

# IoT Based Site Specific Nutrient Management System

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**Abstract-** Agriculture is part of every country without which there would be an imbalance in the biological cycle. Technology has to be made used for farmers in agriculture in many ways. A farmer has to make the land suitable for cultivation of specific crops. The moisture, minerals, nutrients, color etc. of the soil are to be considered before he plans to cultivate his land. Soil testing is essential for modern agriculture to optimize the production in order to get high yield and profit in less duration. It also protects the environment from fertilizer overuse and saves money and energy during cultivation. The purpose of this work is to develop an IoT based Site Specific Nutrient Management (SSNM) system that provides the right amount of nutrient source such as Nitrogen (N), Phosphorus (P), Potassium (K) and pH to the soil. This is an affordable model that is developed using IoT and sensors for analyzing the level of nutrients in the soil. The model is implemented using IoT devices and sensors and is tested.

**Indexed Terms-** IoT, Nutrients, Sensors and Soil testing

## I. INTRODUCTION

Site Specific Nutrient Management is an approach that is based on plant growth which is used everywhere. SSNM directs the farmers to provide right amount of nutrients to soil. Nutrient Management [1][3] and recommendation process in India is still following the conventional methods which is tedious to follow and apply. The SSNM provides an approach for providing nutrients based on the requirement of the crop. SSNM is a concept that deals with the study of nutrient management of soil and thereby providing exact fertilizer to the crop in order to achieve high yield and productivity. Depending on the geographical location, the type of soil varies in terms of characteristics such as color, nutrients, minerals etc. Dynamic change in the climate leads to dramatic change in soil content such as level of nutrient and pH. And hence, before a farmer decides to grow a crop, he collects the soil for

testing process to check whether it suits the selected crop growth.

In the existing system, the farmer collects the soil from every part of the land and gives it to the KVK (Krishi Vigyan Kendra) which is located at every district where they test the level of nutrients and give the end result to the farmers. By looking at the report the farmer has to decide how much amount of fertilizer he need to provide to the crop growth. But not all farmers will be knowledgeable to properly analyze the report and act to that. With SSNM this problem is

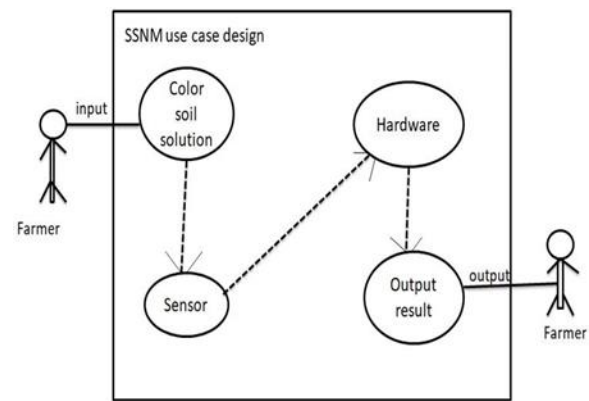


Fig. 1. SSNM use case

overcome as the farmer can himself test the soil and can be able to get all the notifications related to soil for the cultivation of crops.

The farmer has to collect the soil from every part of his land as the quality of the soil is not evenly distributed across the cultivation land. This collected soil is taken in four different test tube (N, P, K, pH) and made into color solutions using water and capsule. When this colored solution is placed on the color sensor, based on the color of the soil solution the level of nutrients in the soil is calculated. To get exact and accurate color of soil solution, the Light Dependent Resistor (LDR) light sensor is passed through the test tube. This overall data is collected in the desktop and mobile application where farmer can easily get all the

information related to soil nutrients. This entire process is shown in Figure 1.

The rest of the paper is organized as follows. Literature survey is given in section II. System process of SSNM system is discussed in section III. The existing method used in soil testing and monitoring is briefed in section IV. The methodology of the proposed work is explained in section V. The implementation, results and analysis are discussed in section VI. And finally the conclusion is given in section VII.

## II. LITERATURE SURVEY

In [1], an agricultural land with one acre dimension is considered. The soil characteristics like temperature, humidity and pH are sensed using sensors. The information collected is sent to the central station using ZigBee technology. Sensors are placed at the corner of the field and at the center as the soil characteristics varies from one point in the field to another. In [2], a serried sampling of the soil is done to check the nutrients present. By using the classical mathematical statistics, the soil characteristics is determined with utmost accuracy. A mathematical model has been proposed which calculates the statistical means of the nutrients present in the soil. Experiments are done and results are obtained which show appealing outcome.

In [3], a soil sample from one meter depth is considered for testing. IoT sensors are used to sense the values of pH, moisture, N, P and K. A GSM module carries the sensed data to a web-based server by making use of Arduino. The sensed values are compared with the standard data set values and the recommendation is given. This information is sent to the farmer through SMS. In [4], a decision tree ID3 algorithm is used for soil nutrient management. The experiments and results shows that the algorithm can be used to accurately calculate the amount of fertilizers that are needed for cultivation. Also the soil nutrient zones can be classified efficiently. The ID3 algorithm uses the information gain rate as the criteria for classification.

In [5], the soil sample is collected using ASD FieldSpec Pro FR. The relationship between nutrients and soil characteristics are analyzed. Inversion model

is used for nitrogen and soil organic. The experiments and results showed that the information on nitrogen and soil organic can be read remotely using IoT sensors.

## III. SYSTEM PROCESS

The soil quality differs from one geographical region to another. The nutrients present in the soil may not be suitable for all the crops. And hence cultivation of crops is dependent on location. And sometimes the soil lack required nutrients required for the crop growth. And to increase the productivity, the farmer has to put fertilizer containing required nutrients. The nutrient requirement for the growth of crops is dependent on geographical locations, time of year, soil management and climate. Hence, the management of nutrients includes methods for applying N, P, and K to satisfy field specific requirements of any crop for supplemental nutrients. Proper guidelines and recommendations are to be provided which allow farmers to decide the quantity of fertilizers and the time at which it has to be added to the soil.

The process of calculating the amount of nutrients required by a crop involves a series of steps. The farmer has to first set a target on his yield and then he has to identify what amount of nutrients are to be supplied to achieve his set target. The amount of nutrients existing in the soil is also important while calculating the deficit nutrients. These steps are to be followed for obtaining good productivity and yield. The steps are as follows:

1. Set a yield target A farmer before making use of SSNM, has to choose a suitable crop that can grow well in the chosen cultivation land. Then he has to set a target on the yield which is based on soil quality and his experience. The target set should be attainable, otherwise he may not get the expected yield. And sometimes because of excess amount of fertilizers, the crops may get destroyed, thereby resulting is less yield. Now the farmer has to test the soil characteristics and has to decide the action on how his target can be achieved. The amount of nutrients is decided and accordingly is applied to the soil. Setting the yield target is most important as it can help farmer on his budget plan.
2. Usage of existing nutrients SSNM recommends the use of natural nutrients that exists in the soil,

manure, leaves residue and water. The amount that is needed on top of existing nutrients is to be calculated and can be provided accordingly. The natural source is considered to be the best for any crop growth. It provides a healthy development to the crops when compared with the artificial nutrients that are put to soil. Hence efficient use of existing nutrients is done first to get expected yield target

3. Applying suitable fertilizer based on requirement Fertilizer N, P and K are applied to fill the gap between the natural source of nutrients and the yield to be achieved. If there is any miscalculation in the quantity of fertilizer that is applied, then the target may not be reached. The quantity of fertilizer needed is calculated based on the yield target and the existing natural nutrients. The fertilizer is added to maintain the fertility of soil. There are certain considerations while applying fertilizer to soil which gives better yield when followed.
  - Apply only a small amount of fertilizer N during the early stages of crop growth
  - Later as the crop grows, find the amount of N needed based on the leaf color chart (LCC) and apply N accordingly.
  - Apply fertilizer P at the beginning or during plant growth whichever seems to be advantageous. Fertilizer K can be applied in two halves one at the beginning and the other during crop growth.

#### IV. EXISTING SYSTEM

Currently farmers don't have access to the soil test directly. They have to take the soil to the center and get it tested. It may take few days to get the report. This process is cumbersome to the farmers as the centres are not situated at every villages and they have to frequently visit soil testing centres at different stages of crop growth. The process that is followed at the testing centre involves soil titration and usage of LCC.

##### A. Soil Titration

The farmer collects the soil from every region of his land. The regions will be equidistant or there may be fixed regions as recommended by the testing center. The soil is taken to the center, wrapped in a tissue

paper and is dried for 2 to 3 days. A solution is prepared by using this dried soil. By using titration method the level of nutrients in the soil is calculated. The color of the soil solution determines the nutrients present. This is a laboratory procedure and needs expertise in the field. A farmer cannot perform the titration process.

##### B. LCC

The leaf color chart provides details about the amount of N, P and K concentration present in the leaves. A LCC is shown in Figure 2. LCC has different shades of green with corresponding levels of N, P and K. If the farmer finds that the leaves doesn't have proper nutrient content, then he will use suitable fertilizer whichever is lacking to increase the amount of N in the soil. Nitrogen is most important at every stage of plant growth. Nitrogen has to be applied at every stage of crop growth as it is a vital nutrient that helps is better yield. Similarly Potassium and Phosphorus are also needed in the right amount for better yield.

Separate leaf color charts are available for N, P and K. These charts are standardized based on the research and experience of researchers and farmers in the past years. It is quite difficult for a farmer to understand the



Fig. 2. Leaf color chart

LCC and its comparison results. The concerned personnel at the soil testing center compares the color and then gives a report to the farmer which can be easily understood by the farmer about the level of nutrients that are to be applied. This is a simple and cost-effective method that is used to determine the level of N, P and K.

V. METHODOLOGY

SSNM is implemented using IoT and web application. Various IoT devices are made use of in developing the proposed system. The microcontroller used is Arduino and the Wifi module used is ESP8266. A TCS230 color sensor is used for sensing the soil solution color. This system can easily be operated by a farmer if he is given proper guidance regarding the setup. The system architecture diagram is shown in Figure 3. Brief details about the devices used are as follows:

A. Arduino

Arduino is a microcontroller which is used in many IoT applications. Its is easy to use as well as program. The code is directly loaded onto the memory of Arduino. This device doesn't need an operating system to function and hence boots fast. Any number of times the program can be loaded onto the memory. Many students and hobbyists are using Arduino for creating wide rage of projects. It is inexpensive and supports many sensors. The program is written and loaded by making use of Arduino IDE. The program can be written using Python, C or C++. Arduino comes in different variants such as Uno, Nano, Redboard, Leonardo etc.

B. ESP8266 NodeMCU

NodeMCU is a development board that comes with 128 KB of RAM and 4 MB of flash memory. Program can be loaded onto it which can run without an underlying operating system. It is of smaller scale as compared to Arduino with respect to memory, processing power and number of input and output pins. NodeMCU is mounted with a Wifi module which can be used for Wifi based IoT applications.

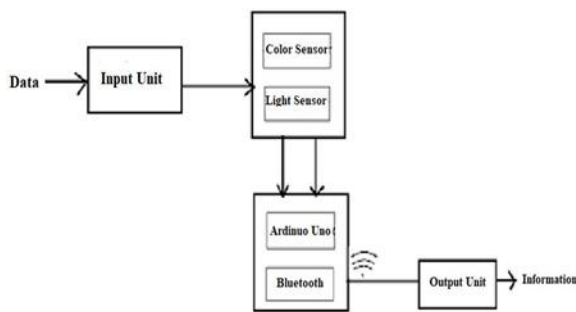


Fig. 3. Architecture diagram of SSNM

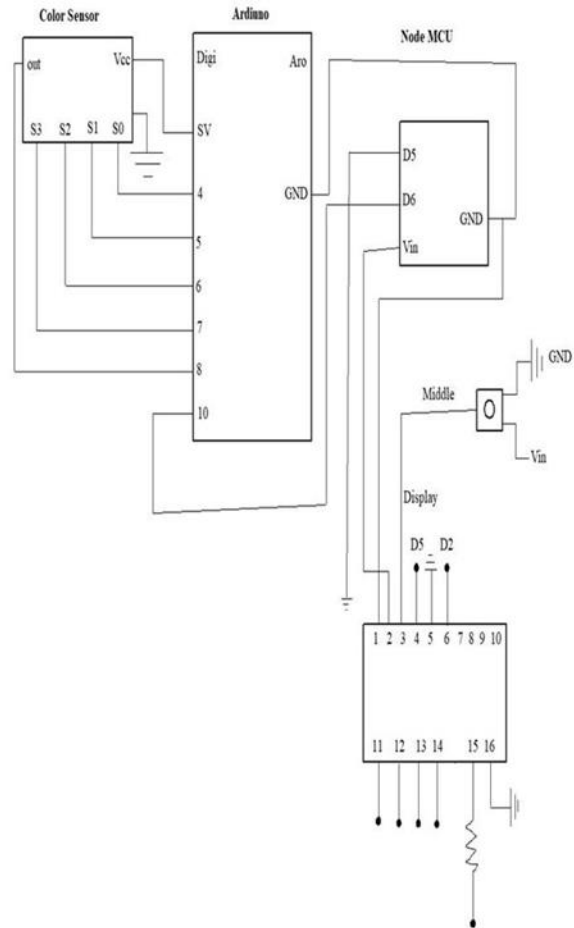


Fig. 4. Circuit diagram of SSNM

Comparatively NodeMCU is cheaper than Arduino which makes it a better choice when the number of sensors to be connected are less. NodeMCU can be used as an extension for Arduino when the number of sensors connected are more. This board supports realtime operating system functions.

C. TCS230 color sensor

The TCS230 is a color sensor which makes use of 8 x 8 array of photodiodes for light sensing. The sensed light is converted into a waveform which can then be processed by Arduino to detect the color of light.

Apart from these devices a LED display device is used which displays the color value in RGB format. The Arduino, NodeMCU and the color sensor are connected as shown in circuit diagram in Figure 4.

VI. RESULTS AND ANALYSIS

The implementation of the SSNM system is done using IoT devices. The soil is collected and solution is prepared in a test tube and it is held in front of the color sensor to sense the color. The color sensor sends the data to the Arduino microcontroller which processes



Fig. 5. Hardware connection on a breadboard

the input data to render the color values in RGB format. A display device is also connected which shows the RGB values of the soil solution. The hardware connection is shown in Figure 5. The devices are connected using a breadboard.

The current implementation is limited to the detection of color values and identifying the soil nutrient content. This work can be extended so that the farmer can receive the information about the amount of fertilizers N, P and K that are to be supplied to the soil. By considering the yield target as input, the system could be developed to calculate the deficit nutrients that are needed based on existing nutrient contents in the soil. The whole process of soil monitoring and calculating the amount of fertilizer can be automated using this IoT setup. And even the information can be sent through a SMS on farmer's phone which would be more comfortable and convenient.

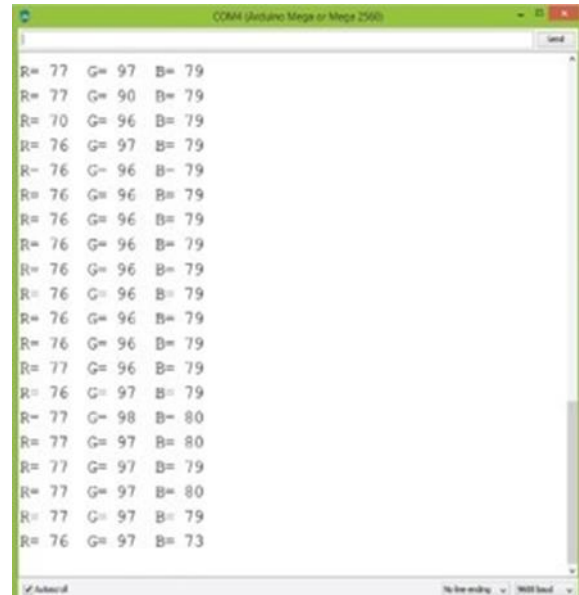


Fig. 6. Terminal output of SSNM

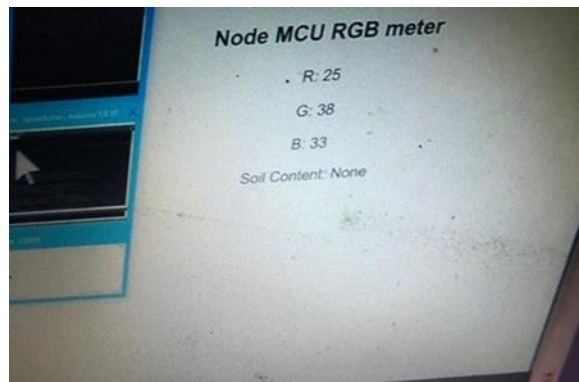


Fig. 7. Webpage output of SSNM

Apart from showing the output on a LED display device, the implementation also outputs the result on the terminal window. Continuously the color is sensed and the values of RGB are output on the screen. This is shown in Figure 6. The terminal output is for testing purpose for the developer and is of no concern to the farmer. The implementation shows accurate color values that is sensed by the color sensor.

The data that is sensed and processed is sent to the web server from where it can be accessed by an end user. The web page displays the RGB values and the soil content. The information on the color and the corresponding soil content has to be stored in the database. The program makes a match with the correct values of RGB and outputs the result. The recommendation on the quantity of nutrients that are

to be applied to soil could also be included in the web page. The web page output is shown in Figure 6. The results are compared with the historical values and the output seems to be promising. The implementation could be designed as a product which will be easy to use and manipulate the results.

#### CONCLUSION

The process of checking the nutrient level in the soil is a tedious task to farmers as it involves many procedures to be followed at the soil testing center. The farmer has to spend many days before he gets the soil test report. This process is made easier with the use of IoT devices and sensors. The farmer can now collect soil samples and make a soil solution in a test tube and can check the nutrient levels at his location. He don't have to take repeated assistance from the experts in making use of this proposed system once he is used to it. The hardware setup is inexpensive and can be owned for private purpose. The complete setup is portable and easy to relocate. The information regarding soil nutrient level is obtained through SMS or through web page.

The information on the amount of fertilizer to be applied could be obtained by the farmer at his fingertips. The complete assistance regarding soil monitoring and fertilizing is automated so that farmer finds it easy to achieve his targeted yield.

The SSNM removes the use of LCC by embedding the color sensing part in the implementation. If every farmer makes use of the technology, then there would be a drastic rise in the yield and growth in the economy.

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