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Soil Health Testing using IOT Devices

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Abstract

For proper farming, soil testing has become a need. There are numerous soil testing procedures available. Soil quality used to be performed in companies and research institutions, and it required a years and a lot of work to get findings. Soil testing using numerous moveable sensors is now possible in today's environment, thanks to technological improvements and digitization. The internet of things has made it easy to link devices to the network. Soil health testing is one of the most contributing factors in farming. In this paper, we are talking about detecting soil health using some of the IoT devices. This technique is one of the prominent reasons why precision agriculture is being enthusiastically adapted by a huge number of farmers these days. Here we will discuss the existing methods used for testing of soil health and the proposed system with some of the IOT devices which might help enhance the process of soil testing.

Keywords: Internet of Things, Soil Testing, Soil Moisture, agricultural area, crop production, DHT11

INTRODUCTION

Years of farming have eroded the soil's rich diversity and nutrition. As a result, combining agriculture with technologies has become critical in order to reclaim fertility. In this digital age, the agriculture sector is undergoing a radical transformation and is reliant on precision farming. Robots, sensors, GPS, data-analytics software, and many different types of technologies are being used to produce healthier crops with greater yields. This has the ability to move this industry to the next section of productivity and profitability. Precision farming is another way to embrace the theory of IoT in agriculture. The farming activities engaged in conventional farming include watering fields, cultivating crops with necessary fertilizers, andso on. These procedures are carried out by hand.

[1, 2] Crop production is primarily determined by a farm's soil health. This is a useful tool for farmers. This determines soil fertility for more efficient and cost-effective crop production. Soil testing allows us to determine the nature of the soil, whether this is acidic or base, and which crop will produce the most in that soil. The plant rate of nutrient absorption can be predicted and decided on the type of minerals which are available in the soil. There is a deterioration in crop production due to insufficient levels of nutrients. Macronutrients are a great need for the nutrients needed for the growth of plants. Proper use of fertilizer is also needed for better growth. Over usage of fertilizers leads to the reduction in harvesting production rate. In many parts of India, manual fertilization is still preferred.. This type of hand-made fertilizer makes the soil condition even worse. The demand for food and Crop production is increasing rapidly. The type of crop and growth of plants is the deciding factor of the quantity. Farmers measure the nutrient content of the soil in order to obtain soil nutrients and select the right crop several times to plant in the agricultural area so that they can maintain soil health and crop production.

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THE EXISTING SYSTEM

Determining soil health tests, a scientific approach for rapidly detecting soil fertility and estimating which Crop Yields would be suitable for the need for plant nutrients, refers to chemical analysis in the soil. Other characteristics including surface, composition, pH, exchangeable cations, water level, electrical properties, and chemical degradation factors are tested in order to prescribe soil additives like alkaline soil gypsum and acidic soil mortar. The majority of soil testing procedures are of two categories [3–5].

Soil Testing in Laboratory

Soil testing in the laboratory is a method wherein samples of soils are brought up in the laboratory fortesting. It may take days or weeks to test the soil, depending on the nature of the soil. The farmers take the samples of soil and give them to the laboratories for soil testing purposes [2]. The NPK values of soil are detected by using chemical analysis.

Soil testing on Mobile

In this type people test and make recommendations about fertilizer-related tests and are done once per crop. Hence, this method is not suitable for the effective production of crops and it doesn't give accurate results. The following three methods are used for detecting the soil fertility. They are as follows:

1. Spectroscopy
2. Conductivity and
3. Electrochemical sensor methods.

These are cost effective and won’t give any accurate results [3].

SOIL HEALTH PARAMETERS

Key factors such as the need to balance food production to meet growing population needs, existing food security threats, and climate change affecting crop production encourage farmers to look for new ways to increase productivity and productivity.

The top priorities of smart agriculture using IoT focuses majorly on soil, weather, moisture, temperature, nutrients, and crop conditions. Following are some of them:

Soil Temperature: The temperature of the soil affects the growth of root, inhaling, decomposition, and mineralization of nitrogen. Farmers must ensure that the mostoptimal temperatures are used when planting and fostering crops in order to maximize productivity. Low-temperature sensors and equipped with wireless technology such as infrared can provide farmers with official updates on soil temperature if properly maintained.

Soil Moisture: Water is an essential source of nitrogen for all plants and is required for photosynthesis. Soil moisture also regulates soil temperature, which has a large impact on crop yield. Entombed probes with electrodes aid in the accurate monitoring of soil moisture content. IoT sensors that approximate soil moisture can supervise and automate irrigation while also collecting data on soil humidity and temperature..

NPK Measurements: Nutrients like nitrogen, potassium and phosphorus can also be detected by IoT sensors. Farmers can detect nutrient deficiencies and determine whether additional nutrient content in the soil is required to increase crop fertility. These sensors are relatively new to the market and employ a range of techniques to maximize accuracy. These sensors, in addition to monitoring NPK content, aid in detecting the pH level and contaminant content of the soil. As all of these sensors can detect disturbances in soil nutrient content in real time, they are important in farm fields, greenhouses, and research of soil.

Solar Radiation: Another significant use of IoT in the agriculture sector is to calculate various types of solar radiation. The amount of heat emitted by the sun that surrounds the ground is referred to as solar radiation. It is important for photosynthesis of plants and hence has a huge effect on productivity of crops. The amount of radioactivity that soil receives and absorbs influences soil temperature fluctuations as well as soil moisture evaporation. Cultivators can use IoT instruments to monitor photosynthetically active radiation (PAR), ultraviolet (UV) rays, as well as shortwaves to better understand correlations and trends [4–6].

Weather: Environmental factors such as rainwater, wind direction and speed, humidity, snowfall temperature, and air pressure all have an impact on farm productivity. Growers can collect data on a regular, automatic, and remote basis using IoT-based connected devices. They provide in-depth, data-driven insights into farming conditions, making farming more accurate and scientific. It also allows growers to optimize the available resource utilization, eliminate waste, and save the time and money of labor.

PROPOSED SYSTEM

The system proposed here is totally IoT based with which can be tracked and displayed on mobile devices. The microcontroller here is the system's main component. The microcontroller used for the proposed system is the Node MCU with ESP8266 Wi-Fi shield and sensors used are temperature and soil moisture along with light intensity. The system is cheap and is simple to use. Data is collected from sensors and uploaded to a server, where it is used to draw a graph. We can use this system for a variety of purposes by connecting various devices such as water pumps, and we can control it with our mobile phone that has internet access [5–10].

Here, we have used the microcontroller Node MCU 1.0 (ESP826612E) WIFI shield module and the different types of sensors which are as follow:

1. Soil moisture sensor
2. pH Meter
3. DHT11 - Humidity Sensor.

The system consumes a very small amount of power and is simple to use. The data that is being captured is being tracked with an accurate date and timestamp. The system is built in such a way that we can communicate with our proposed system in real time and offer suggestions to farmers at any required time (Figures 1–6).

Node MCU 1.0 (ESP8266 12E WIFI shieldmodule)

Built-in version of the old Esp8266 WIFI - on-chip system running on the system. Esp8266 EX includes a 32-bit Ten silica processor standard digital peripheral interface, antenna, switches, RF balun, amplifiers, filters, and power management modules. It uses very low power and a clock speed of 160MHZ. It has a power-saving architecture and three modes of operation: sleep, active, and sleep paralysis. Figure 5 and 6. Approximately 80% of processing power will be available through the user application and development due to real-time operating system (RTOS) and WIFI stack shows in Figure 1.

Soil Moisture Sensor-YL-38 + YL-69

Soil moisture reduces the level of moisture indirectly by using another part of the soil as a representative of moisture, such as electricityresistance, dielectric, or indirectly by neutrons in Figure 2. This sensor could be used to test the moisture content of the soil; when there is a lack of water in the soil, the module output is high; otherwise, the output is low. By using this sensor, one can quickly water a flowering plant or another plant that needs automatic watering. The module has three output modes: digital output, analogue output, and serial output with precise readings [10].

Figure 1. Node MCU 1.0(ESP8266 12-E Wi-Fi).

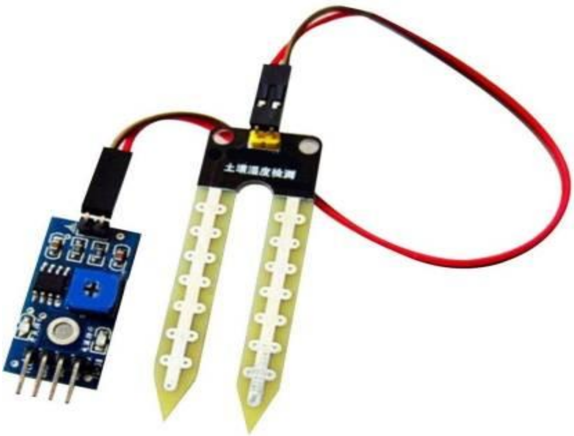

Figure 2. Soil Moisture Sensor.

Soil pH Meter

It is a soil pH meter with two functions. It will provide the soil's moisture and pH. A two-in-one pH meter and soil analyzer is an ideal tool for any farmer or gardener. This handy tool makes it simpleto determine the soil ph. including its moisture content. This tool portrays a clear outline of when to desalinate the soil and maintain an optimal watercontent, which is important for healthy plant growth. The important advantage of this particular tool is that it can be used to tell the pH level of the soil. Individual plants require different pH levels inorder to grow quickly and healthily. This tool evaluates pH and assists you in providing fertilizersas needed shows in Figure 3.

Figure 3. Soil pH Meter.

Temperature and Humidity Sensor – DHT11

The DHT11 sensor is a low-cost humidity and digital temperature sensor. It measures the surrounding air with a thermistor, measures humidity with a capacitive sensor, and outputs a transmitted data (no analogue input pin spinrequired). The only disadvantage of the DHT11 sensor is that we can only get new data from it every 2 seconds, as demonstrated by using the libraries, and sensor readings can be up to 2 minutes old [9] shown in Figure 4.

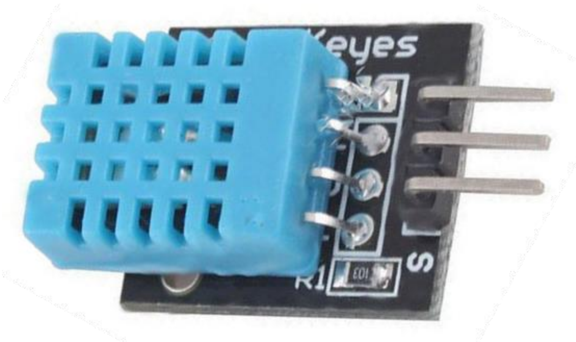

Figure 4. DHT11 Sensor.

ARCHITECTURE OF THE PROPOSED SYSTEM

Architecture of the System

A full explanation and system architecture is the conceptual arranged in a way that facilitates reasoning about the system's structures and behaviours is known as an architecture description.

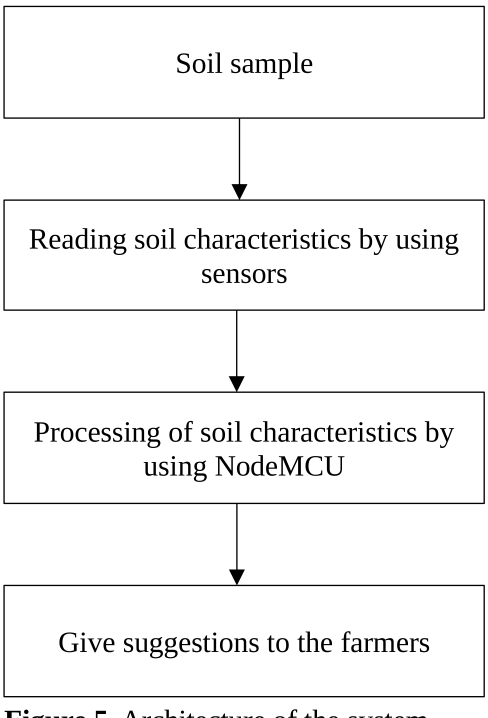

Figure 5. Architecture of the system.

Block Diagram of the System

The following paragraph will discuss about how sensors are used in very low power consumption

Working Principle

The pH Meter, DHT11 Humidity Sensor, Soil Moisture Sensor, and Node MCU Wi-Fi shield start making up the system. The pH Meter in this system is used to measure the pH level value of the soil along with the soil moisture level. If the pH value is greater than 7, the soil is basic; and a value of 7 is neutral, which is ideal for many plants. If the pH level value is less than 7, the soil is acidic. Depending on the pH level, we can advise farmers on which vegetables will produce the most in that specific soil. Figure 7. The sensor's data is sent to the IoT Cloud Platform (Thingspeak.com). In this cloud server engine, we can create a platform that can be used publicly or privately as per the user's choice to display data with the correct timestamp and date [7].

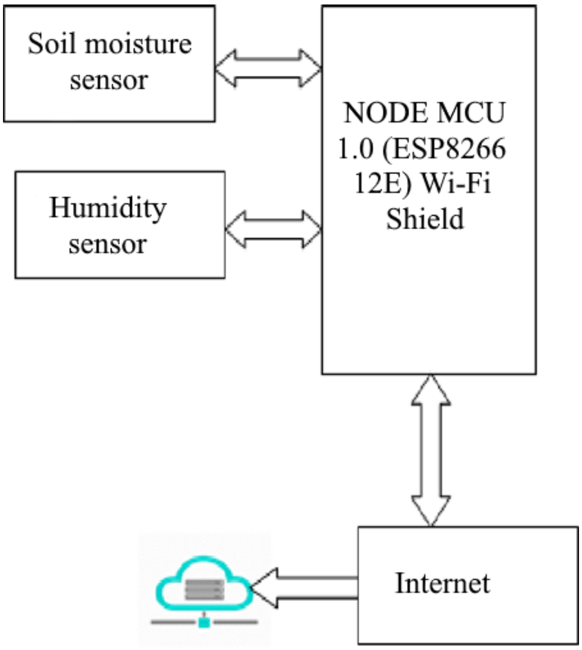

Figure 6. Block Diagram.

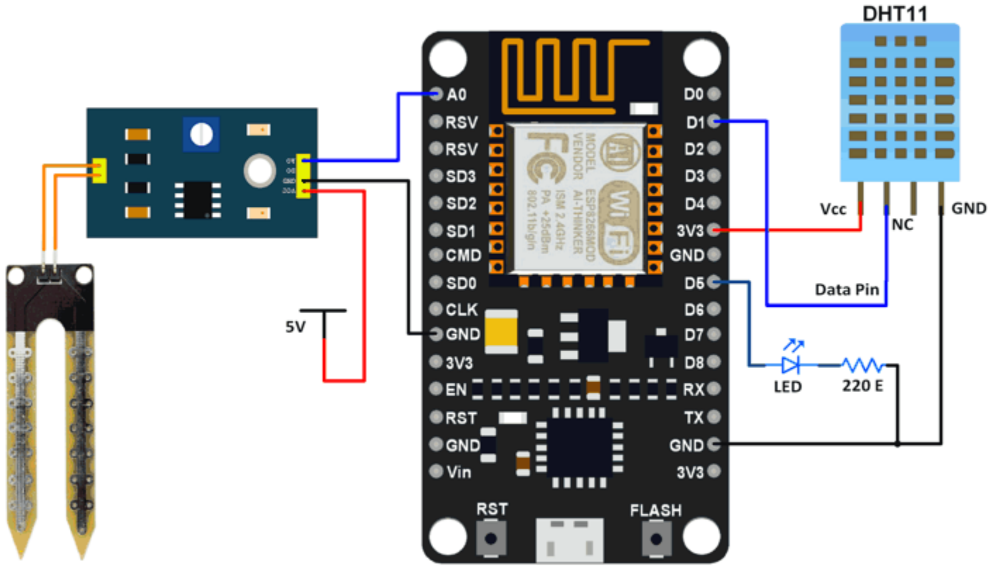

Figure 7. Connection diagram.

METHODOLOGY

This research experiment was conducted at Thakur Institute of Management Studies, Career Development and Research (TIMSCDR) and nearby areas in Mumbai, India. This experiment was conducted to study the use of IoT devices for testing of soil health. We had conducted an experiment with available resources from the college to get interactive and accurate reports aboutthis research.

We had conducted this experiment for a period of 6months and formed our questionnaire as shown in Table 1 and noted the set of observations shows in Table 2.

Table 1. Questionnaire.

Question No.	Survey Question
Q1.	Have you ever used an IoT for soil testingbefore ?
Q2.	Did you find IoT devices favourable ?
Q3.	Was working with IoT devices for soiltesting more beneficial ?
Q4.	Was this method more time consuming ?
Q5.	Is this more financially beneficial ?
Q6.	Does this method produce accurate results ?
Q7.	Did you find the documentation helpful ?
Q8.	Were the IoT devices easily available inyour area ?
Q9.	Do you think there should be more soilhealth parameters ?
Q10.	Would you recommend this method to yourpeers ?

Table 2. Survey answers.

Test No.	Question No.	Yes (%)	No (%)
T1.	Q1.	98%	2%
T2.	Q2.	93%	7%
T3.	Q3.	91%	9%
T4.	Q4.	87%	13%
T5.	Q5.	80%	20%
T6.	Q6.	96%	4%
T7.	Q7.	92%	8%
T8	Q8.	83%	17%
T9.	Q9.	95%	5%
T10.	Q10.	90%	10%

RESULTS AND ANALYSIS

The IoT enabled Soil Testing system using mobile, pH value levels and soil moisture of soil is reliable and capable for monitoring agricultural health parameters. The output can be viewed in the serial monitor of the Arduino unit.

CONCLUSION

The "IoT Enabled Soil Testing" program takes the study of soil moisture sensors and moisture sensors and stores them in a cloud server, where the graph is drawn based on soil fluctuations, temperature and humidity. The detectors and microcontroller have successfully connected to thecloud for IoT Enabled Soil Testing. The data was successfully saved and it can be remotely accessed. All of the observations and experimental setup demonstrate that this is a total solution for testing the soil health parameter. Users can access the data and determine whether there are any variances in pH value and soil humidity. By implementing this system, users such as farmers will be able to monitor and boost the efficiency of their vegetables. The Arduino IDE is used for coding, and WIFI is used to store sensor data in a cloud server called Thingspeak.com. This work can be expanded by incorporating advanced technologies and developing new cost-effective approaches to soil testing.

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