Real Time Nitrogen, Phosphorus, Potassium (NPK) Detection in Soil using IoT

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Abstract. The Soil testing centers basically check only for primary nutrient values of the soil like Nitrogen, for growth of leaves, Phosphorous for root growth and Potassium for overall functions of plant which takes lot of time for reaching results to the Farmer. But in this system NPK values along with Temperature, Pressure and Humidity are also sensed for making the process efficient and make farmer to access the results along with suggestions in no time using their personal digital devices. The type of the soil solely depends upon primary conditions of the soil like temperature, moisture and humidity. Ideal soil temperature and realistic soil temperature are the two parameters for plant growth. Usually the temperature lies somewhere between ideal and realistic temperature. Soil temperature is the ratio of heat in the soil and the heat between atmosphere and soil. For organic forming the temperature is the key parameter for plant growth. The heat coming from the sun is absorbed by the soil, resulting temperature of the soil. The solar radiation is directly proportional to the heat reaching the soil. Humidity is the amount of moisture that is presented in the soil. The DHT11 sensor is used to measure temperature. Soil moisture is the prime factor for farm productivity. The moisture content depends on the number of water molecules attracted by the soil particles. Atmospheric humidity is expressed as a percentage of moisture in the air. The humidity around plants can be increased using gravel trays with water poured in it. Excess water cannot get enough oxygen from soil and lack of water obstructs plant growth. Hence level of moisture is significant for planting. The level of moisture is detected using moisture sensor. Each nutrient is added with reagent to form color. The darker color indicates increased concentration of the nutrient that is present in the soil. The color detection using Color sensor enhances accuracy parameters. In this process both manual and automated processes are included.

Keywords: NPK; Color sensor; Temperature sensor; Humidity sensor; IoT

1 Introduction

The extraction of nutrient values evolves the process of testing the condition of the soil. The soil analysis helps in analyzing the condition as well as predicting the type of crops that suits the soil condition. In due course, if the process is delayed, the soil parameters may vary. Real time detection of NPK values assists in obtaining the accurate values. In this paper, IoT based device is used to NPK values using color sensor. As primary conditions are also important in analyzing the condition of the soil, temperature and humidity values are also detected using DHT11 sensor. Using sensors the quality of soil is determined repeatedly and the NPK values will be captured. This reduces the time in taking soil samples to test centers and sending results back after analyzing.

2 Literature Survey

Soil analysis and Crop analysis plays significant role in cultivation. In general the detection of Nitrogen, Phosphorous and Potassium can be calculated by adding calcium sulfate and Mehlich. The color can be traced using filtration process and color comparator boxes. One of methods used for NPK analysis is Nitrogen Kjeldahl. Total Kjeldahl nitrogen (TKN) is the sum of organic nitrogen, ammonia (NH3), and ammonium (NH4+). To calculate Total Nitrogen (TN), the concentrations of nitrate-N and nitrite-N are determined and added to the total Kjeldahl nitrogen. Today, total Kjeldahl nitrogen is a required parameter for regulatory reporting at many treatment plants. The NPK analysis is done using Colorimeter which is used for environmental and biological applications. The plant growth characteristics were analyzed using NPK analysis. NPK analysis and decease detection in plants is done using IoT and the results were made it available. The analysis part is done using statistical analysis[1]. Fertilization plays important role in cultivation. It improves productivity in plants[2]. The effect caused due to loss of N, P or K leads to leaching, wet and dry conditions. Volatile ammonia lands are to be focused in rice lands[3]. NPK detection is pretty much used in crop analysis. NPK values and moisture are detected using corresponding sensors and ThingSpeak cloud is used for cloud to store data sensed by sensors[4]. Electro chemical, radio and optical sensors are used in analyzing soil conditions. Image processing and Neural network approach are very much accurate when detecting NPK values[5]. Soil fertility is evaluated using prediction and classification. Neural network provides better prediction results in classification [6,13,14]. The investigation of physiochemical properties of tobacco plants and the uptake of NPK were done using pot experiments[7]. Environmental risks and economic loss of sugarcane crop can be increased with N detection[8,11,15]. This paper suggests NPK analysis using IoT and made it available through mobile. The detection of NPK analysis is performed prior and are analyzed as low/medium/high are done based on threshold values set by Agro forums.

3 Real Time analysis of NPK using Sensors

The mechanism exhibited and various steps carried out are illustrated in Fig.1.

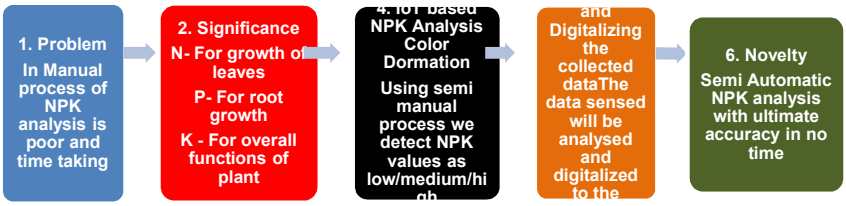


Fig.1. Outline of NPK Analysis

In the conventional process the soil is collected using V method and the soil is sieved. The sieved soil is then tested for NPK values by adding reagents. Later the change in color is compared the NICE color charts. As the color of soil is changed during the entire process leads to erroneous results. The presence of NPK values will be estimated based on the color of the liquid formed with the naked eye detection using the color chart shown above. If the process is delayed, the colors formed will be changed and will not give exact analysis. The time consumed for transferring the soil to research centers takes some amount of time and by the time the process starts, the conditions of the soil may change due to environment effect. Fig.2 shows the preparation soil in detecting color for NPK detection manually.

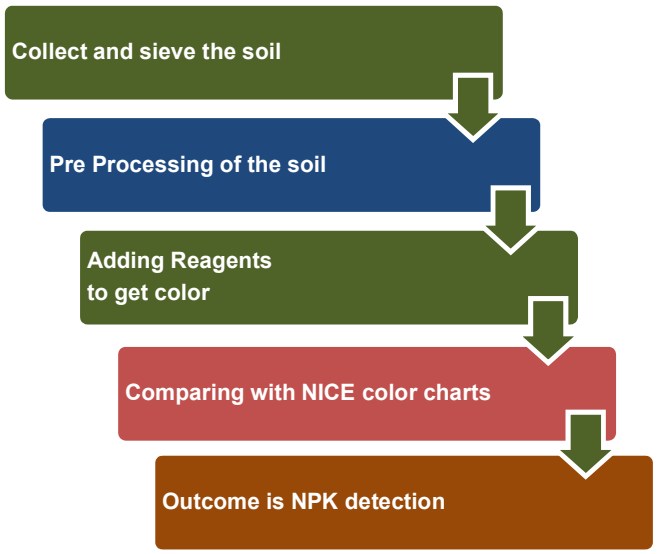


Fig.2. Manual process of Soil testing.

In real time IoT based analysis is done. The color detection is done using Color sensor and the data is uploaded in cloud for real time analysis and is then compared with the color charts for NPK detection. This is interpreted in Fig.3. As the process is carried out in real time using sensors, exact detection will be traced. The sensed values will be sent to cloud and then used for NPK detection. The process is carried out in 4 stages. 1. Preprocessing of the soil, 2. Adding reagents to estimate NPK values, 3. Detecting color using color sensor and 4. Estimation of NPK level in the soil

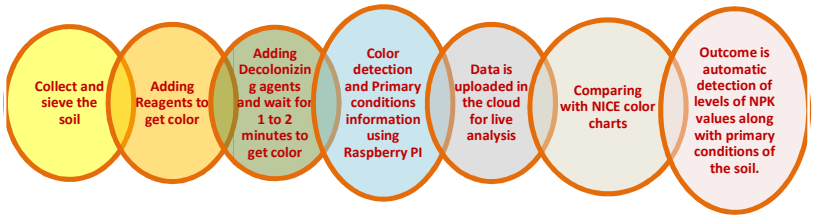


Fig.3. NPK analysis in Real time using IoT.

3.1. Preprocessing of the soil

The soil must be collected from one acre of land from four different corners and from the middle. We should choose the area in such a way that it must be exposed to sun and no pesticides must be applied on it from past 6 months' time duration. The soil is to be collected in V model. V model is a model in which the soil can be digged in v model using aagar (instrument to dig the soil). We must take soil from 15 cm down to the surface of soil. The soil may be in rock form or in any other form. The soil must be collected from the 15 cm down to the surface of soil. The soil sample collection area must be exposed to sunlight and no shade must be on that particular region.

The soil taken from 5 places are combined and undergone into *sieving* method. Sieving is a method in which the rock particles in the soil will be powdered. Now the powdered soil undergoes into sieving in which the rock particles and fine soil are separated. We should ensure that the soil is finely powdered. Take 500 grams of soil for testing. The Finely powdered soil can undergo into several chemical reactions to estimate values of Nitrogen, Phosphorous and Potassium that are present in the soil.

3.2. Adding reagents to estimate NPK values

i. Adding reagents to estimate Nitrogen

Take 5cc of soil and 25 ml of nitrogen reagent 1 into the soil and shake for 5-10 minutes. Then add a pinch of decolonizing agent into the soil and mix well. Filter the solution using funnel and filter paper. Next add 2 drops of nitrogen reagent 2 and mix

well. Wait for 1-2 minutes for color forming.The liquid formed in this process is separated from the soil and is used to detect color.

ii. Adding reagents to estimate Phosphorous

Take 5cc of soil and 25 ml of phosphorous reagent 1 into the soil and mix well for 15 minutes. Add a pinch of decolonizing agent and mix well. Filter the solution using funnel and filter paper. Add 2 ml of phosphorous reagent 2 and mix well. Wait for 1-2 minutes for color forming. The liquid formed in this process is separated from the soil and is used to detect color.

iii. Adding reagents to estimate Potassium

Take 5cc of soil and add 25 ml of potassium reagent 1 into the soil and mix well for 10-15 minutes. Add a pinch of decolonizing agent and again mix well. Filter the solution using funnel and filter paper. Add 1ml of potassium reagent 2 into clear solution and mix it well. Wait for 1-2 minutes for color forming. The liquid formed in this process is separated from the soil and is used to detect color.

3.3. Color detection using Color sensor

Hereinafter, the process is automated using IoT technology using Raspberry Pi and the color detection is done using Color sensor(TCS 3200). The values detected will be sent over the cloud and can be deployed in any web server or mobile based application. This accurate analysis of prediction is achieved as it can be carried out at field itself.

3.4. Estimation of NPK level in the soil

As per the recommendations of Nice Chemicals Private Ltd.(NICE), an ISO certified company, the range of levels of NPK deficiencies are estimated based on the color formed, is mentioned in the below diagram. The diagrams are taken from the Soil Testing Kit, Hand book prepared by NICE. Color Sensor (TCS 3200) sensor detects color formed from the liquid which is formed after adding reagents. Moisture sensor is used to detect moisture. Raspberry PI 3 is used for microcontroller. Temperature and Humidity sensor DHT11 is used to detect primary conditions of the soil. The color detected by the sensor is compared with the diagram and then the estimated values are deduced. The color values obtained from the Color sensor is compared with colors listed in the chart. Based on that, NPK estimation values will be given (Fig.4.for Nitrogen color chart, Fig.5. Phosphorus color chart, Fig.6.Potassium color chart, Fig.7. Temperature and Humidity and Fig.8 Moisture.

4 Results

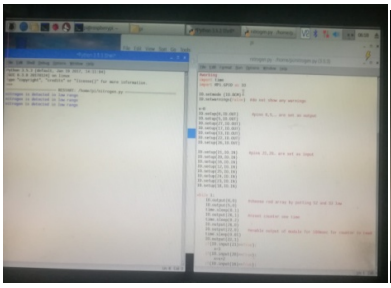


Fig. 4. Nitrogen detection

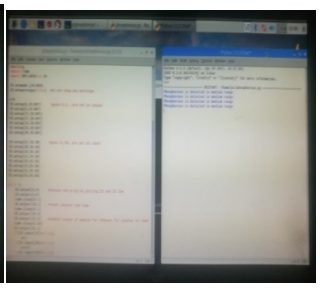


Fig.5. Phosphorous detection

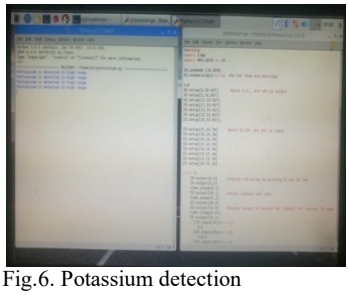


Fig.6. Potassium detection

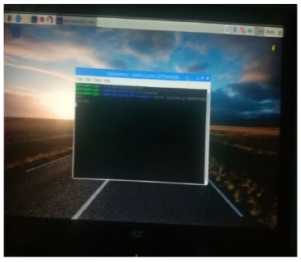


Fig.7. Temperature and humidity detection

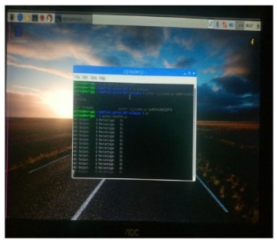
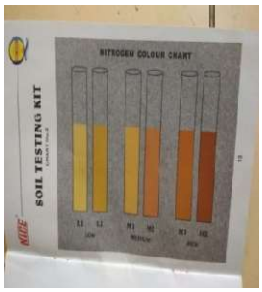
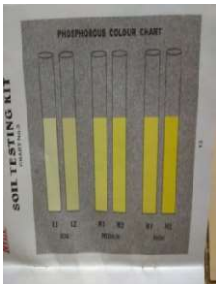
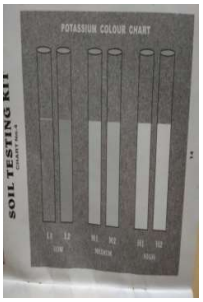


Fig.8. Moisture detection

NPK accurate values will be retrieved as the detection of color is through sensor. The surface is analyzed on the fly, hence there will be no change in color of the soil. If we input preprocessed soil, NPK analysis is done efficiently. The process is semi automatic. Farmers are able to know the condition of the soil in time through online. The color charts from NICE are used to compare color as in Fig.9.







a). Nitrogen Color chart. b). Phosphorus color chart c). Potassium color chart.

Fig.9 Color charts taken from NICE

NPK detection using Python are summarized as below:

RGB Analysis
enter red value145
enter green value79
enter blue value29
nitrogen_high
phosphorous_low
potassium_low
>>>

The manual process is digitized using IoT and the results are also tested through program by comparing RGB values instead of naked eye. Hence, it gives accurate results. The tracing of primary nutrients such as Nitrogen, Phosphorous and Potassium that are present in the soil are done using Color sensor. In this ecosystem, the NPK analysis along with primary conditions of the soil is analyzed to provide base information for cropping. Also, by comparing soil color with the color charts, the level of NPK will be detected using this IOT based ecosystem. The heart of the invention is the information is made available over the Internet for further use. The data from ThingSpeak cloud is retrieved from web server to provide user required information. This reduces testing time and improves accuracy measures. As the color component is compared through online, this system provides accurate results, when compared with the manual process. The process can operate continuously for 1 or 2 hours for analysis. During the process, some of the values may be changed. The process works efficiently with 90% accuracy based on observations made.

Conclusion

Digitalizing the results make Farmer or owner of land benefited in taking exact measures to soil on time. NPK accurate values will be retrieved as the detection of color is through sensor. The process is semi automatic, as reagents are added manually. Farmers are able to know the condition of the soil in time through online. The tracing of primary nutrients such as Nitrogen, Phosphorous and Potassium that are present in the soil are done using Color sensor. Color sensor is used to detect the color of the soil. Temperature and Humidity sensor is used to test the primary conditions of the soil. In this ecosystem, the NPK analysis along with primary conditions of the soil is analyzed to provide base information for cropping. The detected values are sent to web server. This is the real time application and is made available on the Internet. For developing organic foods and agriculture reforms, it gives information which type of the crop fits for the tested soil.

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