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Soil Health Monitoring System

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Abstract: ***As in India agriculture provides employment opportunities for rural people on a large scale. It is an important source of livelihood and still our agriculture sector is facing challenges. And one of those challenges is productivity of land. Typically, collecting data from the field involves quite a bit of time. Currently, there is no such machine which can automatically test all required data. It is measured by collecting samples, sending to a lab, waiting days or weeks, and then only receiving a snapshot and report of the condition of field from that one day. As this is time consuming process and due to the lack of information about the nutrients present in soil farmers are not able to decide about crop, fertilizer and irrigation that would be best suited to the soil. Hence we need a portable device which can analyze the soil nutrients on real time basis. This research focuses on developing a comprehensive soil probe measuring everything from soil macronutrients (Nitrogen (N), Phosphorus (P), Potassium (K)) to soil moisture, pH and soil humidity. This research comprises of an electronic device which would detect macronutrients with the help of three LEDs as light source and a LDR as a light detector. The wavelength of LEDs is chosen to fit the absorption band of each nutrient. The nutrient absorbs the light from LED and the LDR convert the remaining light that is reflected by reflector to current. The system utilizes a microcontroller for data acquisition therefore the output from the transducer is converted into a digital display reading and it involves the concept of IOT as a webpage is included in it for review and analysis of all the data collected by the farmer ,in both Hindi and English with some suggestions.***
Keywords: ***NodeMCU, LED, LDR, Optical transducer, NPK soil***

I. INTRODUCTION

India is ranked second in terms of population. With this growing population demand of food has been increasing exponentially. But due to lack of information about productivity of land i.e. Soil Health farmers are not able to meet the requirements. Hence, Soil health is a term which is widely used within discussion on sustainable agriculture to describe the general condition or quality of the soil resource. It is about importance of managing soils so they are sustainable for future generations. To improve the quality and quantity of crops, every agricultural land must contain sufficient nutrients, which consists of Nitrogen (N), Phosphorus (P) and Potassium (K).

These three elements nutrients promote the growth of the plant in different ways - Nitrogen promotes the growth of leaves and vegetation, Phosphorus promotes root and growth and Potassium promotes flowering, fruiting and keeps regulation of nutrient and water in plant cell. A NPK ratio of 4:2:1 is generally considered as ideal and acceptable for macro-level monitoring of consumption of plant nutrients for the country as a whole. The soil health data card is very important parameter to monitor for every crop season. But to determine soil health method of soil sample test in laboratory is used which is quite a time consuming task, and we are not able to get real time data of soil.

Hence we have created the most comprehensive soil probe measuring everything from NPK to soil moisture and microclimate, all season long. Optical detection method based on absorption principle is implemented in this study due to the optical characteristics own by NPK soil. An optical transducer is developed to measure and to detect the presence of Nitrogen (N), Phosphorus (P) and Potassium (K) of soil.

The N, P, and K value of the sample are determined by absorption light (RGB) of each nutrient. The optical transducer is implemented as a detection sensor which consists of three LEDs as light source and a LDR as a light detector. The wavelength of LEDs is chosen to fit the absorption band of each nutrient.

The nutrient absorbs the light from LED and the LDR convert the remaining light that is reflected by reflector to current. The system utilizes NodeMCU for data acquisition therefore the output from the transducer is converted into a digital display reading and also uploaded on locally hosted webpage. In addition to this Microclimate (Air temperature and humidity) is measured by DHT11. The soil moisture is measured with the help of the Soil moisture sensor and the PH is measured with the help of the PH sensor**.** Data flow of this proposed model is shown in Fig.1.

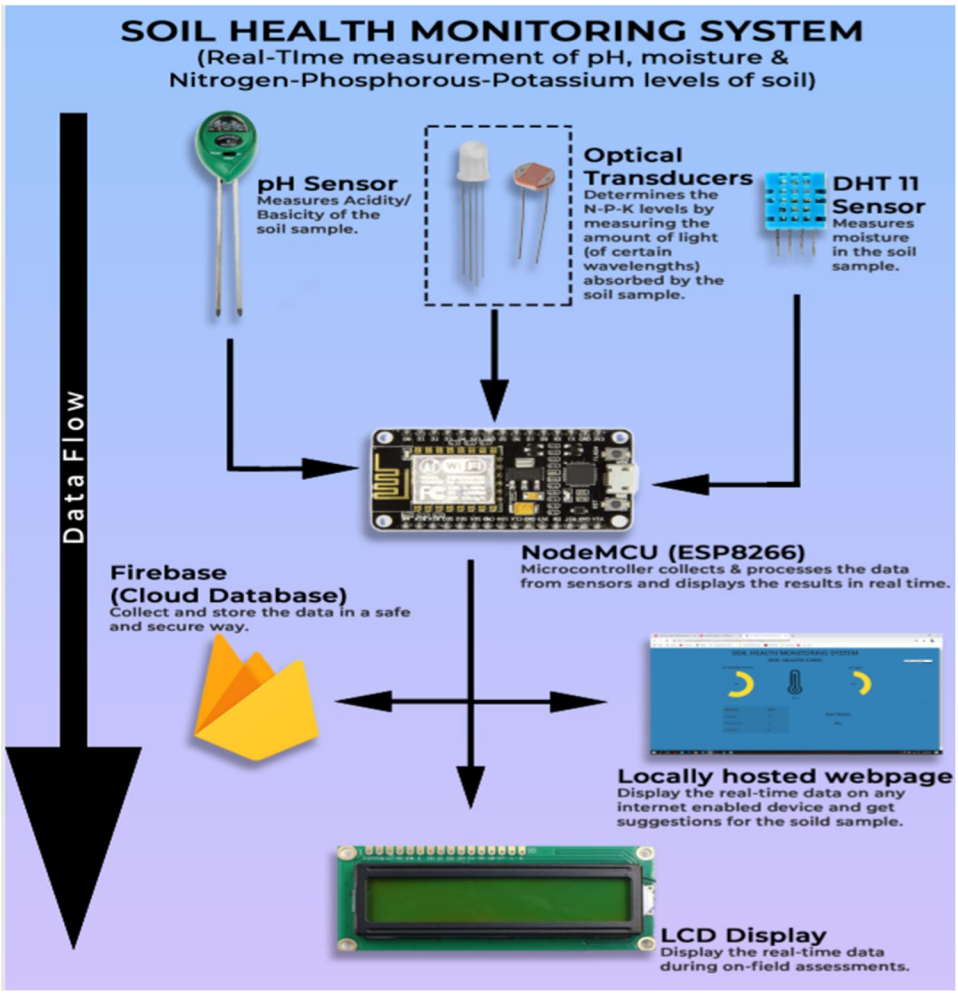

Figure 1: Data flow representation of soil health monitoring system.

A. Method

The optical transducer was formed by the integration of light transmission system and light detection system. The NodeMCU microcontroller was used to operate the light source in a transmission system. Apart from that, it is also used as a data acquisition from the light detection system and provides liquid light transmission system utilized three LEDs with different wavelength. Each of the LED was chosen according to the spectrum absorption wavelength by the NPK soils. Table I lists optical characteristics of NPK soil absorption and the corresponding LED emittance.

The LDR sensor module was applied as a light detector in the light detection system. LDR (Light Dependent Resistor) also known as photoresistor works on the principle of photoconductivity. When the light falls on its surface, then the material conductivity reduces and also the electrons in valence band are excited to the conduction band. It depends on the light, when light falls on the LDR then the resistance decreases and increases in the dark. In our model LDR received the light reflected from the soil where the soil received the light from the LED. This received light by LDR is converted into current and the data was sent to the NodeMCU for further analysis such as digital conversion and display it on LCD screen and by utilizing the concept of IOT this data is sent to the locally hosted webpage. We have included DHT11 sensor to get knowledge of soil humidity. Also soil moisture is measured with the help of the Soil moisture sensor which uses capacitance to measure dielectric permittivity of the surrounding medium. In soil, dielectric permittivity is function of the water content. This sensor averages the water content over the entire length of the sensor. pH sensor is used to measure pH content of the soil. The overall block diagram of optical transducer with microcontroller, sensors and display (LCD and Webpage) is shown in Figure 2. Webpage in addition to soil health data card also includes suggestion part regarding the soil health and its improvisation. As farmers do not have English proficiency background, Hindi translation of webpage is also available.

Table I

Nutrient	Absorption Wavelength (nm)	LED	Wavelength (nm)
Nitrogen(N)	438-490	Red	460-485
Phosphorous (P)	528-579	Green	500-574
Potassium(K)	605-650	Blue	635-660

II. EXPERIMENTAL SET-UP

Before conducting the soil test measurement, the transducer was initially optimized by varying the distance between LED, reflector and LDR sensor module. During measurement, the LED and the LDR was positioned in parallel facing both in the same direction. The light gets reflected by the reflector and gets detected by the LDR. The effect of the incident light

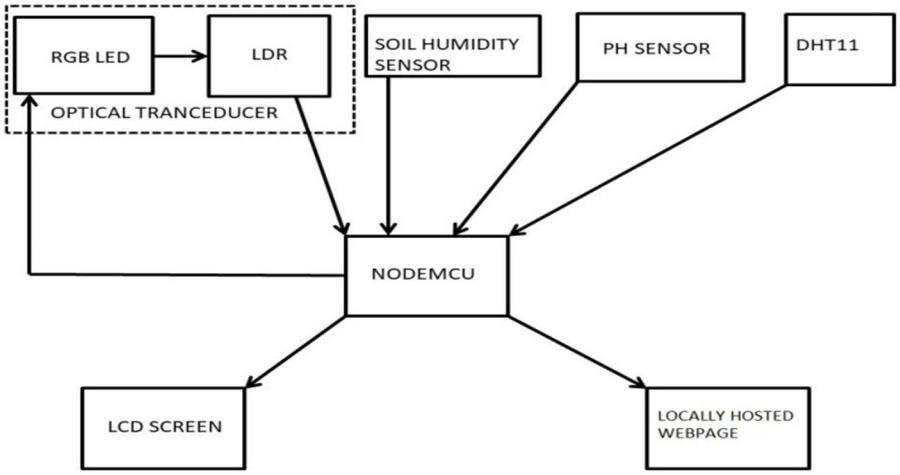

Figure 2: Block diagram of proposed model

emitted to the detector was investigated to determine an optimum optical path length of the transducer. The soil test absorption measurement was conducted using the developed optical transducer with four types of soils. Two types of the soils with different nutrient were obtained from a nursery shop while the other two were taken from residential areas. The sample specification is listed in TABLE II. Each of the soil samples with optimum thickness was placed on top of the reflector under the illumination of LED light.

According to Beer's Law, absorbance (A) has the following equation:

$$A = -\log_{10}(I_1/I_0)$$

Where I_1 is transmitted light and I_0 is incident light. The difference in light intensity level was evaluated by the LDR and the absorption rate was measured through the reflected light detected by the LDR sensor module and convert into voltages. The detected voltage for each nutrient was compared with a threshold values that was developed by the microcontroller which was used to determine the deficiency of nutrient content in soil into three voltage levels; High, Medium and Low. These values were determined based on the absorption rate of each nutrient during the sample measurement.

Table II: Soil Sample Specification

Sample	Nutrient Content
Sample 1	Low Nutrient
Sample 2	Intermediate Nutrient
Sample 3	High Phosphorous
Sample 4	High Potassium

In addition to macronutrients, DHT11 which is Humidity and Temperature Sensor, which generates calibrated digital/Analog output by interfacing with NodeMCU, gives data of soil humidity and soil moisture is measured with the help of the Soil moisture sensor and the pH is measured with the help of the pH sensor. Experimental setup is shown in Figure 3.

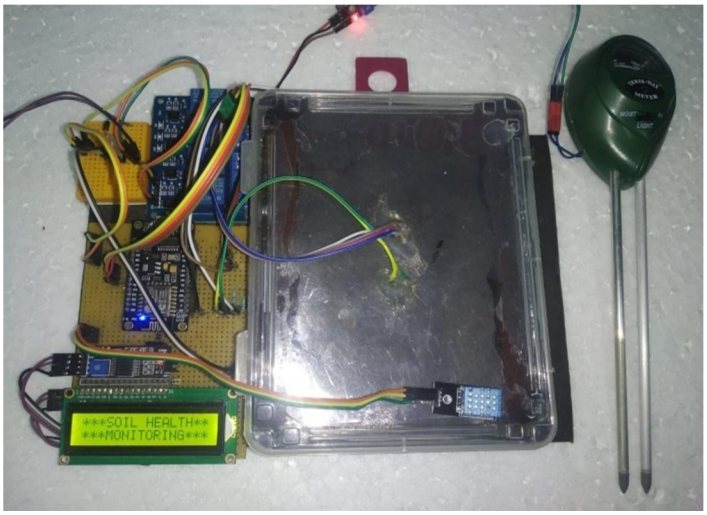

Figure 3: Experimental setup of soil nutrient checkup

III. EXPERIMENTAL DATA AND RESULT

The responses of the LDR sensor module, due to LED illumination for different light and calculating the threshold values for NPK soils in three levels: High, Medium and Low are illustrated in TABLE III. The value x indicates the absorption ratio for each nutrient. Table IV summarized the nutrient content in Sample 1, 2, 3 and 4 based on the threshold value in Table III. A sample is placed in the transducer and then the LDRs collect the reflected rays send the value to micro controller. The input signal is converted in corresponding voltage values by ADC. The ratio of transmitted light(i.e. red, green and blue) and received by LDR gives us the ratio which tells us soil health(i.e. N,P,K respectively) present as high, medium, low by comparing with the threshold values and then displaying it on LCD display and webpage as shown in Fig.4. Also, soil humidity, pH and soil moisture uploaded on web page along with NPK status is shown in Fig.5.

Table III

Nutrient	High	Medium	Low
Nitrogen(N)	0.15<x<0.36	0.36<x<0.55	x>0.55
Phosphorous(P)	0.12<x<0.26	0.26<x<0.45	x>0.45
Potassium(K)	0.13<x<0.28	0.28<x<0.48	x>0.48

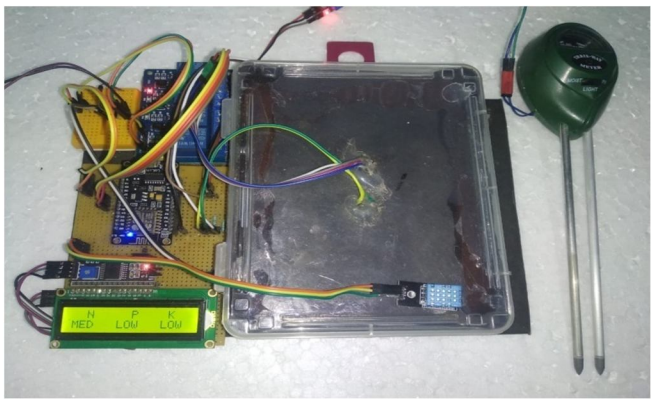

Figure 4: NPK levels display on LCD screen

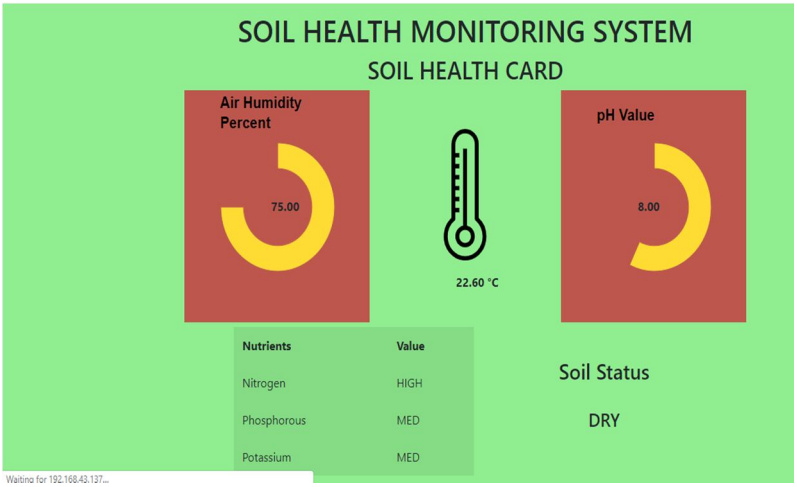

Figure 5: Display of NPK status along with other parameters

Table IV

Sample	Nitrogen(N)	Phosphorous(P)	Potassium(K)
1	Low	Low	Low
2	Low	Medium	Medium
3	High	High	High
4	Medium	Medium	High

Therefore, the NPK soil content in each sample can be easily determined with only particular nutrient should be dispensed to the sample.

IV. CONCLUSIONS

After a simple and easy installation, it makes crop planning and management easier than ever, with insights about soil's fertility both now and into the future. It can be used for the plant growth and productivity of the farming. As a conclusion, the optical transducer; LEDs and LDR with microcontroller as an alternative method of determination of the deficiency N, P or K in the soil is successfully developed and tested. This project can reduce the problems in determining the amount of nutrients (majorly NPK) in soil with a cheaper cost. Light absorption of nutrients by the optical transducer and developed threshold values for each nutrient which decide the level of nutrients into three voltage levels: Low, Medium and High. Also with the help of DHT11sensor, Soil pH and Soil Moisture probe we measure soil humidity, pH and status of soil whether it is moist, dry or wet. This whole determined data is displayed on the LCD screen display and also by applying the concept of IOT data is uploaded on the webpage with the suggestion framework i.e. the type of nutrient soil is lacking and how to enrich soil organically. Also, specific crops are targeted individually and the required nutrients for a healthy growth of the crops are suggested

V. ACKNOWLEDGEMENT

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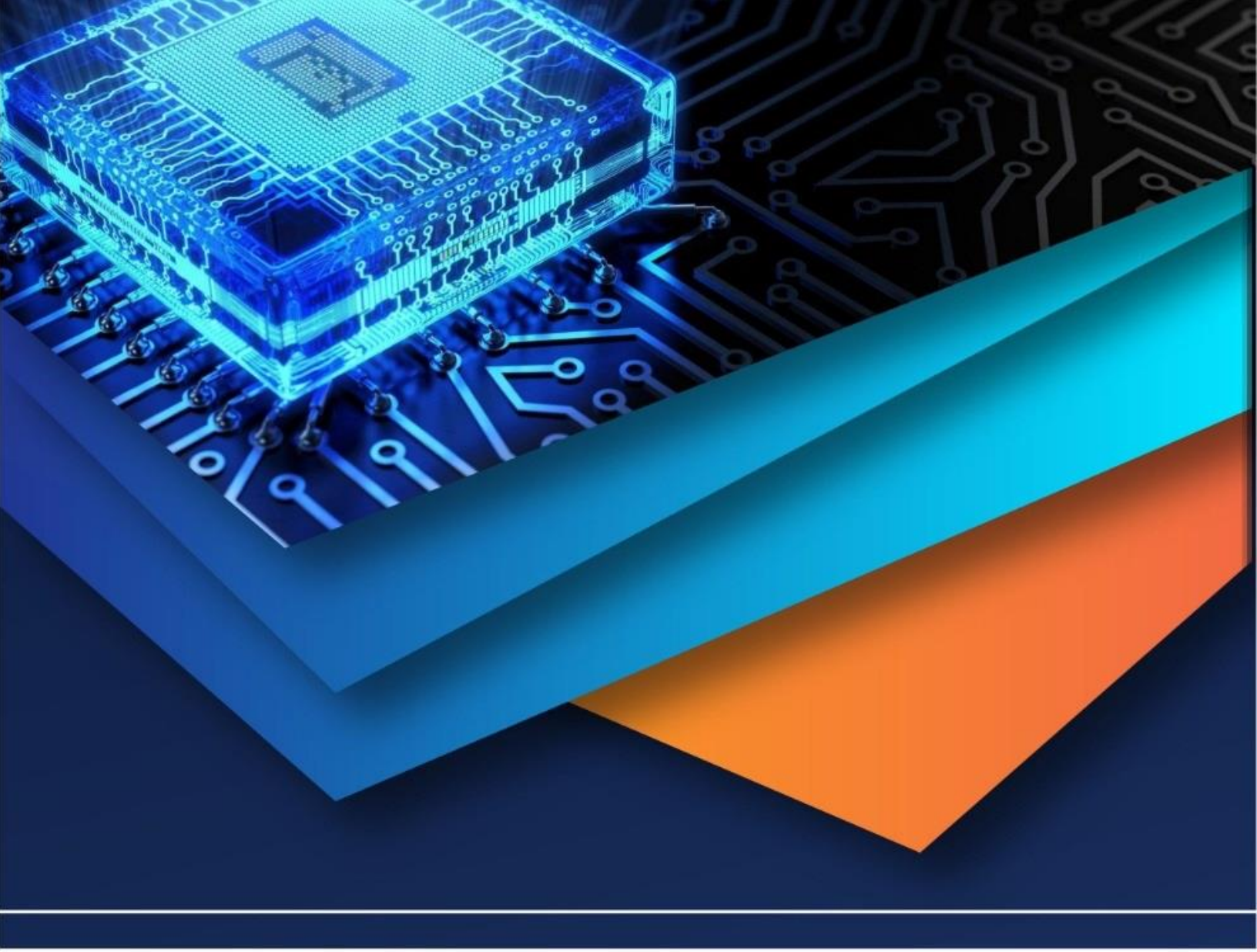

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