

# Soil nutrients monitoring and analyzing system using Internet of Things

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**Abstract**— Indian agrology system is highly based upon the production of food crops. Quality of crops depends upon the nutrients level of the soil. Our nation consists of majorly productive lands in different type of soils. Macro nutrients and micro nutrients are the kind of soil nutrients. Weather the quality of the crop will be improved by addition of fertilizers. This fertilizer can make the crop to rich yield as well as poor yield. The amount of fertilizer is a major factor for the richness of the yield. This proposed IoT based android system is used to test the soil nutrients level and also helps to evaluate the value of fertilizers need to be fed. It evaluates the fertilizer level in an efficient manner and known to the famers. Highly previsioned sensors are used to improve soil nutrients level. This effective proposed system makes the farmer into more educate with the handling of the fertilizer

**Keywords**- Soil nutrients, NPK sensor, Humidity, Fertilizers, NodeMCU

## I. INTRODUCTION

Soil is a one of the earlier originated material in world. Soil processing is method is used to analyze a particular soil decide to agrology or urbanization. It is especially to reduce vast of empty lands. It is easier to harvest land usage. In the way of agrology, educate the soil materials for the suitable crop towards high productivity as well as yield. Sensors are the passive elements to analyze a particular parameter in a particular period of time.

Internet of things is a virtual device or network is used to store and transfer the data to the users. It manages both the front and back end devices [1]. Soil nutrients's are the major deciding element for the field of work to flour [2]. Soil nutrients are divided commonly into macro nutrients and micro nutrients. N-Nitrogen, K-Potassium and P-Phosphorus are all significant nutrients and it is also called as NPK value of the soil. This is one of the feature-based parameter value. Micro nutrients are such as sodium, calcium, Sulphur and zinc. The primary motto of the IoT technology is used to reduce human errors and manpower. It makes the system more efficient with in both efficacy as well as cost effective. It will easy to find out the value of NPK and micro nutrients with the help of eminent sensor units [3].

Soil nutrient analysis using wireless sensor networks (WSN) helps to find and analyses soil fertility remotely [4], Soil analysis details, very useful on the selection of crop and development of irrigation decision support systems [5]. Big data and artificial intelligence for the food safety and agriculture production management system is proposed. Using Internet of things, it assists the food value and safety [6]. This system is more efficacy and eminent in the crop management and its disease analysis. Internet of things used to monitor the activity and process control in agrological activities. It maintains a surplus survey about the crop protection and maintenance. It produces the suitable crop and soil condition as well as weather monitoring [7]. IoT based soil moisture monitoring system was proposed. It was developed using esp8266microcontroller [8]. IoT based system was proposed to monitor the various environmental factors which involves in the crops growth, which was implemented using ATMEGA328 Microcontroller with various sensors interfacing [9]. Air Quality monitoring was developed using Arduino with the interfacing of NH3 Sensor, co sensors, Wi-Fi module and LCD [10]-[15]. Level of Nitrogen, Phosphorus, Potassium and moisture level of soil has analyzed using Wireless Sensor Networks (WSN) [16]. Every farmer need to have the individual system to check the soil parameters by placing the sensors in the fields. The existing systems can't be accessed by the other farmers and they are not recommending any suggestions regarding the type of fertilizers to improve the nutrients of soil and suitable crops for the type soils. Because crops should be selected based on the soil type and its nutrients to grow the crops more healthily and to get more yields [17].

In the proposed system, anyone soils can be analyzed remotely by sending the soil samples. The NPK sensors, moisture sensors and DHT11 sensors are used estimate the level of major nutrients of soil and nutrients data will be transmitted to the cloud as well as displayed in LCD. The user will get the soil fertility report at the convenience on their Android mobile application or website or email. Based on the report, farmer may find a specific crop according to profit and risk level. The proposed system also recommends the fertilizers which to be used to suit the needs of the desired crop, thus improving the quality of the soil and in turn, increase the yield.

## II. SYSTEM DESIGN AND METHODOLOGY

This smart Soil nutrient level analysis is improved with the help of numerous embedded sensors and controllers. This system was developed in a manner as shown in fig.1. This vast description about the embedded sensors is in the following sub-sections.

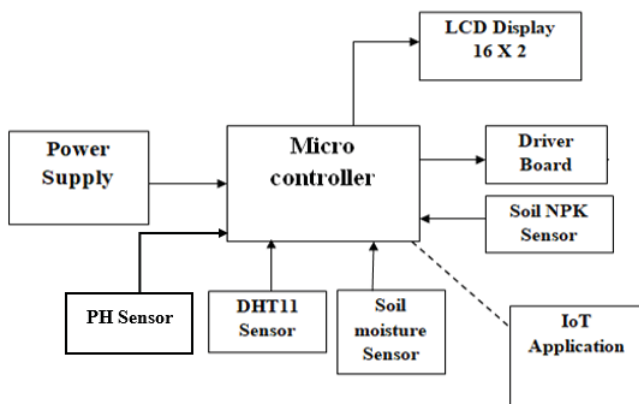


Fig. 1. Block diagram of the proposed system

### A. Node MCU Microcontroller

In this Node MCU microcontroller is one of the low cost IoT platform and it ensure the problems in the form of virtually. It has on-chip micro-controller with Wi-Fi and Bluetooth module. Programming of Node MCU is similar to Arduino programming. But Wi-Fi /Bluetooth module to be interfaced externally with Arduino board [18]-[20]. So this system has developed with Node MCU.

### B. Soil NPK Sensor

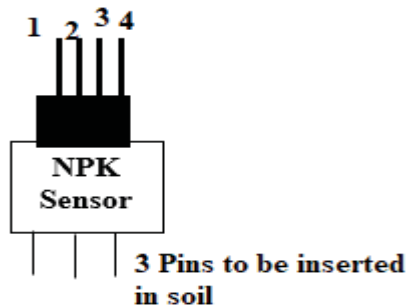


Fig. 2. Soil NPK Sensor pin details

Soil NPK sensor is a high precision digital sensor, it computes original nitrogen, phosphorous and potassium values of the soil sample. It is suitable for all the variety of soil materials. Pin details of NPK Sensor is shown in fig.2, where pin 1 and 2 are the power supply and ground pins. Pins 3 and 4 are the sensor output pins, which gives the NPK levels of soil to the microcontroller. This sensor is used to measure the pH level of soil

### C. Soil Moisture Sensor

Soil moisture sensor is a passive eminent device, which is used to measure the volumetric water content of the soil sample [8]. It has four terminals such as VCC, ground, Analog output pin and Digital output pin. Here Node MCU reads sensor data from the digital output pin.

### D. DHT11 Sensor

DHT11 sensor is used to sense the composite of the temperature and humidity of the soil sample. It is easily calibrating wet and temperature measurement of the soil sample. It is more reliable and compact long-lasting material.

### E. PH Sensor

Digital type soil pH sensor is used to find the crop growing ability of the soil. Generally, well nutrient soil has the pH value in the range of 6.5 to 7.5. From the sensed value of pH sensor, acidity and alkaline level of soil can be estimated. To improve the fertility of soil, pH value should be in the range of 6.5 to 7.5. If the soil pH value is out of the neutral range, it indicates the soil nutrient deficiency.

## III. WORKING

The entire high precision sensor interfaced with the Node MCU microcontroller. It unites all the values of humidity, moisture, water content and NPK values. Sensors read the value of the particular environment and the data transmitted into the cloud data storage with the help of internet of things. Sensor values are compared with margin values of each soil parameters. If the sensor values of the impact factors met or increase, the data values send to the mobile applications with the help of web servers. The soil nutrient analysis results can be accessed through mobile application or website. This website or Mobile application have the various menus to display the requirement of fertilizers and recommends the crops which are suitable for that soil to get more yield. Since if the soil has nutrient deficiency, it will affect the quantity of yields and affect the health of consumers [21]. The clear working of the proposed system is given as flowchart in fig.3.

The proposed system is providing soil analysis details along with the suggestions about the fertilizers requirement and suited crops for that field. So this system will be more helpful for the farmers to improve the level of yields and farmers can get more revenue.

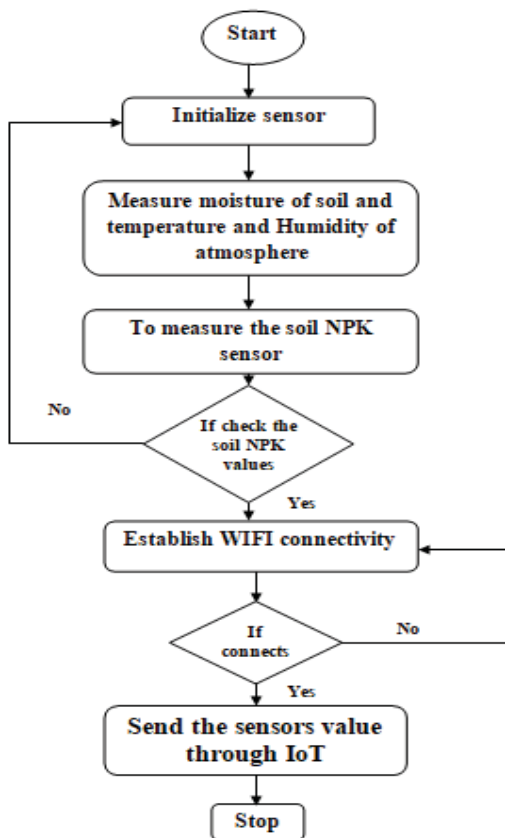


Fig. 3. Flow Chart of Soil nutrients level analyzer.

The microcontroller sends the measured soil parameter values to the mobile application or web server through Wi-fi module. Soil analysis report is displayed in Mobile application/ website. Also the proposed system displays the availability of nutrients in the soil based on the measured pH range as shown in table 1.

TABLE I. AVAILABILITY OF NUTRIENTS IN DIFFERENT pH RANGE OF SOIL

	pH Range		
	<6.5	6.5-7.5	>7.5
<b>Soil nature</b>	Acidic	Neutral	Alkaline
<b>Availability of Sufficient nutrient's for crops growth</b>	Iron, Manganese, Boron, Copper and Zinc	Nitrogen, Phosphorus, Potassium, Sulfur, Calcium, Iron, Magnesium, Boron, copper, zinc and Molybdenum	Potassium, Sulfur, Calcium, Magnesium and Molybdenum
<b>Major Nutrient deficiency</b>	Nitrogen, Phosphorus, Potassium, Sulfur, Calcium, Magnesium	NIL	Iron, Magnesium, Boron, copper and zinc

If the soil pH is more acidic, it has nutrient's deficiency in Nitrogen, Phosphorus, Potassium, Sulfur, Calcium, Magnesium. If the soil is more alkaline, there has deficiency in the level of Iron, Magnesium, Boron, copper and zinc [23]. The availability of all nutrients are good when the pH range is 6.5 to 7.5. Crops won't grow well in all soils with any range pH. Some crops can grow even in alkaline soil and some crops can grow even in acidic soil. Based on the soil pH value, the proposed system gives the recommendations for the farmers

to choose the proper crops to ensure the crops well growth and good yields as shown in table 2.

TABLE II. CROPS RECOMMENDATION BASED ON SOIL pH VALUE

pH Range	Recommended crops
<5.5	Blueberries, Potatoes, citrus fruits
5.5-6.5	Barely, Corn, Cotton, Peanuts, Paddy, Soybeans, Watermelon, Wheat, Garlic, Pumpkin, tomato, cauliflower, Tobacco, Apple, Grapes, Plum, watermelon
6.5-7.5	Its suitable for most of the crops
7.5-8.5	Garlic, Asparagus, Tomato, Cabbage, Cauliflower, Cucumber, Pumpkin, Bitterguard, Sugarcane, Mustard, Rice, Maize, Banana, Spinach, Coconut, Grape, Datepalm, Pomegranate

Some of the soil nutrients play the major role on the well growth of crops such as Nitrogen, Phosphorus and Potassium than other nutrients. So, its very important to analysis about the level of N, P and K in the soil. Our proposed has NPK sensor to find the content of N, P and K in soil more accurately. Table 3 shows the marginal range of N, P and K quantities required for good fertility soil.

TABLE III. MARGIN VALUE OF N, P AND K FOR HEALTHY SOIL

Nutrient	Threshold Value
Nitrogen	280-560kg/ha
Phosphorus	10.0-25Kg/ha
Potassium	110-280Kg/ha

The proposed system compares the measured N, P and K values with the threshold values. If the measured values N, P and K are lesser than its threshold value, the soil has nutrients deficiency. Most of the farmers are using fertilizers randomly without knowing the deficiency contents. It causes to affect the growth of crops when any content become excessive [22]. So our proposed system recommends the suitable fertilizers based on deficiency contents as shown in table 4.

TABLE IV. FERTILIZERS RECOMMENDATION FOR SOIL NUTRIENTS DEFICIENCIES

Deficiencies	Recommended Fertilizers
<b>Nitrogen</b>	Urea, mono-ammonium phosphate, di-ammonium phosphate, ammonium nitrate, calcium ammonium nitrate, ammonium sulphate, urea ammonium nitrate
<b>Phosphorus</b>	Ammonium polyphosphate fertilizers
<b>potassium</b>	Muriate of potash, sulphate of potash
<b>More Acidic</b>	Limestone
<b>More alkaline</b>	Sulphur based fertilizers, ammonium-based fertilizers

#### IV. RESULTS AND DISCUSSION

Proposed Methodology have successfully tested given soil sample and predicted soil type, crops suitable for growing, pesticides and fertilizers can be used to get good yield. We



have also predicted what other crops a farmer can grow in his land, steps to prepare his land, what fertilizers should be used to prepare his land for the crop survival and good yield, Data is displayed in graphs and farmers can access this data through our website

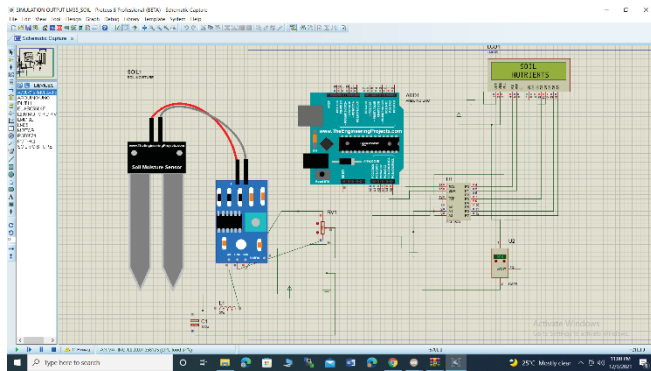


Fig. 4. Simulation model of soil nutrients analysis system

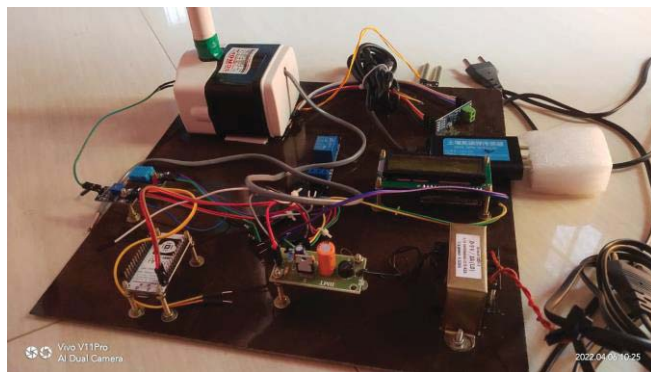


Fig. 5. Prototype model showing temperature and humidity in display

Using Tinker Cad online simulator, Sensors have successfully identified soil nutrients data, soil temperature and humidity from the given soil sample by passing inputs as intended as shown above figure.4.

Apart from the finding of nutrients level and pH value, soil temperature and humidity also the factors selecting the crops for the cultivation. Temperature and humidity values can be used to estimate the environmental conditions. This also plays the role to select the crops [24][25]. The proposed system having the respective sensor interfacing (temperature and humidity sensors) which helps to find the effective crops for the field. The prototype of Soil nutrients monitoring system in shown in fig. 5.

IoT application is built using JavaScript, PHP, HTML and CSS languages. Here farmers can access their soil report data by entering their UUID or Sample-Id that has been forwarded to their registered mobile number or Registered Email. Farmers can contact Research lab by the contact form provided below. They can access data including soil sample report, recommended fertilizers and recommended crops. those can be used for greater yield with graphical data in that website as shown in the figure 6.

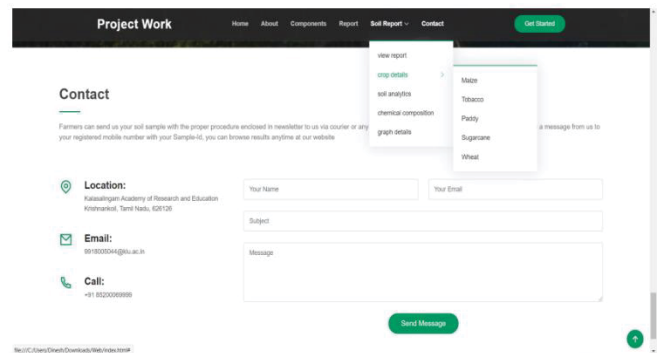


Fig. 6. Website showing the fertilizer and crops recommendations

## V. CONCLUSION

In this advancement of smarter agrology system is most useful for the upcoming decades. High precision sensors are used to enhance the proposed system into more effective. It resolves poor knowledge about the fertilizer management to the farmers. It will enhance the system as well as enrich the quality of the crop and seeds. This proposed IoT based system neglects human errors and reduce the human resources. Web portal-based setup is used to analyze full historical fertilizers usage. It will be easy to identify our lands transformation after few more years. This proposed system is more efficient compare than traditional chemical based soil testing. It is also more compact and tests the soil sample easily by the users. Wi-Fi based IoT setup informs any minute changes in nutrient level or weather changes to the farmers. This system makes easy the job of farmer. In future, this proposed system enhances itself by implanting deep learning algorithms. It increases efficiency and more users friendly.

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