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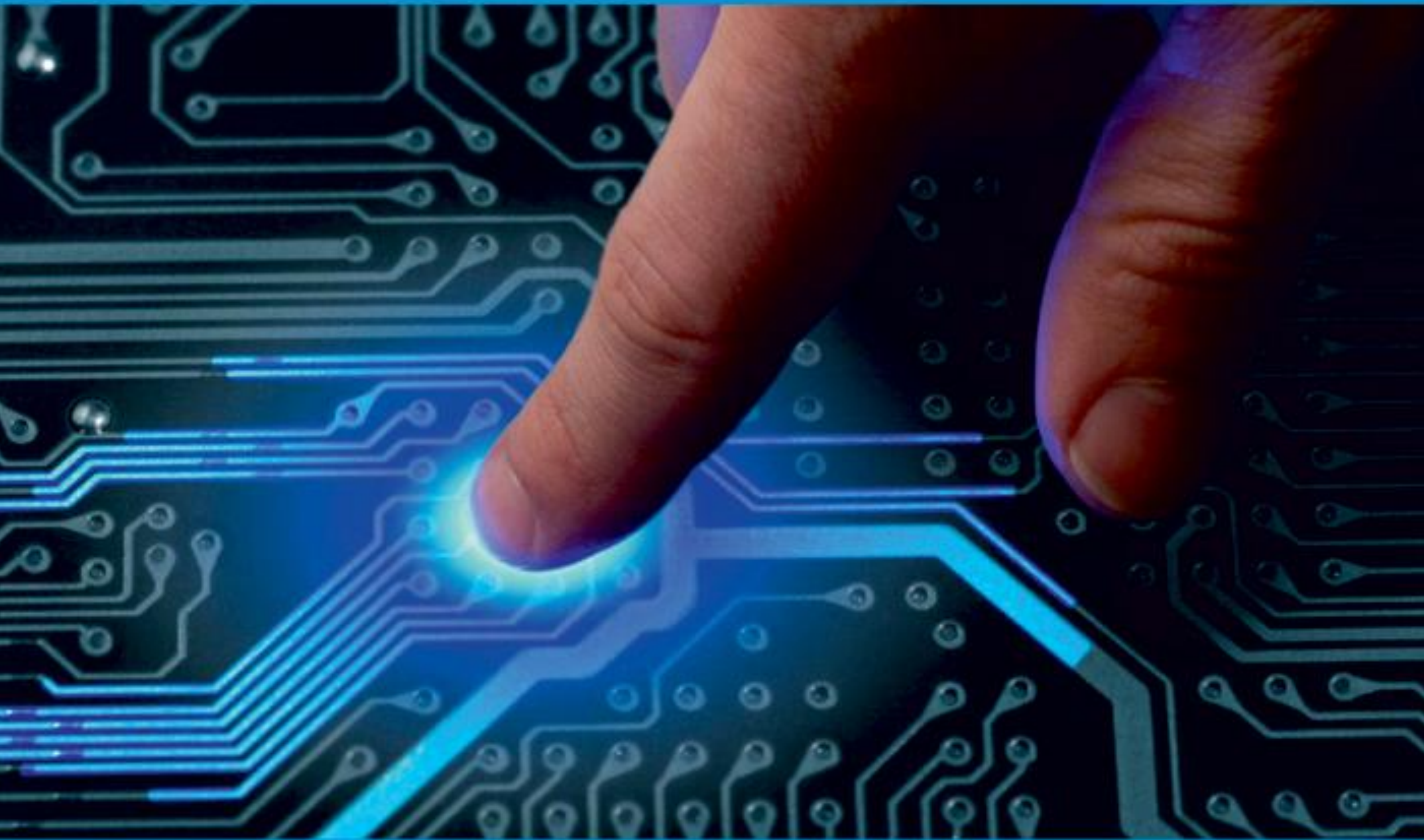

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Precision in Agriculture soil using NPK sensor by Mobile Application

A. Jenish Jeba Asir [1], L. Jeya Kumar[2], Godwin.S.F[3], Mr. G. Prince Devaraj[4]

Professor, Department of IT, Francis Xavier Engineering College, Tirunelveli, Tamil Nadu, India

Student, Department of IT, Francis Xavier Engineering College, Tirunelveli, Tamil Nadu, India

ABSTRACT: Abstract: Agriculture is essential to the growth of our nation's economy. The primary determinants of crop output are soil fertility and moisture content. Fertilizer recommendations are often made in accordance with the nutrients found in the soil. An adequate amount of fertilizer must be recommended after a soil nutrient analysis, which is primarily carried out in a laboratory setting. Measuring soil nutrients manually takes a lot of time. Because so many farmers don't test their soil in a lab and instead keep growing the same crop on their field year round, the soil becomes less fertile. A system that uses wireless sensor networks to implement precision agriculture has been developed. This system allows for remote monitoring of soil fertility as well as other parameters like temperature, pH, and moisture content of the soil. This approach offers a more efficient and convenient alternative to traditional manual soil testing methods, potentially leading to improved agricultural productivity and sustainability.

KEYWORDS: Soil Moisture, Sensors, Nitrogen, Phosphorus, Potassium, Mobile Application

I. INTRODUCTION

Food production began with agriculture. In agriculture, soil is a valuable resource. An important factor in the cycle of production is the physical and chemical state of the soil. Soil analysis is a useful technique that farmers can use to increase crop output. In this sense, soil testing is essential to crop growth. In the proper ratio, farmers can supplement the soil with either organic or inorganic nutrients. The primary soil macronutrients that affect yield maximization are nitrogen (N), phosphorus (P), and potassium (K). Fertilizer supplementation, both excessive and insufficient, can significantly slow down agricultural output and lead to lower-quality produce. The market for agricultural products grows as the population does. Automation of agricultural activities is crucial for productivity gains. Fertilizers must be added in sufficient amounts to preserve crop quality. The amount of fertilizer to be added is determined by the current NPK values in the soil [1]. Measuring soil parameters is crucial for site-specific applications in agricultural farm settings. Due to the rise of the Internet of Things, which provides wireless technology for measuring numerous soil properties, traditional farming is evolving into smart farming [2, 3]. The continued demand for crops may be met thanks to precision farming, made possible by technological advancements. The two main things that increase the need for precision agriculture are low cost and low labor. Maintaining crop quality and enabling farmers to expand their cultivation is made possible by regular monitoring of NPK values as well as soil pH, temperature, and humidity [4–7].

Current

The following are the system's salient features:
1. A single, comprehensive real-time soil monitoring system that works with a variety.
2. A sensor will be used to measure temperature, pH, moisture content, and the macronutrients nitrogen, phosphorus, and potassium in the soil.
3. The system uses the Firebase (Google) cloud for data storage and is coupled with Arduino and Node MCU (ESP32).
4. A user-friendly smartphone application is created to provide soil data and the amount of fertilizer that is suggested for various crops based on the soil's nutrient content.

The approach and solution used to solve the problem are covered in this paper. From now on, we will talk about the findings and how the mobile application helps to view the soil's pH, temperature, moisture content, and nutrient values in real-time, as well as recommend how much fertilizer is needed for the intended crop.

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II. LITERATURE SURVEY

A review of the literature on NPK sensors for precision agricultural soil sensing through a mobile application could address a number of important topics. Here is a survey outline to help you with it:
1. Introduction to Soil Management and Precision Agriculture: - Explain what precision agriculture is and why it's important in today's farming.
Talk about how soil management affects agricultural output.
Explain how NPK sensors work to track the nutrients in the soil.
2. NPK Sensor Technology:
Describe the concepts underlying the operation of NPK sensors.
Talk about the various NPK sensor types (such as optical and electrochemical) and their benefits and drawbacks.
Examine the precision and dependability of NPK sensor data in comparison to conventional soil testing techniques.
3. Mobile Applications in Agriculture:
Draw attention to the expanding usage of mobile applications for data gathering, analysis, and making decisions in the field of agriculture.
Talk about the advantages of mobile applications for giving farmers remote access and real-time data.
4. Combining Mobile Applications with NPK Sensors:
Examine research or initiatives that have used mobile applications and NPK sensors to monitor soil nutrients.
Talk about the features of these mobile apps, including as warning systems, nutrient recommendations, and data visualization.
5. Experimental Research and Case Studies:
Provide case studies or experimental studies that make use of mobile applications and NPK sensors in precision agriculture.
Emphasize the research methods, results, and conclusions from these investigations.
6. Difficulties and Future Prospects:
List difficulties including sensor precision, affordability, data integration, and user interface design.
Talk about current projects or potential future paths for advancing NPK sensor technology and precision agriculture-related mobile application features.
7. Conclusion:
Provide an overview of the main conclusions drawn from the literature review.
Talk about how NPK sensors and smartphone apps might improve soil management techniques and the sustainability of agriculture.
To provide readers a thorough understanding of the subject, don't forget to highlight new research and advancements in the area.

III. METHODOLOGY

Using NPK sensors for precision agriculture soil sensing via a mobile application necessitates a methodical and comprehensive approach. The first step in the technique is to precisely define the study's goals, which could include lowering input costs in agriculture, increasing crop output, or better managing nutrients. Next, appropriate NPK sensors are chosen based on criteria such as precision, cost-effectiveness, compatibility with mobile devices, and suitability for the intended soil types and crop types. Concurrently, a platform for mobile applications is built or selected, making sure it can work in unison with NPK sensors and provide features like real-time data collecting, analysis, visualization, and decision assistance. The user interface (UI) of the program must be carefully designed, giving priority to a simple and easy-to-use interface that is customized to the end users' demands and level of technical expertise.

Determining the amounts of nitrogen (N), phosphorus (P), and potassium (K) in the soil is critical since each element has a different effect on plant growth and development. This is where the soil fertility tester comes in. As nitrogen is necessary for both protein synthesis and photosynthesis, two important activities that propel plant growth and vitality, it is also critical for promoting the growth of leaves and other plants. Contrarily, phosphorus encourages the growth of roots and strengthens a plant's defenses against environmental stressors, contributing to the general resilience and health of the plant. In the meantime, potassium promotes the growth of fruits and flowers as well as the flow of sugars within the plant, both of which are essential for successful reproduction and the transportation of nutrients.

A soil fertility tester is used by inserting it into the soil and causing a chemical reaction that changes the

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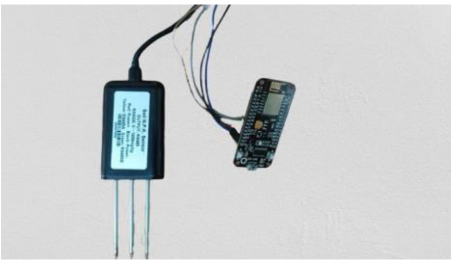
Table 1.Specification of Soil Moisture Sensor

Sensor Model	ESP32 WIFI
Range	50m -200m
Soil probe Dimension	6cm *3cm
PCB Dimension	3cm*1.5cm
Input	3.3-5V
Output Signal	Analog



SPECIFICATION OF SOIL TEMPARATURE SENSOR

Sensor Model	ESP 32 WIFI
Range	-55 celicus to +125 celicus
Accuracy	+0.5 celcius
Cable Length	36 inches

SPECFICATION OF SOIL PH SENSOR

Range	0 to 14
Number of Samples	5 to 10 Samples per acre
Operating Environment	-40 celicus to 50 celicus
Response time	<= 1minute

IV. ARCHITECURE DIAGRAM EXPLANATION

Soil Moisture Sensor

As a vital source of information about the moisture content of soil, soil moisture sensors are an indispensable instrument in contemporary agriculture. These sensors work using a variety of theories, including frequency domain reflectometry (FDR), resistance-based, capacitance-based, and time domain reflectometry (TDR). They correctly measure variations in the dielectric constant or electrical conductivity to ascertain the moisture content of the soil. In order to minimize water stress or waste, crops must receive the appropriate amount of water at the appropriate time. This knowledge is essential for improving irrigation operations. In addition to saving water, good irrigation management encourages nutrient uptake, strong root growth, and general crop health, all of which increase crop quality and yields. Soil moisture sensors are also essential since they lower the water and energy consumption of irrigation systems, which results in cost savings.

NPK Tester

NPK sensors, sometimes referred to as nutrient sensors, are specialized tools used in agriculture to determine the concentrations of the three main nutrients in soil: potassium (K), phosphorus (P), and nitrogen (N). These nutrients are essential for the growth and development of plants; nitrogen helps the growth of leaves and other vegetation, phosphorus encourages the development of roots and their ability to withstand environmental stressors, and potassium supports the development of fruits and flowers as well as the movement of nutrients within plants. The concepts of optical, electrochemical, or spectroscopic approaches are commonly employed by NPK sensors to precisely measure

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the quantities of these nutrients in soil samples. Farmers and agronomists can make well-informed decisions about soil management techniques, crop health monitoring, and fertilizer application with the use of the data that NPK sensors provide an excellent in the determination of identification of the components of the soil

Soil Temperature sensor

Devices called soil temperature sensors are made to gauge the temperature of the earth at different depths. Due to the fact that soil temperature is a major factor determining plant growth, microbial activity, nutrient availability, and general soil health, these sensors are essential to agriculture and environmental monitoring. There are several varieties of soil temperature sensors, each with a unique operating principle and degree of precision, such as thermocouples, resistance temperature detectors (RTDs), and thermistors. In order to record temperature fluctuations throughout the soil profile, these sensors are usually buried at particular soil depths. In order to evaluate the thermal characteristics of the soil, track seasonal temperature variations, plan irrigation schedules according to crop requirements that are temperature-sensitive, and maximize planting timings, data from soil temperature sensors is gathered.

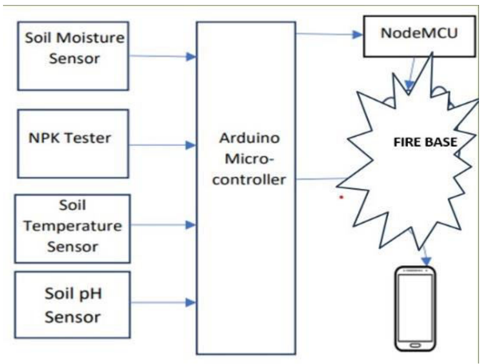
Soil pH sensor

With a pH range of 0 to 14, where 7 is neutral, values below 7 indicate acidity, and values over 7 indicate alkalinity, soil pH sensors are tools used to test the acidity or alkalinity of soil. These sensors are essential to agriculture because soil pH affects microbial activity, nutrient availability, and general soil health. The pH of the soil can affect how well plants absorb nutrients. For instance, in acidic soils, some nutrients, like phosphorus, are less available, while in alkaline soils, manganese can become toxic. The majority of soil pH sensors operate on the basis of electrochemical principles, which involve inserting a probe into the soil to measure the voltage produced by the concentration of hydrogen ions in the soil solution**.**

Arduino Microcontroller

From hobbyist tinkering to commercial applications, the Arduino microcontroller is an open-source platform that is widely utilized and versatile for a wide range of electronics projects. The Arduino is primarily made up of a small programmable circuit board with an integrated microcontroller chip (usually an ARM or Atmel AVR CPU) and a number of input/output pins for attaching different actuators, sensors, and other electronic parts

The Arduino microcontroller is a great option for rapidly and effectively prototyping and creating electrical systems because of its interface capabilities with sensors, motors, displays, and other hardware components. Because of its modular design, which promotes experimentation and creativity, users may easily explore the worlds of electronics and programming and bring their ideas to reality.



Node MCU

Based on the ESP32 Wi-Fi module, the NodeMCU is a well-liked open-source development board that is renowned for its affordability, portability, and robust features. Because it has integrated Wi-Fi connectivity together with a microcontroller unit (MCU), it's a great option for a variety of applications such as sensor networks, home automation systems, and Internet of Things projects. The NodeMCU board may be programmed by novices using the Lua programming language, while expert developers can take advantage of its extensive features.

The NodeMCU's unique capability of connecting to Wi-Fi networks makes it possible for devices created with it to communicate over local networks or the internet. This connectivity makes it possible to integrate the cloud, log data, monitor and manage equipment remotely, and communicate in real time with web services.

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Fire Base

Google created Firebase, a feature-rich platform that makes developing mobile and online applications easier. One of its main features is the Firebase Realtime Database, a cloud-hosted NoSQL database that allows users and devices to synchronize data in real-time. This makes it perfect for interactive applications like chat platforms and teamwork tools. With support for many authentication mechanisms, including social login, email and password, and custom authentication, Firebase Authentication streamlines user management and access control.

Scalability and dependability are guaranteed, development efficiency is increased, and time-to-market is shortened thanks to Firebase's integration of various services into a single platform. Google's infrastructure and best practices help developers concentrate on the features and user experiences of their apps rather than the intricacies of the backend

V. EXPERIMENT RESULTS

This method provides the output for a variety of soil parameters for a range of soil samples. It also suggests the appropriate amount of fertilizer, minimizing the use of extra fertilizer and increasing productivity. Accurate results are achieved through technological advancement, leading to increased cultivation. Thus, by offering real-time responsive data, precision agriculture improves farming operations.

FERTILIZER RANGE OF NITROGEN IN SOIL

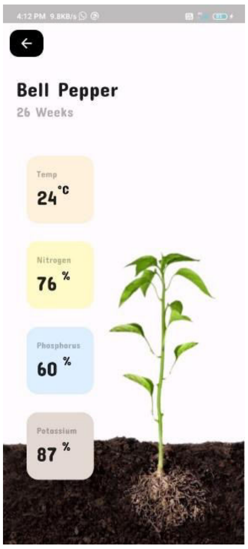
Levels	Range
Low	0-280kg/ha
Medium	280-450kg/ha
High	>450kg/ha

FERTILTIY RANGE OF PHOSPHORUS IN SOIL

Levels	Range
Low	0-11kgP /ha
Medium	11-22kgP/ha
High	>22kgP/ha

FERTILTIY RANGE OF POTASSIUM IN SOIL

Levels	Range
Low	0-118kg K/ha
Medium	118 – 280 kg K/ha
High	>280kg K/ha



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Farmers can ensure optimal use of fertilizers by applying the proper quantity with the help of recommendation systems. For a particular crop, let N_{m}, P., and K_{m} represent the measured values of nitrogen, phosphorus, and potassium, and let N, P_{r}, and K_{r} represent the ideal values.

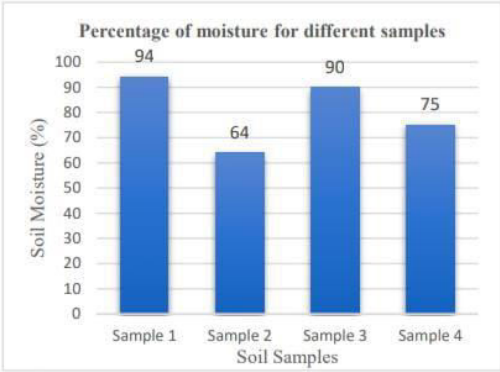

Fig 6. Percentage of soil moisture for different samples

The following formula can be used to determine the difference between the measured and optimum nutrients:
Allow the discrepancy between the ideal and measured values.
Nitrogen is N
N_{m} - N_{r} equals N_{r} (2)
Let P_{f} = P_{m} - P_{r} be the difference between the measured and ideal Phosphorous values.
Allow the discrepancy between the ideal and measured values.
K_{f} is potassium.
= K_{m} - K_{r} is K_{f}. **(4)**
The recommended amount of fertilizer is determined by this differential, and the value display in the mobile Application

VI. CONCLUSION

In real time, this device records and reports the temperature, pH, N, P, and moisture content of the soil. As a result, a software system that shows the measured oil parameter values and suggests fertilizer for crop rowing is proposed. A crop's ability to grow gradually depends on a number of micronutrients, including copper, iron, manganese, molybdenum, and zinc, in addition to soil macronutrients like N, P, and K. These micronutrients also affect crop output. With the correct integration of additional components and requirements, the system can be expanded to measure these factors.

VII. FUTURE SCOPE

Integration of advanced NPK sensors with machine learning algorithms and big data analytics can lead to more accurate and precise nutrient mapping, allowing farmers to tailor fertilization strategies and soil amendments based on specific soil compositions. This can optimize crop yields, reduce input costs, and promote sustainable agricultural practices. Using NPK sensors for soil composition analysis aligns with sustainable agriculture. NPK sensors can be integrated into IoT (Internet of Things) platforms and sensor networks deployed across agricultural fields. This interconnected system can provide real-time monitoring of soil nutrient levels, environmental conditions, and crop health.

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