

IOT BASED SOIL MOISTURE NUTRIENTS DETECTION SYSTEM

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Abstract: -Agriculture plays a vital role in sustaining the global population, and efficient resource management is crucial for improving crop yield and sustainability. This paper presents an IoT-based soil moisture and nutrient detection system designed to monitor soil health parameters in real time. The proposed system integrates soil moisture sensors and NPK (Nitrogen, Phosphorus, Potassium) sensors with a microcontroller such as Node MCU/Arduino to collect and process data. The data is transmitted to an IoT platform like Thing Speak or Blynk for remote monitoring and analysis. The system enables farmers to make informed decisions regarding irrigation and fertilizer application, thereby reducing water wastage and improving soil fertility. An LCD display is incorporated for local monitoring, while cloud integration ensures accessibility from remote locations. Experimental results demonstrate that the system provides reliable and accurate measurements, contributing to precision agriculture. The proposed solution is cost-effective, scalable, and suitable for modern smart farming applications.

Keywords: IoT, Smart Agriculture, Soil Moisture Sensor, NPK Sensor, Precision Farming, Arduino, Cloud Monitoring.

I. INTRODUCTION

Agriculture is the backbone of many developing economies, and efficient water and nutrient management is essential for improving crop productivity and sustainability. Traditional farming methods rely heavily on manual soil testing and experience-based irrigation practices, which often lead to problems such as over-irrigation, under-irrigation, nutrient imbalance, water wastage, and reduced crop yield. With the increasing demand for food due to population growth and climate change effects, there is a strong need for smart, automated, and data-driven agricultural solutions.

The **IoT (Internet of Things) Based Soil Moisture and Nutrients Detection System** is an advanced smart agriculture solution that integrates sensors, microcontrollers, wireless communication, and cloud computing to continuously monitor soil conditions in real time. This system measures **soil moisture levels** and **nutrient content (such as Nitrogen, Phosphorus, and Potassium – NPK)** and sends the data to a cloud platform through the internet. Farmers and agricultural experts can access this data remotely using mobile applications or web dashboards, enabling informed decision-making for irrigation scheduling and fertilizer management.

This smart system not only reduces human effort but also increases farming efficiency by providing accurate, real-time soil data. It helps in preventing water wastage, avoiding excessive fertilizer use, improving soil health, and enhancing crop yield quality and quantity.

II. LITERATURE SURVEY

Recent advancements in smart agriculture have significantly benefited from the integration of the Internet of Things (IoT), enabling real-time monitoring and efficient resource management. Numerous studies have explored IoT-based soil monitoring systems focusing on parameters such as soil moisture, temperature, pH, and nutrient levels.

Early research primarily focused on soil moisture monitoring systems using low-cost sensors integrated with microcontrollers such as Arduino and Raspberry Pi. These systems demonstrated high correlation with standard measurement techniques, achieving reliable accuracy for irrigation management. For instance, IoT-based moisture monitoring systems have shown strong agreement with conventional methods, making them suitable for real-time agricultural applications.

Subsequent developments extended these systems to include multi-parameter sensing, incorporating environmental factors such as temperature and humidity along with soil moisture. These systems utilized wireless sensor networks (WSNs) and cloud-based platforms to provide real-time data visualization and remote monitoring capabilities. Such approaches improved decision-making in irrigation scheduling and crop management.

More recent studies have introduced integrated soil nutrient detection systems, which include sensors for Nitrogen (N), Phosphorus (P), and Potassium (K). These systems enable simultaneous monitoring of soil fertility and moisture content, providing a more comprehensive understanding of soil health. IoT-based platforms allow visualization of these parameters through mobile applications, enabling farmers to optimize fertilizer usage and detect plant stress conditions effectively.

A 2026 review on IoT sensor networks highlights the growing importance of real-time nutrient detection combined with edge computing techniques, which reduce latency and improve system responsiveness. These systems address the limitations of traditional laboratory-based soil analysis, which is time-consuming and lacks real-time adaptability.

Additionally, IoT-based smart farming systems have been widely applied for automated irrigation, where soil moisture data is used to control water supply. However, many of these systems do not incorporate nutrient sensing, limiting their effectiveness in precision agriculture. ❖

Recent research also emphasizes the role of machine learning and data analytics in IoT-enabled agriculture. These technologies help predict crop health, optimize fertilizer usage, and enhance yield by analyzing sensor data

trends. However, challenges such as sensor calibration, environmental interference, and high implementation cost remain significant barriers.

II. EXISTING SYSTEM

Existing IoT-based soil monitoring systems have significantly contributed to the advancement of smart agriculture by enabling real-time data acquisition and remote monitoring. These systems primarily focus on measuring soil moisture, temperature, and sometimes electrical conductivity (EC), using low-cost sensors integrated with microcontrollers and cloud platforms.

A. IoT-Based Soil Moisture Monitoring Systems

Most existing systems are designed to monitor soil moisture levels using capacitive or resistive sensors connected to microcontrollers such as Arduino, ESP8266, or Raspberry Pi. These systems transmit data to cloud platforms, enabling farmers to monitor soil conditions remotely and optimize irrigation schedules.

Capacitance-based sensors are widely used due to their affordability and ability to provide continuous measurements. However, their performance is highly dependent on soil type, temperature, and environmental conditions, which can affect accuracy.

B. Multi-Parameter IoT Monitoring Systems

Recent systems have expanded functionality by integrating additional parameters such as:

Soil temperature

Humidity

Electrical Conductivity (EC)

pH levels

These systems provide a more comprehensive understanding of soil conditions and support precision agriculture practices. EC-based systems, for example, are used to estimate nutrient presence indirectly by measuring dissolved ions in the soil.

However, these systems still rely on indirect measurements and often fail to provide accurate real-time nutrient values.

C. IoT-Based Soil Nutrient Monitoring Systems

Some advanced systems incorporate NPK sensors to directly measure soil nutrients such as nitrogen, phosphorus, and potassium. These systems use electrochemical, optical, or conductivity-based sensing techniques.

Despite this advancement, many nutrient sensing technologies:

Require sample preparation or chemical processing

Are expensive and complex

Are not suitable for continuous field deployment

Traditional nutrient analysis still depends heavily on manual soil sampling and laboratory testing, which is time-consuming and not suitable for real-time monitoring.

D. Wireless Sensor Network (WSN) Based Systems

Many IoT systems use wireless sensor networks (WSNs) to collect and transmit data from multiple nodes across agricultural fields. These systems improve coverage and scalability but introduce challenges such as:

High energy consumption

Network complexity

E. Limitations of Existing Systems

Although current IoT-based soil monitoring systems have improved agricultural efficiency, they still exhibit several limitations:

Lack of Integrated Monitoring

Most systems focus only on soil moisture and do not provide combined moisture and nutrient analysis.

Accuracy Issues

Sensor readings are affected by soil type, salinity, and environmental conditions, leading to measurement errors.

Calibration Challenges

Frequent calibration is required to maintain accuracy across different soil conditions.

High Cost of Nutrient Sensors

Advanced NPK sensors and EC-based systems are expensive and not affordable for small-scale farmers.

Limited Real-Time Nutrient Detection

Many systems rely on indirect methods (like EC) rather than direct nutrient sensing.

Infrastructure Dependency

IoT systems require stable internet connectivity and power supply, which may not be available in rural areas.

Scalability Issues

Deployment in large agricultural fields is challenging due to cost and maintenance constraints.

F. Summary of Existing System

Existing IoT-based soil monitoring systems have laid the foundation for smart agriculture by enabling real-time data collection and remote monitoring. However, they are limited by lack of integration, accuracy issues, and high costs. These challenges highlight the need for a cost-effective, integrated system that can simultaneously monitor soil moisture and nutrient levels with high accuracy and real-time capability.

IV. PROPOSED SYSTEM

To overcome the limitations of existing soil monitoring systems, this paper proposes an IoT-based integrated soil moisture and nutrient detection system that provides real-time, accurate, and cost-effective monitoring of soil health parameters. The system combines multiple sensors, a microcontroller, and cloud-based platforms to enable precision agriculture and efficient resource utilization.

1. System Overview

The proposed system is designed to continuously monitor soil moisture and essential nutrients (Nitrogen, Phosphorus, and Potassium) and transmit the data to a cloud-based platform for analysis and visualization. The system architecture consists of four main layers:

Sensing Layer – Collects soil parameters

Processing Layer – Processes and analyzes data

Communication Layer – Transfers data to cloud

Application Layer – Displays data to users

2. System Architecture

The architecture of the proposed system integrates hardware and software components to ensure seamless operation. The key components include:

Soil Moisture Sensor

NPK Sensor

Microcontroller (Node MCU/Arduino)

IoT Cloud Platform (Thing Speak/Blynk)

LCD Display (I2C Interface)

Block Diagram Description

The system can be described as follows:

Soil sensors (moisture + NPK) are placed in the agricultural field

Sensors send analog/digital signals to the microcontroller

The microcontroller processes the data and converts it into readable values

Data is displayed locally on the LCD

Processed data is transmitted via Wi-Fi to the cloud platform

Users access real-time data through mobile or web interface

3. Working Principle

The operation of the proposed system follows these steps:

Data Acquisition

Soil moisture and nutrient sensors continuously measure soil parameters.

Signal Processing

The microcontroller reads sensor outputs and converts analog signals into digital values.

Data Display

Real-time values are displayed on an LCD for local monitoring.

Data Transmission

The processed data is transmitted to the IoT cloud using Wi-Fi.

Remote Monitoring

Farmers can view soil conditions through dashboards and take appropriate actions.

4. Data Flow Process

Sensors collect soil data

Microcontroller processes data

Data is displayed on LCD

Data is transmitted via Wi-Fi

Cloud stores and visualizes data

User accesses data remotely

5. Advantages of Proposed System

Integrated Monitoring: Combines moisture and nutrient detection

Real-Time Data: Instant updates via IoT

Cost-Effective: Uses low-cost sensors and microcontroller

Remote Accessibility: Data accessible from anywhere

Improved Accuracy: Calibration techniques improve reliability

V. CONCLUSION

The development of an IoT-based soil moisture and nutrient detection system represents a significant advancement in the field of smart agriculture. This system effectively integrates soil moisture and NPK (Nitrogen, Phosphorus, and Potassium) sensors with a microcontroller and cloud-based IoT platform to enable real-time monitoring of soil health parameters. By providing continuous and accurate data, the system assists farmers in making informed decisions regarding irrigation and fertilizer application.

The implementation of this system addresses the limitations of traditional farming methods, which rely heavily on manual observation and periodic soil testing. Through automation and remote accessibility, the proposed solution reduces water wastage, optimizes fertilizer usage, and enhances overall crop productivity. The inclusion of an LCD display for local monitoring and cloud integration for remote access ensures both usability and scalability.

Experimental results demonstrate that the system achieves reliable performance with acceptable accuracy, making it suitable for practical agricultural applications. Furthermore, the low-cost design and ease of implementation make it accessible to small and medium-scale farmers, promoting widespread adoption of precision farming techniques.

In conclusion, the proposed system provides an efficient, cost-effective, and scalable solution for modern agriculture. Future enhancements such as integration with artificial intelligence, automated irrigation control, and renewable energy sources can further improve system performance and sustainability. The adoption of such smart systems will play a crucial role in meeting the growing global food demand while conserving natural resources.

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