International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-3, January 2020

Prediction of Nutrients (N, P, K) in soil using Color Sensor (TCS3200)

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Abstract : The major aim of this research is to use color sensor for the detection of NPK,Nitrogen (N), Phosphorus (P) and Potassium (K) level in soil. A color sensor is used to measure and to detect the presence of NPK content of soil. The color sensor's photodiode is designed to decide the amount of additional contents of these nutrients that has to be added into the soil to increase soil richness and fertility. "Smart Soil Quality Predictor" is going to check the presence and the amount of three main nutrients which are nitrogen, phosphorus and potassium in the soil and manage the deficiency of particular nutrition by comparing standard absorption wavelength to observed one. The color sensor is implemented as a nutrition detection sensor which consists of four LEDs as light source and a photodiode as a light detector. The light from LEDs falls on soil and reflected back after absorption. The TCS3200 color sensor is associated with eight * eight arrays of photodiodes with four completely different filters. By suitably selecting the photodiode filter's readings, able to find the intensity of the various colours. The nutrient absorbs the light from LED and the photodiode convert the remaining light that is reflected by reflector (sample) to current. The color sensor has a current-to-frequency converter that converts the photodiode's readings and results into square waveform with a frequency that is directly proportional to the light intensity of the chosen color. This frequency is then, read by the NodeMCU. Finally, using NodeMCU microcontroller, the output from the color sensor is converted to digital readable form. The existing system has NPK kit which utilizes liquid soil sample, but in this research detection is done on solid soil sample which is more feasible. This will act as a proposed solution to next generation cropping system which will be more economically viable with respect to crop production.

Keywords : Color Sensor, NPK soil, LED, photodiode, NodeMCU.

I. INTRODUCTION

In today's era technology incorporates a huge and efficient impact on society. Technology is bringing major changes within the living of humans. It has its application in various fields like banking, communication, business, health care. Technology conjointly has its valuable impact within the field of agriculture. Day by day ease in farming and crop production is improving, but one aspect which can't be compromise is that of soil quality and nutrition deficiency in it [1].

Revised Manuscript Received on January 30, 2020.
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For the growth of good crop, one of the most important factors is to avail rich quality of soil. The rich and sufficient amount of fertilizers should be added to the soil to maintain the quality of crop along with the concern of sustainable development [1]. The quality of the soil is measured with respect to three main nutrients, i.e., Nitrogen, Potassium and phosphorus [2]. Nitrogen is present in the form of ammonium (NH^{4+}) and and nitrate ($NO3^{-}$). Metallic elements potassium present in its ionic kind i.e. K+. The orthophosphates, H2PO4- and HPO42- are macro compound of phosphorus that is needed for plants growth.

Nitrogen- It is useful and responsible for increasing yield, quality and vegetative growth.

Phosphorus- Alike human beings, plants also contain DNA and RNA in which the major component is phosphorus. It also acts as a critical aspect of root development, crop maturity and seed production.

Potassium- it's liable for the living of over eighty enzymes everywhere the plant part that is responsible for the plant's ability to survive in extreme cold and hot areas and conjointly to survive in varied climatic disasters like drought and floods [3, 4].

These nutrients are very important. Therefore, to measure the presence and amount of content in the soil this research has done. Earlier many researchers have done the work but they all make use of various module [3-6] but here we can check the quality of soil by using a single sensor device that is known as TCS3200. The color sensor which is getting manufactured nowadays uses IR filters for accurate and real-time color measurement. It can be built an automated system which helps in completion of nutrition check in less time. Moreover, human intervention is not needed. This soil predictor is cost-effective, can be possess by individual and easy to use.

The nutrition detection method is based on the principle of absorption and reflection [6, 7]. The soil sample is brightened up by a light source, light energy gets absorbed by the nutrients, then reflected light rays are absorbed by arrays of the photodiode and converted into a current which possesses the ability of semiconductor [6]. The distinction between the particular wavelength of color and therefore the quantity of light rays absorbed by the sample provides the result. Microcontroller NodeMCU acts as the heart of a system and displays the reading onto the screen.

II. CONSTRUCTION

A. COLOR SENSOR

Based on its construction and working methodology, a color sensor is divided into three main categories.

1. Light to photo-current conversion.
2. Light to analog voltage converter.
3. Light to digital conversion.

Here, we are using light to digital conversion color sensor. The photodiode inside the sensor converts light energy into current then that is converted into a digital display with the help of current to a frequency converter.

B. PHOTODIODE

The main part of the module is the **TCS3200 chip,** which consists of an 8 x 8 array of photodiodes. The photodiode absorbs the reflected light from soil sample and then converts it into current. Each photodiode has either a red, green, or blue filter, or no filter. To eliminate location bias among the colors, the filters are evenly distributed throughout the sensor [9].

TCS3200 chip consists of various color filters-

- 16 photodiodes with a red filter – sensitive to red wavelength
- 16 photodiodes with a green filter – sensitive to green wavelength
- 16 photodiodes with a blue filter – sensitive to blue wavelength
- 16 photodiodes without filter.

C. LED

The LED acts as a light source in the system. The four LEDs attached to the color sensor emits the light which is absorbed by the soil sample and the rest of the light is reflected back to the sensor that is detected by a photodiode and converted into current. These four LEDs are illuminated white light and can generate red, blue and green [9] as white light is made up of seven colors. The sensor also has an inbuilt current to a frequency converter. This frequency is then read by the NodeMCU microcontroller.

D. MICROCONTROLLER

Node MCU is a type of open-source microcontroller that includes Firmware [3] which runs on ESP8266 Wi-Fi that helps in prototyping or building IoT products**.**

III.METHODOLOGY

The figure 1 demonstrate the use of color sensor as nutrition detecting sensor. The color sensor works by illuminating soil sample with white light and measuring the intensity of reflected light with the help of TCS3200 chip present in sensor. The NodeMCU microcontroller helps to maintain the intensity of light that is falling on soil sample. Further, NodeMCU also helps store the nutrition values in data warehouse through ESP8266 wi-fi module and displays result on LCD.

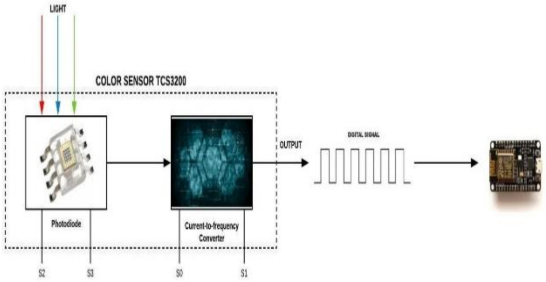

Fig.1. Schematic diagram for working of color sensor and microcontroller.

The light transmission system that is four LEDs of color sensor utilizes three different color's wavelength that is red, green and blue [4] which is related to Nitrogen, potassium and phosphorus value. The difference between standard absorption wavelength and the sample absorption wavelength of particular color gives the amount of presence of nutrients. Photodiode receives the light reflected from soil whereas soil receives the light from LEDs as light transmitting source [5]. Table 1 illustrate different wavelengths.

TABLE 1. Wavelength range of NPK soil and LED emittance.

Nutrient	Absorption wavelength (nm)	Color	Standard Wavelength (nm)
Nitrogen (N)	445-485	Blue	450-495
Phosphorus (P)	505-565	Green	495-570
Potassium (K)	625-685	Red	635-700

In the eight x eight array of photodiodes, sixteen photodiodes have Red filters, sixteen have Blue filters, sixteen have green filters and also the rest sixteen photodiodes are clear with no filters [6]. The sensing element comprises four differing types of filter lined diodes. Here S2 and S3 are choice inputs which may activate the filters of specific photodiode. The photodiodes are connected in parallel, sanctioning the S2 and S3 LOW and HIGH in several combos so as to pick varied color [6]. Since every photodiodes are coated with totally different filters every of them will discover the corresponding colors. The various values of S2 and their corresponding active filter is shown in Table two. At a time all 3 filters will be activated by activating S2 and S3 in a very loop. If we have a tendency to select the red filter, solely red incident light will get through filters, blue and green are prevented. By measuring red reflected light, we will get the intensity of red light [5, 6]. Similarly, once different filters are activated we are able to get blue or green light. To determine the nutrient quantity, the frequency is measured from sixth pin once every filter is activated.

Fig. 2. TCS3200 color sensor module

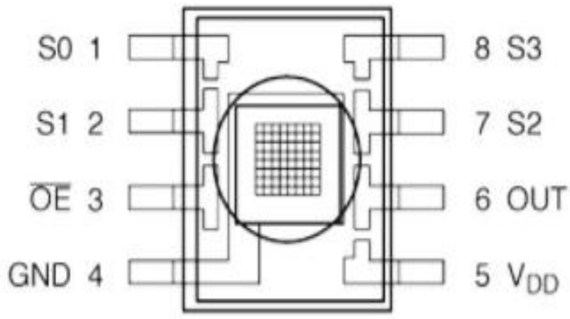

Fig. 3. TCS3200 color sensor pin configuration

Steps to set pins-

- First set the input pins as input and output pins as output. During the selection of input and output pin, analog pins are not needed.
- Set S0 and S1 to high or low to aline desired frequency scaling.
- Activate each filter by setting the value of S2 and S3 to HIGH or LOW in a loop. Assess frequency 'f' from sixth pin to urge corresponding color strength. Compare frequencies of each color toexamine nutrients within the sample.

TABLE 2. Input and output pin values for activation of photodiode filter.

S2	S3	Photodiode Type
Low	Low	Red
Low	High	Blue
High	Low	No filter
High	High	Green

IV.EXPERIMENTAL SETUP

The experiment is conducted by placing color sensor at a distance of 3 cm from the soil sample. The perfect distance is set up by varying the length between sample and reflector, and then selecting a distance which is most accurate for the angle of incidence and reflection. In sensor, the LED and photodiode are designed in parallel direction such that they are facing in the same direction i.e. towards the sample. The four LED's illuminate the soil sample and photodiode collects reflected light after absorption by soil sample. The schematic diagram of the experimental setup for measuring soil sample is shown in Fig. 4. The three types of soil sample are tested in order to compare the soil quality on the basis of nutrition composition. Two samples are taken from the farming land and rest two are taken from residential area.

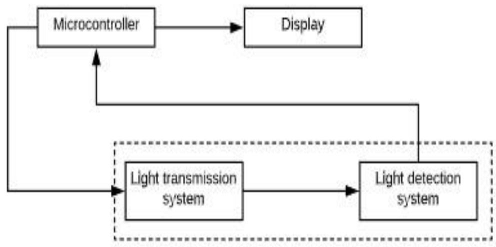

Fig. 4. Block diagram of Color Sensor.

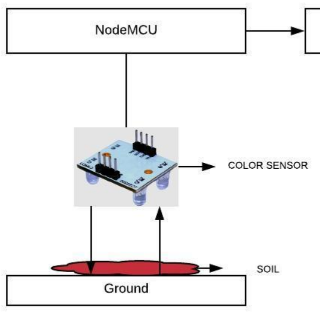

Fig. 5. Schematic diagram for measuring nutrient in soil sample.

The absorption rate was measured through the reflected light detected by the photodiode sensor module and convert into voltages. The detected voltage for each nutrient was compared with given absorption wavelength in TABLE 1 that was developed by the Arduino microcontroller which was used to determine the deficiency of nutrient content in soil. These values were determined based on the absorption rate of each nutrient during the sample measurement.

V. RESULT ANALYSIS

1. Determination of which light color is absorbed by nutrient-

By comparing the standard range of wavelength absorb by specific nutrient and wavelength of various colors, this gives out the most accurate color's wavelength which is approximately equal to light absorbed by nutrition. Then that particular photodiode filter is activated for the nutrient measurement. The various nutrition absorption wavelength and their corresponding color's wavelength is shown in table

2. Determination of path length between soil sample and sensor-

The perfect distance is set up by varying the length between sample and reflector, and then selecting a distance which gives most accurate reading for the angle of incidence and reflection for specific color rays. 3 cm is the most accurate distance, then this path length is maintain between soil sample and sensor.

3. Determination of nutrition in soil-

TABLE III shows high, medium or low values for NPK soils in three different samples.

The bar charts in Fig. 6. depicts the comparison between soil samples. The highest quantity of nitrogen contained in sample 1 because it exceeds the wavelength of 485. Sample 2 contains high phosphorus and low nitrogen. The highest potassium content is present in sample 3. Thus in this way measure of NPK are determined in soil sample.

TABLE 3. The nutrient content level in samples.

Soil Sample	Nitrogen(N)	Phosphorus(P)	Potassium(K)
Sample 1	High	Normal	Low
Sample 2	Low	High	Normal
Sample 3	Normal	Low	High

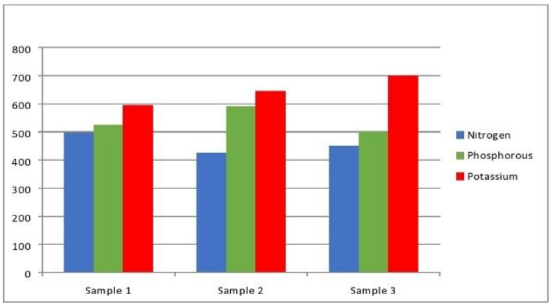

Fig. 6. Comparison of nutrient content in sample.

VI. CONCLUSION

This research concludes that, the color sensor; TCS3200 with Node MCU is used for determination of the nutrients N, P and K in the soil which is successfully developed and tested. This research can reduce the problems of fellow farmers in determining and calculating the amount of nutrients in soil with a cheaper cost compare to other devices. It can likewise decrease the undesired utilization of fertilizers to be added to the soil. This can be determined by light absorption of nutrients from led's of color sensor and display the values for NPK of soil. In the future, with the help of this research we can predict suitable crops for that soil and we can use our soil predictor in laboratories for accurate and fast results.

ACKNOWLEDGMENT

Authors are thankful to CSE department of AITR, also thankful to senior faculties of EC department.

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