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PH measurement of soil to provide assistance in Agriculture

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Abstract

The paper presents the on go soil pH mapping portable system to map the soil pH profile of the agricultural areas, including hardware, software, and database systems. A CPU and embedded soil sensors are part of the hardware system (GPS, soil pH, soil moisture sensor to record soil profiles) the management of sensing and mapping inputs is to make agricultural production more lucrative, enhance product quality, and safeguard the environment. One of the most significant difficulties of precision agriculture is the difficulty to get soil properties quickly and cheaply. Several academics and firms have sought to produce portable soil sensors that can assess mechanical, physical, and chemical qualities.

Although the sensors are based on electrical and electromagnetic ideas, additional technologies discussed in this study may be ideal for improving the quality of soil-related data in the near future.

Keywords— Soil sensors; Crop; Mapping soil properties

I. Introduction

The interchange of water, energy, and carbon fluxes between the land surface and the atmosphere are influenced by soil moisture, which is an important variable in the earth system and selecting the best crop for a given piece of land to maximize yield. The initiative also focuses on making data analysis easier by georeferencing it. The equipment can sample soil from a moving vehicle in the field, particularly from a tractor's plough linked to a moving tractor, to mix the different layers of soil and acquire the precise measurement. With the aid of electrodes calibrated using accessible standards, the gadget is capable of monitoring the temperature, moisture, and pH of the soil.

Soils with a loamy texture have functionally equal proportions of sand, silt, and clay. These medium-textured soils are frequently thought to be good for agriculture since they are easy to cultivate and maybe quite productive for crop development.

Correspondence

Soil sens is a technology- A low-cost smart soil monitoring device may be of assistance to farmers who are faced with difficult farming decisions.

What is causing the decrease in soil fertility in India?

Rapid decreases in soil fertility are linked to rising food needs, nutrient mining in agricultural regions with the corresponding shifting of produce to cities, and agricultural intensification without respect for long-term fertility management.

II. Sources and Solutions

When fertilizers are applied in the correct amount, at the right time of year, and with the right procedure, the amount of fertilizer that enters aquatic bodies is considerably reduced.

By keeping animals and their excrement out of streams, nitrogen and phosphorus are kept out of the water, and stream banks are protected.

Farmers use chemical fertilizers and animal dung to add nutrients to their fields, which give crops the nitrogen and phosphorus they need to develop and create the food we consume. However, if nitrogen and phosphorus are not properly absorbed by developing plants, they might be lost from farm fields, compromising air and water quality downstream.

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During rain events and when the snow melts, extra nitrogen and phosphorus can be carried off farm fields and into rivers, and it can also seep through the soil and into groundwater over time. Eutrophication of water bodies is caused by high quantities of nitrogen and phosphate.

The system has applications in open farms, greenhouses, gardening, and research and agricultural labs, and can assist enhance the efficiency of water utilization in agriculture. It can provide advice on how to best use water according to the needs of the crop and the land.

III. Literature review

Previous research has compared satellite soil moisture estimates to in-situ sensor data all across the world. Modeled projections have been compared to satellite soil moisture predictions in several investigations.

Over the state of Iowa, the Iowa Flood Center (IFC) runs a high-resolution rainfall-runoff model. The model divides the environment into hillslopes and channel connections, which together constitute a river drainage system.

Soil moisture estimations from satellites provide a chance to "correct" model-based soil moisture levels in space and time. To take full use of this possibility, we must first comprehend the uncertainties in satellite-based estimations and how they fluctuate in space and time.

The temporal variability is particularly prominent in Iowa, where there is a distinct cycle of vegetation growth (row crops of corn and soybean), and it has long been known that vegetation contributes to the uncertainty in satellite soil moisture.

Satellite soil moisture missions offer a once-in-a-lifetime chance to examine the worldwide water cycle. They provide data on soil moisture, which helps anticipate floods and droughts. Estimates of soil moisture, model projections of soil moisture, and in situ sensor readings are three different types of soil moisture data. In contrast to in situ sensor measurements, satellite and model estimates have a broader geographical range, making them more suited to studying soil moisture dynamics and variability.

Brightness temperatures at vertical and horizontal polarizations at 1.4 GHz, which are sensitive to water content in soil and plants, are measured using spaceborne L-band microwave radiometers. To determine soil moisture, the brightness temperature is used with other land surface characteristics. Brightness temperature sensitivity to soil moisture reduces under thick vegetation settings, where plant water column density is high. Even yet, the sensitivity is strong up to and including corn crop levels of vegetation. The time-variant inaccuracies of satellite soil moisture have been studied in a few research.

In the Corn Belt, for example, Walker et al. conducted a seasonal review of SMAP satellite soil moisture. The time-variable biases generated by vegetation misrepresentations in SMAP soil moisture retrievals were explored by Zwieback et al. They investigated errors in soil moisture retrievals over croplands in the United States using a Bayesian variant of triple collocation analysis (TCA). Wu et al. employed TCA to investigate the time-variant errors of SMAP and Advanced Scatterometer soil moisture products more recently.

In general, prior analyses of soil moisture estimations have yielded important information about errors and their origins across the world. Only a few studies, however, have focused on predominantly agricultural regions, where satellite soil moisture products are more prone to inaccuracies.

In the surface water cycle, soil moisture is critical. It is a reflection of the groundwater state and serves as a connection in the water exchange process between the land surface and the atmosphere. Because water is so critical for crop development, being able to estimate and map soil moisture is crucial for precision agriculture and sustainability applications like irrigation scheduling and basin water management. Furthermore, crop yield estimate is influenced by soil moisture.

Soil texture, terrain, land cover, and climate all influence soil moisture. As a result, the moisture content of the soil fluctuates over time and distance. The surface and root-zone soil moisture have a physical connection that is based on diffusion mechanisms. Traditional in-situ soil moisture assessment methods are based on single-point measurements over a narrow region surrounding the sensor. Due to heterogeneity, this point-based technique is ineffective for assessing soil moisture in large-scale regions. Furthermore, establishing dense networks of agrometeorological stations is not cost-effective. Extrapolation of single-point data to larger scales is also time-consuming, difficult, and costly, particularly for diverse regions.

Soil moisture was calculated at large and regional sizes using advanced remote sensing technologies. Optical and thermal techniques, microwave methodologies, and synergistic approaches are the primary groups of remote sensing technologies utilized for determining soil moisture. The link between soil moisture and soil reflectance, or between surface temperature and soil thermal characteristics, provides the basis for optical and thermal techniques. Increased water content in the soil lowers reflection in a nonlinear relationship, according to studies of soil moisture and reflection in various soil types. Drought or dry soil conditions impair the development of plants, making them vulnerable to water stress.

The backscatter and emission characteristics of soil are modified by soil texture, surface roughness, and vegetation in both passive and active microwave methods. Because of variations in the dielectric characteristics, changes in the quantity of water on the target surface impact the scattering and absorption behaviors.

Active sensors offer a larger spatial resolution but a lower soil moisture sensitivity, whereas passive sensors have a finer spatial resolution but a better soil moisture accuracy. Synergistic strategies have been created to overcome the shortcomings of various methodologies by integrating multiple approaches, resulting in improved soil moisture sensitivity. Active and passive microwave data, as well as active microwave and optical data, are frequently employed as synergistic approaches.

In addition, global satellite-based soil moisture databases have been compiled, with the first global multiannual dataset obtained from the European Remote Sensing (ERS) Satellites ERS-1 and ERS-2 scatterometer (SCAT) observations being published in 2003. EUMETSAT's Advanced Scatterometer (ASCAT), JAXA's Advanced Microwave Scanning Radiometer-2 (AMSR-2), ESA's Soil Moisture Ocean Salinity (SMOS), and NASA's Soil Moisture Active Passive (SMAP) are just a few of them. These methodologies and the usage of these datasets, however, have several drawbacks.

Disaggregation of remote sensing data for calculating root-zone soil moisture has been created to overcome spatial resolution constraints. The majority of root-zone soil moisture measurement methods rely on extending surface soil moisture estimates. Essentially, data assimilation methods have been developed by employing satellite-driven surface soil moisture data or global soil moisture datasets directly.

Another study looked at combining disaggregated remote sensing data with land surface or hydrological models to improve root-zone soil moisture estimates. The complicated input parameters of both empirical equations and physically-based models, however, have a significant impact on the accuracy of soil moisture retrieval methods.

Even though access to a wide range of datasets has grown more convenient, most datasets are insufficient for direct analysis. As a result, data refining has become a crucial step before statistical modeling. Even though clustering has been employed in a variety of soil moisture-related applications, it has never been used as a data refining tool.

The following are the major components that were used:

- Customized Microcontroller (ESP8266+ ATMega328p)
- Servos (30 kg/cm and 20kg/cm)
- Bimetallic electrodes (To measure Ph, Moisture)
- GPS Module (Neo-6M)
- Instrumentation Amplifiers

IV. The working principle:

Level I:

Data sampling, sensing, and mapping of the soil in various locations across the field so that the data is available to the farmer and aids in making informed decisions about the crop and the amount of fertilizer to be applied to achieve the desired yield.

Level II:

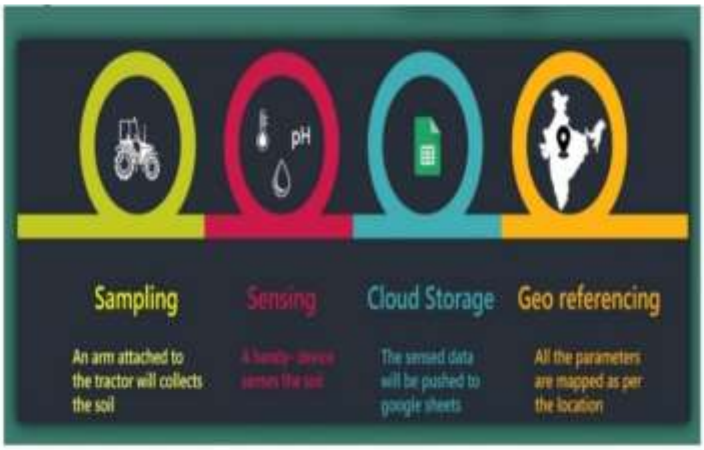
All of the data is saved, and then machine learning algorithms are used to anticipate productive crops and to advise farmers on which crops to plant and how much fertilizer to use so that soil fertility is not degraded.

Soil condition:

The district's soil has been divided into two types: (I) red ferruginous soil and (II) black soil. The soil can be classified into six subdivisions: (I) black clay, (2) black loam, (3) black sand, (4) red clay, (5) red loam, and (6) red sand. These two classes can be split into (I) clay (2) loam (3) sand with finer differences.

Black clay:

The district's most exceptional soil is black. About 23.7 percent of the district is made up of black clay. It maintains moisture for a long time and is quite miry and tenacious when wet. Its genesis is said to be mostly an aqueous lacustrine deposit.



Black loam:

Black loam is a type of alluvial soil that comes in a variety of colours and textures and may be found throughout the area. It makes up 18.2 percent of the district's soil. Because this soil is not very deep, it is prone to erosion by the Vankas (hill streams) in the taluks.

Climatic condition:

Four seasons may be identified throughout the year. The dry and rather a chilly season lasts from December through February. The summer season begins in March and ends in May. The month of May is the warmest of the year. The southwest monsoon follows, which lasts from June to September. The post-monsoon, or receding monsoon season, lasts from October through November. Rainfall: The area receives an average annual rainfall of 685.4mm*. Rainfall in the district normally rises from the north-west to the south-west. The rainy season begins in June and continues until September. September is the wettest month of the year.

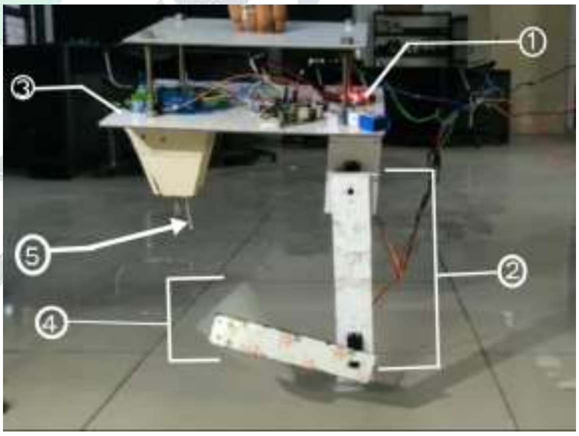


Figure 1: Hardware of Project

1. Hardware control unit
   - ➢ Microcontroller
   - ➢ Wi-Fi module
   - ➢ Amplifiers
   - ➢ Local Storage
   - ➢ Control switch
2. Robotic Arm + Servo motor.
3. Support system.
4. Soil Sample Collector.
5. Sensing Electrodes.

V. Soil moisture sensor:

Soil moisture measurement is the foundation for agricultural refinement to implement water-saving irrigation. Based on its theoretical foundation and research of soil dielectric constant features, a novel soil moisture sensor was developed. Probes, electrical circuits, and wire cables make up most of it. The sensor's calibration was carried out at a working voltage of 2.5 to 5.5 volts. Using the experimental data to assess the regression function, it was discovered that the sensor's output voltage should have a linear negative correlation with the volumetric moisture content of the soil, with R2>0.986 as the coefficient of determination.

Soil samples with varying moisture content were used to test the sensor's accuracy. Absolute mistakes have an average absolute value of less than 2%. The findings reveal that the sensor has a stable and consistent operating performance, high measurement accuracy, and good linearity, and can be used to monitor the moisture in a variety of soil types.

Figure 2:Process of pH

ATmega328 and ESP8266 :

IoT Development Board with ATmega328 and ESP8266 integrated esp8266 Wi-Fi with Atmega328 is inbuilt esp8266 Wi-Fi with Atmega328. It works with the Arduino IDE and the Atmel AVR Studio.

The ESP8266 is a low-cost Wi-Fi microcontroller with a complete TCP/IP stack.

The ESP8285 is an ESP8266 with 1 MiB of flash integrated into it, allowing single-chip devices to connect to Wi-Fi.

Note: This product comes with a free tailored support code for the supplied hardware that will assist you in uploading data to iCloud servers. A Firmware with a Unique ID has already been uploaded to this Development board.

Advantages/Benefits

Embedded systems were utilized to take advantage of microcontrollers and customise the boards that contained them. The possibility to have a 6 channel ADC and internet access to centralise or store data in the cloud was shown. Data storage necessitates the use of the Internet of Things to connect to the cloud. To choose the optimal crop, data will be analysed using Machine Learning techniques.

1) Customized boards design
2) Realtime update in the cloud with respect to change in sensory values
3) Google mapping
4) Hardware sensor module designing
5) Data visualization and security
6) Android application development
7) Internet of Things
8) Smart Farming and Precision Agriculture
9) Machine Learning
10) Local Database

Novel features:

- The first cheap smart farming sensors in the world. Create a network of low-cost sensors that provide the information you need. The most important values should be measured.
- A simple and practical method for sampling soil.
- It is created with the Indian network in mind in the fields
- No data is lost due to the lack of mapping.
- Farmers and residents have easy access to data via a connection.

Country	Crop	Yield increase with lime application, %	Observation
Argentina	Alfalfa	61	
Brazil	Soybean	42	No till; lime applied at the soil surface
Chile	Forage grasses	70	Average of three grass species
China	Cabbage	42	
China	Corn	59	
Ecuador	Pineapple	20	Optimum dose of 0.67 t/A $CaCO_3$; higher amounts induced root diseases
Kenya	Corn	500%	Extremely acidic soil
Kenya	Beans	300%	Extremely acidic soil
Russia	Nine consecutive crops in rotation	As high as 32 (average 14)	Lime applied once during crop rotation cycle
USA	Wheat	35	
USA	Corn	500	

From The Fertilizer Institute (TFI)

Figure 3: After testing soil and following the application of fertilizer so an increase of yield

pH Range		
5.0 - 5.5	5.5 - 6.5	6.5 - 7.0
Blueberries	Barley	Alfalfa
Irish Potatoes	Bluegrass	Some Clovers
Sweet Potatoes	Corn	Sugar Beets
	Cotton	
	Fescue	
	Grain Sorghum	
	Peanuts	
	Rice	
	Soybeans	
	Watermelon	
	Wheat	

Figure 4: Some of the crops based on pH

VI. What inspired us to take up this Innovation?

Because of India's current agricultural crisis, food quality has deteriorated, lowering the product's worth. Farmers' incomes were reduced as a result, and many farmers committed suicide as a result. This demoralised us, so we took a step forward to fix the problem and elevate ourselves to this level. Irrigation advancements have the potential to boost agricultural output to unprecedented heights. Only 20% of agricultural land in the world is irrigated. Despite this, this land produces 40% of the world's crops. The emergence of smart irrigation and soil-moisture monitoring is at the heart of the smart farming revolution, and it will usher in a new era of linked soil.

Farmers are learning how to fine-tune irrigation practices to fit specific soil demands as they begin to embed sensors in the soil. Many farmers, for example, regulate irrigation using the design characteristics of their pivots. They just set the application rate to meet the crop's average maximum need and switch on the water. As a result, they provide close to the proper quantity of water during peak season and over-water in the early and latter stages of the season, with no regard for field changes. The sensors aid in the management of seasonal water application, allowing them to apply less early and late in the season.

Sensors placed across the field can guide differential irrigation rates, resulting in consistent soil moisture, reduced water usage, and improved total output.

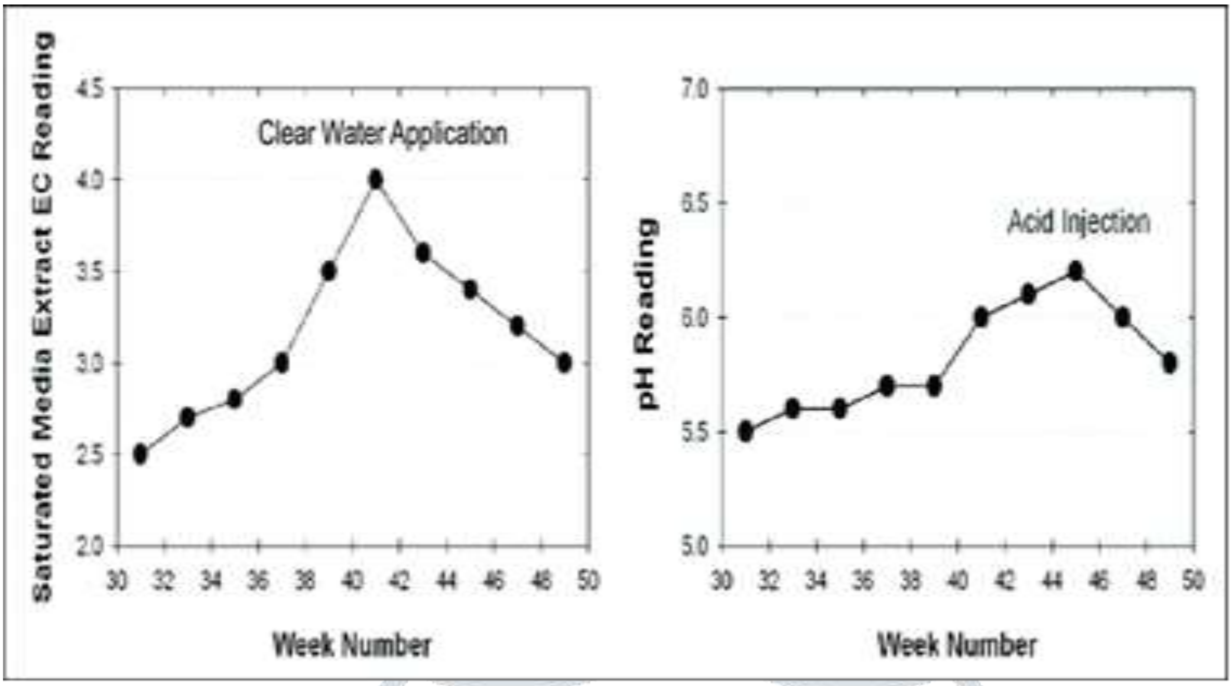


Figure4: Graph showing soil with low ph value and increased ph after applying excellent fertiliser

In India, soil testing is relatively infrequent. This is despite the government of India and several state governments making a concerted effort in recent years to create additional soil-testing facilities, subsidise the cost of testing, and encourage farmers to get their soil analysed. Farmers who had their soil tested were much more efficient in cultivating paddy than their neighbours who had not had their soil tested, according to our research from Andhra Pradesh and Tamil Nadu. Given India's growing usage of chemical fertilisers, spiralling fertiliser subsidies, and growing imbalance in the use of different types of fertilisers, boosting soil testing should be a priority for both state and federal governments.

We also need further study to figure out why farmers don't use soil testing, despite the fact that it appears to improve their efficiency. Is soil testing rare due to supply-side restrictions (such as a lack of testing facilities, poor testing techniques, and findings) or due to a lack of demand from farmers who may not be aware of the benefits.

VII. CONCLUSION

In this study, On-the-go sensors offer the benefit of allowing for non-destructive and quick assessment of soil variability, allowing for more precise soil nutrient management and monitoring. Electrochemical, electrical and electromagnetic, optical and radiometric sensors provide significant promises for real-time mapping of essential soil chemical and physical characteristics to aid precise soil nutrient management and monitoring.

For accurate root-zone soil moisture retrieval in large-scale regions, plants were utilised as a sensory mechanism for determining data clustering contexts based on phenology and soil–air temperature differential. The reference soil moisture and soil temperature data were only utilised to construct the model, while the actual model was built NDVI, NDMI, and LST are remote sensing metrics that may be used to measure solar radiation and air temperature. Importantly, root-zone soil moisture at 30-cm depth was predicted for large-scale agricultural fields without needing soil structure and features data.

If the unfavourable environmental component can be overcome, VIS-NIR reflectance spectroscopy might be used to monitor SOM content in the field. However, soil moisture has a clear impact on reflectance spectra, because it is constantly present in changing amounts, distorting spectra curves and interfering with SOM estimates.

Increased population expansion, along with the growing hazards connected with climate change, necessitates a corresponding rise in agricultural output. The key to completing this difficult task is to assure long-term soil productivity while sustaining high agricultural yields and lowering pollution. Implementing sensor technology for soil nutrient management and monitoring is a step in the right direction in this regard.

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