contents needed for the soil to get optimized crop quality and fertility. The NPK contents in the soil are estimated by using fiber optic based color sensor which absorbs colors of light present in the solution. In this experiment, colorimetric measurement of an aqueous solution of soil has been performed.

After studying this [5] we can conclude that fiber optic sensor is designed to measure the amount of Nitrogen, Phosphorus and Potassium contents in the agricultural soil. The interaction between light incident on the aqueous solution of soil and the soil surface properties helps the NPK sensor to measure the soil contents. This Optic Sensor method is reliable. This system also has demerits such as complex, time-consuming, and high cost.

Green Growth Management by Using Arm Controller [6] used to find the soil content such as humidity, phosphorus, and moisture with the help of different sensors. This system also monitors the sunlight and temperature in the field. This system is used to provide required phosphorus for the plant by collecting sensor's information and through drip irrigation efficient amount is given to the plant. The primary aim of this system is to improve the productivity of the plant by providing proper amount of fertilizers and water. This system is useful for the proper management of plant's growth. Here contents of each plant are mentioned in a database. It includes information about the number of stages of each plant's cycle and requirements of that plant during each stage. Then Moisture, Temperature, Light intensity, Humidity, and Phosphorous are sensed using respective sensors. After this necessary contents are supplied to maintain the requirements of plants up to mark for efficient growth.

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The drip irrigation system is used for supplying the essential contents to the soil. The solenoid valves are used to connect the drip irrigation system.

After studying [6] we found that this system uses sensors for moisture, light intensity, temperature level detection, phosphate, and humidity of agricultural soil. This system includes real-time valve controlling and pump operation. The soil contents are measured by using different sensors. This device helps to increase the plant fertility and efficient use of water in the agricultural field.

Acquisition of Soil pH Parameter and Data Logging using PIC Microcontroller [7] describes the importance of soil pH in the growth of the plant. The analysis of pH gradient and soil quality helps to decide the management strategies required for the development root. The accurate analysis and measurements of pH data are very important for various applications ranging from agriculture sector to the clinical laboratories. Thus generally an inexpensive hand held unit is required for these applications. The pH sensor gives the negative output voltage for pH below 7 and positive voltage value for above 7. The positive and negative voltage values are handled by using signal conditioning circuit. The ADC of the PIC controller converts the amplified pH value to the digital value. Further, the digital value is display on the LCD for the user and also logged into the micro SD cards. Finally, the pH value is sent the former via message (SMS) using GSM module.

In this work [7], we can test the pH value of a different sample of the soil. A pH test is used to measure the acidity of the soil. The soil is considered as neutral if the pH is 7. For an acid soil pH value should be below 7.0 and for alkaline soil, the pH should be above 7.0. The limitation of this system is that temperature causes errors in the pH measurements. So to get the correct soil pH value, the temperature sensor can be incorporated in the system.

Design & Implementation of Soil Analyzer by means of the Internet of Things [8] describes that soil testing is an important tool for a farmer to determine the inputs required for efficient as well as economic production. It is important to measure the nutrients available in the agricultural field. For that in this project, a test bench is used to decide soil type and the amount of nutrients required for the production of good quality of the crop. A device is designed to take the proper reading of the micronutrient present in the soil. This system measures the nutrients of topsoil. The feasible labs normally perform the top soil demanding that has a test, natural resources, and cluster of the compound.

After studying the Design & Implementation of Soil Analyzer by means of the Internet of Things, we found that with help of this system farmers can directly send the farm figures to the attendant and get an instruction for effective fertilization. This will lead to a vast number of facts compilations. The rural people can get the superior plans for the agriculture.

Real Time Embedded Based Soil Analyzer [9] explains today's technology towards agricultural fields. The Real-Time Embedded Based Soil Analyzer can be developed with the reliable automated system. Based on pH value this analyzes different soil nutrients. Real-time embedded based soil analyzer (RTEBSA) measures the electrical conductivity (EC) and pH value of soil sample. The pH sensor calculates the pH of the aqueous solution of the soil. The most common pH value range of soil is 4 to 10. This system also measures the electric conductivity (EC) of the soil water with the help of EC sensor. EC represents the current carrying ability of the soil water. The electric conductivity is a good identification of quantity of nutrients present in the soil for the crops to absorb. Thus a cost-effective Real-Time Embedded Based Soil Analyzer can be used to analyze the various nutrients parameter with help of pH value and the electric conductivity. Based on the availability of the nutrients in the soil, recommendation of the particular crop will be given.

Design and development of soil moisture sensor and response monitoring system [10] regulates the moisture present in the soil. The soil moisture sensor is helpful in the determination of the quantity of water needed in the agricultural field. Nickel is the main component of sensor probe which is an anti- corrosive in nature. The response monitoring system is an efficient system which measures the moisture content in the soil and compares it with the user specified values. If the moisture content is less than the needed value, it generates an alert. This system helps to overcome the problems related to growing and harvesting the crops at an irregular interval. In golf fields water content in the agricultural field is balance using this system.

After studying this paper [10] we can conclude that the soil moisture response monitoring system designed is very simple to handle and understand. The main advantage is that it can be operated by farmers of all age groups. It can be reprogrammable hence we can get many features. We can determine the moisture content at the deeper level and it can b e used for any crops. The depth of Irrigated water can be checked by placing the soil moisture sensor vertically. It is a user-friendly system and uneducated farmers can also use this system.

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Error Analysis in Soil Urea Prediction Based on RF Spectroscopy [11] is a soil-sensing which helps to judge the various soil properties thus enabling the farmer to adjust the inputs accordingly. The purpose of this paper is to construct a soil sensor and analyze the errors in the prediction of a soil nutrient. This is a new method for soil nutrient sensing using RF spectroscopy. Here Partial Least Square Regression mathematical tool is used to calculate the urea content in the agricultural soil based on multivariate analysis. This consists of eight different combinations soil nutrients such as Urea, Lime, Salt, and Phosphate at varying concentration. The other soil nutrients present in the sample are determined with the help of Urea prediction algorithm.

The Error Analysis in Soil Urea Prediction Based on RF Spectroscopy method can be extended for sensing multiple nutrient simultaneously by alternating the algorithm. The study was done to find out the errors in prediction of urea when the concentration of phosphate in the soil was varied from below normal to above normal. The prediction accuracy is within 1 percent when phosphate concentration is within the range of 0.5 to 1.5(i.e. 1.89 gm/15ml to 5.67gm/15ml). When the phosphate concentration doubles reach 1.26 percent in the samples error. It is also possible to use similar analysis for other components used in the study. Thus, a practical system can be developed for urea prediction using FPGA. The PLSR algorithm can be embedded into the FPGA and other features that make the system user-friendly can also be added, such as providing information about the required fertilizer.

Nutrients Detection using UV Spectroscopy [12] explains the different technologies of sensor for determination of important nutrients required in the agricultural soil. Here the outcome of UV spectroscopy for the basic nutrients determined. Here, soil properties are analyzed for the accurate mapping of various primary nutrients. The nutrients needed for the soil are measured using a multi-parametric analytical system by using UV Spectroscopy. After studying this paper [12] we found that the process is performed with the help of chemical methods.

III. CONCLUSION

The various types of soil testing methods have been reviewed and it has been found that overall these techniques have very similar to the processes. All the processes are performed in the chemical laboratory to find the nutrients contents in the soil. But they take more time to get results and difficult to take regular tests during single crop life time. To overcome these problems and to get good production “smart soil analyzer” (SSA) is designed. This method of testing is very simple and avoids the visit to the soil testing centers frequently whenever there is a requirement to test the soil. The yield is increased by more than 40% from the SSA recommendation which is more than the traditional soil testers, and also the time taken to test the soil is minimal.

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