International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 10 Issue 6 ǁ 2022 ǁ PP. 937-942

Agriculture Based Soil Nutrient Analyzer and Water Resource Prediction System Using Machine Learning And Iot

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Abstract — *Agriculture plays a most important role in the economic development of our country in present day. Crop yield primarily depends on soil fertility and moisture content level. Fertilizers are normally depends on the nutrient present in the soil. To recommend a suitable fertilizer level, the soil nutrient analysis is important which is done mostly using laboratory uses. Manual methods of measuring soil nutrients are time requiring. More farmers refrain to perform soil testing in the laboratory and grow the same crop in the land continuously, hence soil loses its fertility. A system has been proposed to adopt precision agriculture using IOT, which enables remote monitoring of soil fertility and other parameters namely soil moisture, pH and temperature. This data is transmitted to the cloud and the corresponding values are displayed on a Display. The proposed Internet of things (IoT) depends software system has the intelligence to recommend the quantity of water and fertilizer which develops the quality of the soil and ensures optimum growth of the crop.*
Keywords - *MoistureSensors, Water Level Sensor,Minerals Sensor, PH Sensor, Arduino.*

Date of Submission: 02-06-2022 Date of acceptance: 14-06-2022

I. INTRODUCTION

Agriculture is the origin for food production. Soil is a precious resource in agriculture. The physical and chemical states of soil play a important role in the production cycle. One of the valuable tools for farmers to develop the crop productivity is the soil analysis. In this regard, soil checking plays a vital role for crop growth. Farmers can add natural or unnatural nutrients to the soil in right proportion. Yield maximization mainly based on soil Macronutrients namely Nitrogen (N), Phosphorous(P) and Potassium(K). Over and under provisioning of the fertilizer can greatly reduse the production rate and results in inferior quality of agricultural products. As population increases, the demands for agricultural produce increases. In order to increase productivity, it is essential to automate agricultural practices.

The quality of crops must be maintained by adding adequate number of fertilizers. The existing values of NPK in the soil decides the quantity of fertilizers to be added. Soil parameter measurement is extremely important for site-specific applications in the agricultural farm areas. Traditional farming is transforming into smart farming due to the prominence of Internet of Things which imparts wireless technology, to checks various soil parameters. With the advent of technology, precision farming allows to meet the ongoing demands for crops. Low cost and less manpower are the key factors that enhances the need for precision agriculture. stable monitoring of NPK values along with pH, temperature and humidity of soil maintains crop quality and facilitates farmers to increase their cultivation. Existing systems provides results only for specific crops or lack measurement of certain parameters.

The prominent features of the proposed system are:

1. An all-in-one real-time soil monitoring system supporting all kinds of crops.
2. The soil macronutrients - Nitrogen, Phosphorous and Potassium, and other soil properties namely moisture, pH and temperature will be determined using sensor.
3. The system is integrated with Arduino and NodeMCU (ESP8266) using Amazon Web Services (AWS) IoT cloud for data storage.
4. A user-friendly mobile application is developed to display soil information and the recommended quantity of fertilizers for different crops according to the level of nutrients present in the soil.

This paper discusses the methodology and solution employed to clear the problem. Hence forth, we will discuss the results and how the mobile application helps to see the nutrient values, pH, temperature and moisture of the soil in real-time and suggest the required number of fertilizers for the desired crop.

II. RELATED WORK

The soil parameters like temperature, moisture, pH, humidity and light are monitored using various sensors. The values obtained are converted to digital using an Analog to Digital Converter and serially sent to the cloud through a Raspberry pi. Finally, the output is displayed in the laptop or in a mobile application. The system supervises the overall soil characteristics with the aid of IoT. In order to maintain efficient crop productivity, soil parameters namely: pH level, soil moisture, temperature and humidity are continuously checking using sensors. A system is designed where the fertility of soil is improved, and the quality of the soil can be increased by the development of optical transducer. The amounts of NPK are obtained as low, medium and high. An Arduino microcontroller is used for data acquisition and the analog output is converted to digital.
A system is designed where a microcontroller-based device is connected to the EC sensor, pH sensor and a colour sensor. The values are read from the sensors and transmitted to a mobile application over Bluetooth serial communication. A system used for the detection of the soil parameters and the pH level with the aid of artificial neural networks and image processing techniques respectively was proposed. The method involved in this system consists of the usage of a colour recognition method in order to develop a soil nutrient analyser and to determine pH.

III. PROPOSED SYSTEM

In this proposed system, the nitrogen sensor and pH sensor are used to detect the soil nutrients. Arduino is the central control unit that controls and coordinates all the associated devices used for suggesting the crops is used to suggest where we can get quality seeds in nearby location. The parameters which are sensed by the sensors are fed to the Arduino. Which in turn will transmit the data to the cloud through ESP8266. The user can view the data via a mobile or a computer. Details such as the soil type and suitable crop are displayed.

A. METHODOLOGY

The main aim is to analytically view the moisture and nutrients of the soil. Figure 1 explains the block diagram of the proposed system where different sensors are connected using the Arduino microcontroller and ESP8266 Wi-Fi module. The Node MCU is connected to the Arduino via Tx and Rx pins for transmission and receival of sensor data. The data from the sensors are sent to the AWS cloud. AWS IoT offers device SDK's for transmitting the sensor data. MQTT connection is provided for sensing devices by AWS IoT which allows users to connect these devices to the Internet for processing and exchanging data which ensures data security and maintains reliability. Wireless Sensor Networks consists of embedded devices which are connected to empower several facilities for measurement at low power and minimized effort.

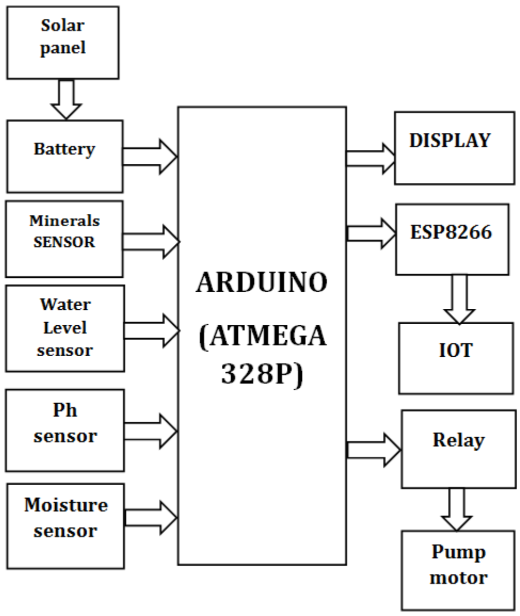

Figure.1. Block Diagram of the Proposed System

When we implement the system for real time tests, theactual implementation for soil analysis with the hardwareconnectionisasshownonFigure3.

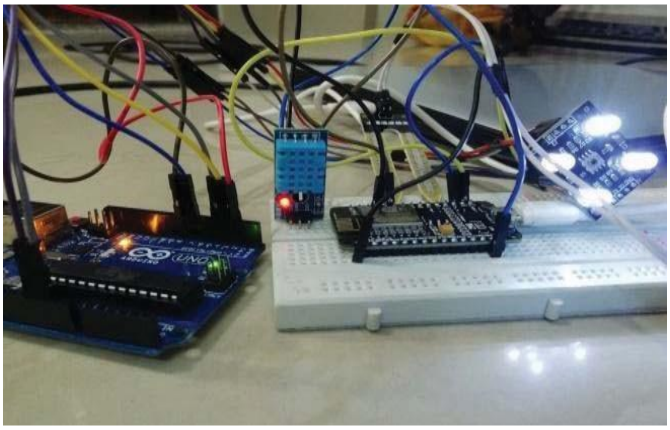

Figure.2. Breadboard Testing Phase of proposed system

AWS is a cloud platform, which enables developers to create, deploy and manage applications on the cloud quickly and easily. AWS cloud resources are accessible with proper security. Cost efficiency, reliability, storage, speed, backup, recovery and easy accessibility are the benefits of AWS cloud. Further, a mobile application is developed which provides information about the various characteristics of the soil and using this information, the farmer would make the right decision in growing the appropriate crop.

The stepwise procedure can be summarized as follows: 1 Open Arduino Droid IDE
2 Select ESP 8266 microcontroller for designing.
3 Write code in Cor CPP in editor window.
4 Compile code on Arduino Droid.
5 Attach ESP8266 to computer port.
6 Now attach DHT11 and Soil Moisture sensor to the ESP8266. (NodeMCU)
7 Upload the code on ESP 8266 to run the code.
8 Now check the readings on serial monitor.
9 Uploading of readings on cloud will take place automatically as per code.
10 Now sign in to your cloud page and see readings at variables which you have already created.
11 Take screen shot of those values.
12 Continue the from 8th step to take next readings.

SOIL MOISTURE SENSOR

In order to measure the volumetric water content in the soil, the soil moisture sensor is used. The soil properties like electrical resistance or the dielectric constant are determined depending on which the soil moisture is evaluated.. The soil moisture sensor contains two probes. The moisture value is obtained by inserting these probes into the soil. The data obtained from the sensor acts as a support system for farmers to manage theirrigation system more effectively. The specifications of the moisture sensor are mentioned in table 1.

TABLE 1. SPECIFICATIONS OF SOIL MOISTURE SENSOR

Sensor Model	FC28
Range	0-1023
Soil Probe Dimension 6	6cm×3cm
PCB Dimension	3cm×1.5cm
Input Voltage	3.3- 5V
Output Signal	Analog

NPK TESTER

In order to test the quantity of nitrogen, phosphorus and potassium present in the soil, the soil fertility tester is used.

The use of the above elements are as follows:

Nitrogen – Helps in promoting the growth of foliage and vegetation. It plays a major role in photosynthesis and protein production.

Phosphorus – Helps in promoting the growth of roots and surviving unpleasant climates.

Potassium – Helps in promoting fruiting, flowering and translocation of sugars.

The soil fertility tester must be implanted in the soil. A chemical reaction would take place, resulting in a change in the analog deflection voltage which is then converted to a digital value.

The formula below can be used to obtain the N, P and K values:

$Nm = \underline{(Av - Ncurr\_low) \times (Ntgt\_upp - Ntgt\_low} + Ntgt\_low$. $(Ncurr\_up - Ncurr\_low)$

Here Nm – Measured Nitrogen (in ppm)
Av – Analog voltage measured by the sensor Ncurr_low – Lower bound of value's current range Ncurr_upp – Upper bound of value's current range Ntgt_low – Lower bound of value's target range

SOIL TEMPERATURE SENSOR

In order to measure the temperature of the soil, the soil temperature sensor is used. These sensors have a variety of designs using thermocouples and thermistors. The voltage reading across the diode shows the working base of the sensor. The sensors transmit electrical signals which are converted into various units of measurement like Celsius, Kelvin and Fahrenheit. The voltage differences are amplified, and an analog signal is generated by the device which is directly proportional to temperature. The specifications of soil temperature sensor are listed in table 2.

TABLE 2 SPECIFICATIONS OF SOIL TEMPERATURE SENSOR

SensorModel	DS18B20
Range	-55°Cto +125°C.
Accuracy	±0.5°C
Cablelength	36 inches

SOIL pH SENSOR

The pH value in soil assumes whether the soil is acidic or basic in nature. The pH value of the soil influences the availability of nutrients and microorganisms. The range of the pH value is between 0 to 14, where 7 indicates neutral. The pH value less than 5.5, indicates strong acidity, pH value less than 6.5 indicates moderate acidity, pH value from 6.5 to 7.5 indicates neutral, pH above 7.5 indicates alkalinity and pH above 8.5 indicates strong alkalinity. An electrical potential difference is obtained between a pH electrode and a reference electrode, which is used for displaying the pH value. The specifications of soil pH sensor are listed in table 3.

TABLE 3. SPECIFICATIONS OF SOIL pH SENSOR

Range	0to 14
Numberofsamples	5 to 10samplesperarea
OperatingEnvironment	−40°Cto50°C
Responsetime	<= 1 minute

IV. RESULTS

The output for various soil parameters for different soil samples are obtained through this system and the recommended quantity of fertilizers are suggested which minimizes the usage of excess fertilizers thereby, maximizing the yield. With the development of technology, accurate results are obtained which improves the cultivation. Thus, precision agriculture makes farming practices more precise by providing real-time responsive data. Figures 5 illustrates the results of the soil moisture obtained from the sensor and figure 6 shows the graphical representation about the percentage of soil moisture present in the sample.

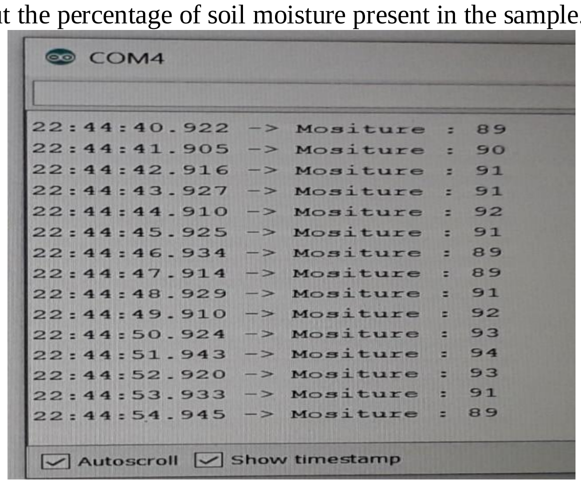

Figure. 5. Moisture value shown in Arduino IDE

TABLE4.NUTRIENTVALUESFORDIFFERENTSAMPLES

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

TABLE5.FERTILIZERRANGEFOR NITROGENINSOIL

FertilityRatingforNitrogen	
Levels	**Range**
Low	0– 280Kg/ha
Medium	280 –450 kg/ha
High	>450kg/ha

TABLE 6. FERTILIZER RANGE FOR PHOSPHORUS IN SOIL

FertilityRatingforPhosphorus	
Levels	**Range**
Low	0– 11kg P/ha
Medium	11–22 kg P/ha
High	>22kgP/ha

TABLE7.FERTILIZERRANGEFORPOTASSIUM INSOIL

FertilityRatingforPotassium	
Levels	**Range**
Low	0–118kgK/ha
Medium	118–280 kgK/ha
High	>280kgK/ha

Table 4 represents the nutrient values for different soil samples and tables 5, 6 and 7 shows the ranges of NPK which ensures the farmers to grow appropriate crops and increase cultivation.
Recommendation system aids farmers to apply right quantity of fertilizers that ensures optimum usage. Consider Nr, Pr and Kr to be the ideal values of Nitrogen, Phosphorous and Potassium for a given crop and Nm, Pm and Km to be the measured values of Nitrogen, Phosphorous and Potassium.
The difference between the ideal and measured nutrients are obtained using the following formula:
Let the difference in the values of measured and ideal Nitrogen be Nf

$$Nf = Nm - Nr$$

Let the difference in the values of measured and ideal Phosphorous be Pf

$$Pf = Pm - Pr$$

Let the difference in the values of measured and ideal Potassium be Kf

$$Kf = Km - Kr$$

Based on this difference, the amount of fertilizer is recommended, and the values are displayed in the mobile application.

V. CONCLUSION AND FUTURE ENHANCEMENT

This system monitors and reports the soil moisture, N, P, K, pH, and temperature values in real-time. Hence a software system is proposed which displays the measured values of soil parameters and provides fertilizer recommendation for growing a desired crop. For progressive growth of a crop, in addition to soil macro-nutrients (like N, P and K), several micro-nutrients like copper, iron, manganese, molybdenum and zinc are also required which impacts the yield. The system can be expanded to measure these factors with proper integration of other additional components along with proper specifications.

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