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IOT based Modern Agriculture Soil Nutrient Monitoring

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***Abstract*— The agricultural yield primarily depends on soil fertility, the moisture level of soil and use of appropriate fertilizers. In the current scenario, the manual method of measuring the soil nutrients is less accurate because of the time difference of soil sample collected at the field and when it is measured in a laboratory. It becomes necessary to create a smarter agriculture practice through Internet of Things(IoT) to address this challenge. Soil nutrient analysis using wireless sensor networks (WSN) enables various application like remote monitoring of soil fertility, analysis, provide a selection of crop and build irrigation decision support systems. In the proposed system, the wireless sensors measure the macro nutrient of soil and transmit the data to the cloud. The user can view the soil fertility at the convenience on their mobile application. It is possible that the farmer may wish to grow a specific crop based on the economic interest. The software system has the intelligence to recommend the fertilizer that is required to be used to suit the needs of the desired crop, thus improving the quality of the soil and in turn, increase the yield. Overall, the proposed system helps farmers to gather real-time information about various soils, their fertility level, suggest crops and fertilizers at the convenience of the mobile app. Finally, this project effort will help farmers to make the right decision, gain better yield and economic advantage.**

Keywords—Nitrogen; Phosphorus; Potassium (NPK) sensor; Cloud; Mobile Application

I. INTRODUCTION

One of the valuable tools for farmers is the soil analysis. Soil analysis help determine the inputs needed for efficient and economical production. Most soils have a large supply of nutrients. However, when soils are continually used for growing, nutrients are removed whenever the crop is harvested. Low nutrition leads to multiple plant disorders and low yield. For better crop yield, the nutrients must be restored to the soil. Hence the farmers must add nutrients to the soil in right proportion. Nitrogen (N), Phosphorous (P) and Potassium (K) are the major nutrients. The application of fertilizer to meet the requirements of the crop by taking advantage of the nutrients already present in the soil is ensured by a proper soil test.

To fulfill increasing demand of growing population over the years there is a need for increasing the food production. To increase crop yield, fertilizers containing Nitrogen (N), Phosphate (P), and Potassium (K) are essential. Improper use of fertilizers in turn results in poor quality in fruits, vegetables lagging in color, size, taste and even quantity. Quantity of recommended NPK is dependent on crop type and on plant growth status . The quantity of fertilizer to be used is further dependent on present contents of N, P, K nutrients in the soil. Researchers are looking for ways to optimize plant yield while minimizing the consumption of fertilizer. Macro- nutrients even vary on a small scale throughout a cultivated field; many researchers are engaged in developing sensors to map these nutrient contents. Integrated crop management systems are designed to check spatial and temporal behavior of N, P, K. Continuous monitoring of N, P, K values along with pH and humidity of soil leads to automating the agricultural practices to improve crop productivity.

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The aim of the project is to analyze the nutrients of the soil in real-time by measuring Nitrogen (N), Phosphorous (P), Potassium (K) values by using sensors. Subsequently, the data from sensors is sent to the blynk cloud. These values are stored in cloud database which helps to access the data from anywhere, anytime.

Blynk is an IoT platform for iOS or Android smart phones that is used to control Arduino, Raspberry Pi and NodeMCU via the Internet. This application is used to create a graphical interface or human machine interface (HMI) by compiling and providing the appropriate address on the available widgets. Further, a mobile application is developed to provide information related to the NPK values present in the soil and if the farmer wishes to grow a specific crop of interest (other than best suitable crop for that soil), then

suggesting how much fertilizers should be added to the soil to make it happen. This paper discusses the methodology and solution employed to solve the problem at hand.
Subsequently, we will discuss the results of the effort and how the mobile application helps to see the nutrient values in real-time and suggest the recommended fertilizers for the desired crop.

II. METHODOLOGY AND SOLUTION

A system is developed to maximize the agriculture yield by nutrient analysis. The salient features of proposed system are:

- Is a real-time soil nutrient analysis system.
- Ability to measure current soil nutrients – Nitrogen, Phosphorus, and Potassium (NPK) values using sensor at the field eliminating the need to carry the soil to the lab.
- Database consisting of soil nutrients (NPK) for various crops including vegetables, fruits,etc.
- For any desired crop, calculate and suggest fertilizers to bring the level of nutrients in the soil to the ideal nutrient values for higher crop yield.
- Provides a user-friendly mobile application to display and access soil information and suggested fertilizers.

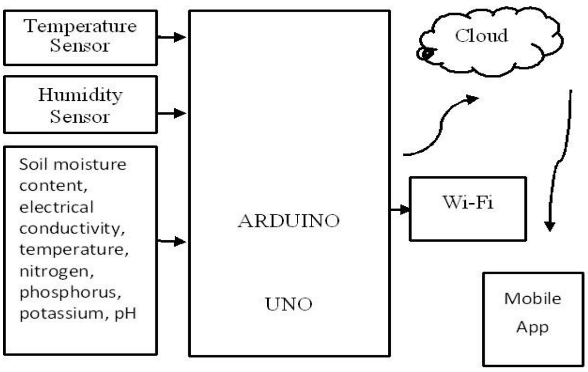


Fig. 1. Block Diagram of the proposed system

The system consists of various hardware and software tools for soil nutrient analysis and suggestion. The sensor measures the soil fertility in terms of N, P and K. The sensor undergoes a chemical reaction when inserted into the soil, which leads to change in an analog deflection voltage. The analog deflection voltage is then converted into digital value. The measured values of such voltage deflection are mapped and N, P and K values are derived using the below formula:

$$N_m = \frac{(x - N_{in\_min})*(N_{out\_max} - N_{out\_min})}{(N_{in\_max} - N_{in\_min})} + N_{out\_min}$$

where N_m is the measured Nitrogen, x is the analog voltage read from the sensor, N_{in_min} is the lower bound of the value's current range, N_{in_max} is the upper bound of the value's current range , N_{out_min} is the upper bound of the value's target range and N_{out_max} is the upper bound of the value's target range.

Similarly, this forumula is used to calculate the P and K values using the ranges provided as per sensor guidelines. The digital value is transmitted onto the microcontroller through UART [3]. Microcontroller (*Zolertia*) transmits the data to the n-Gate via Zigbee which is ultimately sent to the cloud where the data is stored in the database. IBM *Cloudant* database is a NoSQL based distributed database as a service (DBaaS) which delivers fast-growing application data. Multiple Cloudant databases are created for storing the ideal NPK values, and for processing intermediate results.

Let N_i, , P_i , K_i be *Ideal Nitrogen*, *Phosphorous* and *Potassium* recommended for a given crop

Let N_m , P_m and K_m be *Measured Nitrogen*, *Phosphorous* and *Potassium* recommended from the soil under cosideration

The first step is to obtain the difference of ideal and measured nutrients

(i) N_d be the Difference of *Measured Nitrogen* and *Ideal Nitrogen*

$$N_d = N_m - N_i$$

(ii) P_d be the Difference of *Measured Phosphorous* and *Ideal Phosphorous*

$$P_d = P_m - P_i$$

(iii) K_d be the Difference of *Measured Potassium* and *Ideal Potassium*

$$K_d = K_m - K_i$$

Next, calculate the fertilizer to be recommended as:

Table. 1. Guidelines to calculate the fertilizer recommendation for Nitrogen

Nitrogen		
	Recommendation	
	For low fertile Soil, increase Nitrogen by	For high fertile Soil, decrease Nitrogen by
$N_d \leq \pm 50$	No change	
51 to 100 kg	+12.5 kg	-12.5 kg
100 to 175 kg	+25 kg	-25 kg
175 to 250 kg	+37.5 kg	-37.5 kg
251 to 325 kg	+50 kg	-50 kg

Table. 2. Guidelines to calculate the fertilizer recommendation for Phosphorous

Phosphorous		
	Recommendation	
	For low fertile Soil, increase Phosphorous by	For high fertile Soil, decrease Phosphorous by
$P_d \leq \pm 25$	No change	
26 to 75 kg	+12.5 kg	-12.5 kg
76-125 kg	+25 kg	-25 kg

Table. 3. Guidelines to calculate the fertilizer recommendation for Potassium

Potassium		
	Recommendation	
	For low fertile Soil, increase Potassium by	For high fertile Soil, decrease Potassium by
$P_d \leq \pm 25$	No change	
26-50 kg	+12.5 kg	-12.5 kg
51-100 kg	+25 kg	-25 kg
101-175kg	+37.5 kg	-37.5 kg

The mobile application consisting of display and suggestion module, integrates and uses the data in the cloud. The cloud also hosts the software application that provides fertilizer recommendations via indicating amount of nutrients (NPK) that needs to be supplemented to grow a specific crop. This helps the users to adjust the soil to grow an economical crop of interest . Rapid mobile application platform like *Kinetise* is used to develop the Mobile App. The overall architecture and different component interaction is described below:

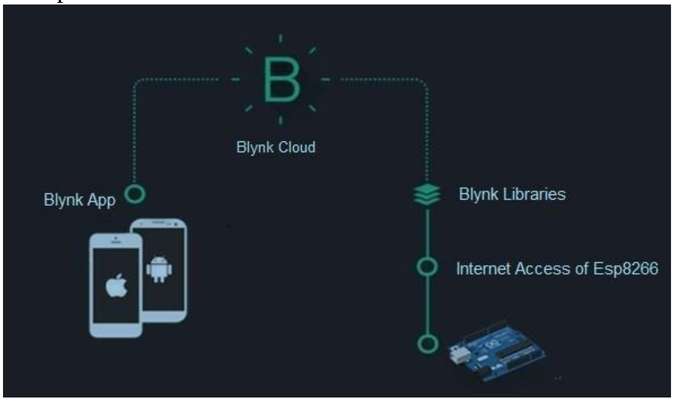


Fig. 2. End-to-end interaction of components from sensor to
end-user app

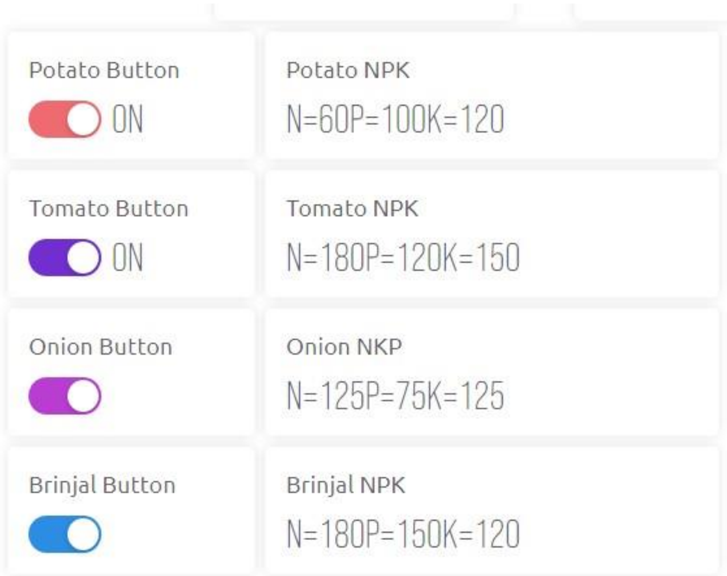
III. RESULTS

The sensor measures the soil fertility in terms of N, P and K. This data is transmitted to the microcontroller through UART. The below picture shows the NPK values transmitted by soil fertility sensor.

Fig. 3. NPK values transmitted by the soil fertility sensor Further, the N, P and K value from the microcontroller which is at the transmitter side is sent to cloud through Arduino. At the receiver end, receives these N, P and K values. Arduino sends the N, P and K values to cloud IoT Platform.

Fig. 4. NPK sensor with cloud platform

The mobile app has interface to various modules such as to view the NPK values stored at cloud, viewing suggestions on crops and fertilizers as shown in Fig5.



IV. CONCLUSION

The wireless sensor network implemented for analysis of soil nutrients provides an efficient scheme to measure the nutrients of soil. This system continuously monitored and reported the NPK values of soil of the land. The real-time measurement and upload of soil nutrient data onto the cloud was achieved. A software system successfully displayed current measured NPK values and provided fertilizer recommendation for growing a desired crop.

The various test results discussed clearly describing the utility of the implemented system. Through this project, the intended objectives were achieved such as:

- Defining and developing a WSN for the control and measurement and analysis of soil nutrients
- Move the soil nutrients in real-time onto a commonly accessible platform such as cloud
- Useful functionalities for farmers that help in making the right choices of crops via best crops suggestion
- Further, providing recommendation in terms of quantity of fertilizers to bring the soil nutrients to a desired level to grow a more economical crop as desired by the farmer The result of the project is positive and is intended to help farmer making better decisions and increase crop yield through the use of technology.

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V.FUTURE ENHANCEMENT

The smart farm helps the farmer to yield high profit by growing the crop without infection and at exact soil moisture content. Due to automatic process it reduces the human effort and view the growth of crop through smart phone. The wireless communication reduces the cost of implementation. In future this is implemented for large area of land. The internet connectivity is required at all the time to communicate the data to farmer. The predefined prediction of weather condition helps the farmer to cultivate the crop based on weather condition.