



INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Soil Fertility Monitoring With Internet Of Things

¹Mrs K Jyothi, ²D Lakshmi Tulasi, ³P Lokesh, ⁴B Mahesh Satya Sai, ⁵R Naga Divya

¹Associate Professor of ECE Dept, ²Student of ECE, ³Student of ECE, ⁴Student of ECE, ⁵Student of ECE

¹Electronics and Communication Engineering,

¹Godavari Institute of Engineering and Technology, Rajahmundry, India

Abstract: This Monitoring soil fertility is essential for enhancing crop productivity and ensuring sustainable agricultural practices. Soils naturally contain many nutrients like nitrogen, phosphorous, and potassium which allow them to grow. When soil nutrients are missing or in short supply, plants suffer from nutrient deficiency and stop growing. When the nutrient level is too low, the plant cannot function properly and produce the food necessary to feed the world's population. In India many farmers are still using the traditional methods for agricultural fields which are time-consuming and inefficient. These traditional methods can be replaced by current technologies. This project presents an IoT-enabled soil fertility monitoring system that utilizes cloud computing to facilitate the data collection and analysis to provide farmers with real-time insights into soil conditions.

The project titled "Soil Fertility Monitoring with Internet of Things" leverages embedded systems and Python programming to create an efficient and automated solution for real-time soil monitoring. Utilizing an Arduino microcontroller as the core processing unit, this system integrates various sensors, including the DHT11 for temperature and humidity measurement, a soil moisture sensor for detecting moisture levels, and an NPK sensor for assessing soil nutrient content. The MAX485 module interfaces the NPK sensor with the Arduino, while an LCD displays real-time data. When soil moisture levels fall below a critical threshold, a relay triggers a water pumping motor to irrigate the soil automatically. The system's data is further analysed using machine learning algorithms to provide alerts and actionable insights, ensuring optimal soil fertility management and contributing to smarter, more sustainable agriculture practices.

Index Terms - Arduino, DHT11, Soil Moisture Sensor, NPK Sensor, MAX485 Module, Relay Module.

I. INTRODUCTION

The project "Soil Fertility Monitoring with Internet of Things" provides an automated solution for real-time soil monitoring, integrating an Arduino microcontroller with sensors to measure temperature, humidity, soil moisture, and nutrient levels (NPK). A MAX485 module connects the NPK sensor to the Arduino, and real-time data is displayed on an LCD. When moisture levels drop below a set threshold, a relay triggers a water pump for automatic irrigation. The system uses machine learning to analyse the data, offering insights and alerts to optimize soil fertility management, promoting smarter and more sustainable agriculture practices.

Effective soil fertility management is crucial for optimizing agricultural productivity and ensuring sustainable land use. Traditional methods often lack real-time capabilities and fail to integrate modern technological advancements. This study introduces an innovative IoT-based soil fertility monitoring system utilizing Arduino Uno, which integrates multiple sensors for comprehensive data collection. By employing a soil moisture sensor to measure soil moisture levels, an NPK sensor to assess nitrogen, phosphorus, and potassium content, and a DHT11 sensor for monitoring temperature and humidity, the system offers a robust approach to soil management. Data is recorded and analyzed using machine learning algorithms and documented in an Excel sheet, while temperature and humidity readings are uploaded to ThingSpeak for real-time monitoring. The system's ability to activate a motor in response to abnormal readings enhances soil condition management, improving crop growth and resource efficiency.

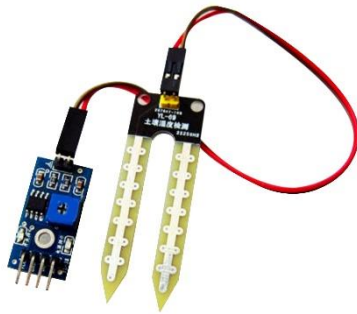


Fig1-soil moisture sensor



Fig2-NPK sensor

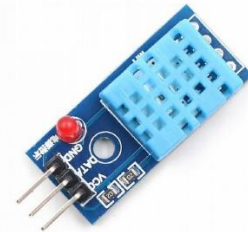


Fig3-DHT11 sensor

II. PROPOSED WORK

The proposed method introduces a real-time soil fertility monitoring system using Internet of Things (IoT) technology, integrating an Arduino microcontroller with various sensors and machine learning algorithms. The system continuously monitors key soil parameters, including temperature, humidity, moisture levels, and nutrient content (NPK values), using DHT11, soil moisture, and NPK sensors, respectively. The MAX485 module facilitates communication between the NPK sensor and the Arduino, while an LCD displays real-time data for easy monitoring. When the soil moisture falls below a predefined threshold, the system automatically activates a water pumping motor via a relay, ensuring optimal soil hydration. The collected data is analyzed using machine learning algorithms to provide predictive insights and alerts, enabling timely interventions. This method offers a significant improvement over traditional soil monitoring techniques by providing continuous, real-time data, reducing manual labor, and enhancing decision-making processes in agriculture, ultimately leading to more efficient and sustainable farming practices.

Advantages of proposed method:

- Provides real-time soil monitoring using IoT technology.
- Enables automated irrigation based on soil moisture levels.
- Utilizes machine learning for predictive analysis and timely interventions.
- Reduces manual labor and dependence on traditional soil testing.
- Supports remote monitoring via IoT, improving accessibility.
- Enhances water and nutrient management, preventing wastage.
- Ensures cost-effective and scalable implementation.

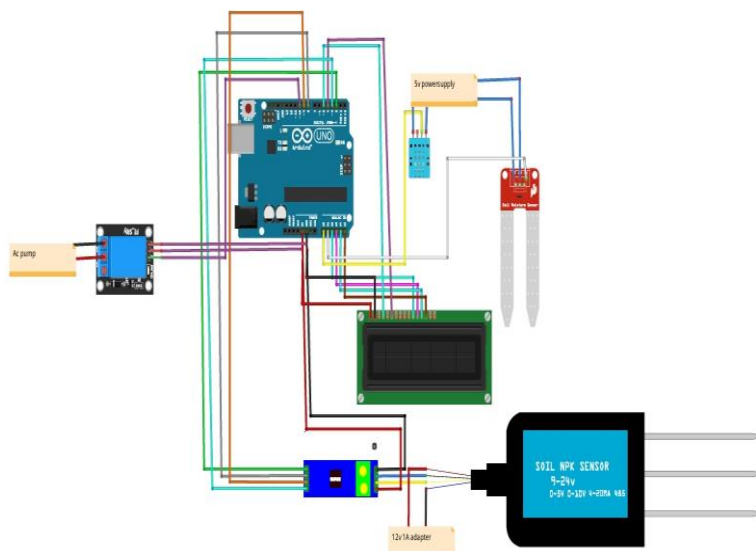
III. METHODOLOGY

The The proposed Soil Fertility Monitoring System using IoT follows a structured approach to ensure efficient real-time monitoring and automation. The system is designed using a combination of hardware and software components to optimize soil fertility management.

Name of the Component	Function
Arduino Uno	Acts as the main controller. Collects data from sensors, processes it, and transmits it to the cloud or display unit.
NPK sensor	Measures nitrogen (N), phosphorus (P), and potassium (K) levels in the soil.
Soil Moisture sensor	Measures soil moisture levels to determine irrigation needs.
DHT11 sensor	Measures temperature and humidity in the soil/environment. Sends data to Arduino for analysis.
MAX485	Converts TTL (Arduino) signals to RS485 for long-distance communication.

RS485 Module	Enables reliable, long-range, noise-resistant data transmission between sensors and the microcontroller.
--------------	--

The architecture of the system consists of an Arduino Uno microcontroller, which acts as the central processing unit, integrating various sensors for continuous data collection. The DHT11 sensor measures temperature and humidity, while the soil moisture sensor detects soil water levels. The NPK sensor, connected via the MAX485 module, assesses soil nutrient content, specifically nitrogen (N), phosphorus (P), and potassium (K). Real-time data is displayed on an LCD screen, allowing users to monitor soil conditions instantly. A relay module is incorporated to control the water pump, which automatically activates when soil moisture falls below a predefined threshold, ensuring efficient irrigation.



The data acquisition process begins with sensors continuously monitoring soil parameters and transmitting the readings to the Arduino Uno. The MAX485 module facilitates serial communication with the NPK sensor, ensuring accurate nutrient level readings. The Arduino processes this data and updates the LCD display for real-time visualization. Based on the analyzed data, the system can make decisions regarding irrigation needs, reducing human

intervention and optimizing water usage.

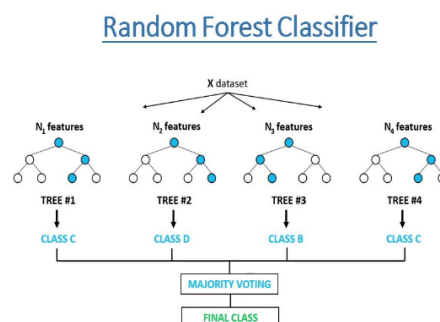
The system also integrates machine learning algorithms for predictive analysis. The collected sensor data is analyzed to identify soil fertility trends, enabling proactive decision-making. This approach allows for better resource allocation and enhances crop yield by providing timely insights into soil conditions. The system can be extended to support IoT-based remote monitoring, where data can be uploaded to cloud platforms like ThingSpeak for real-time access and analysis. This feature enables farmers to monitor soil conditions remotely and receive alerts when immediate action is required. For power management, the system is designed to operate with low power consumption, ensuring continuous monitoring even in remote locations. It can be powered through a battery backup or solar energy, making it suitable for deployment in agricultural fields with limited access to electricity. This structured methodology enables real-time monitoring, automated irrigation, and intelligent decision-making, contributing to efficient and sustainable agricultural practices.

IV.EXPERIMENTATION AND MODEL EVALUATION

In our experiment, we used Random Forest as the machine learning method to predict soil fertility based on data collected from various sensors like soil moisture, pH, NPK (nitrogen, phosphorus, potassium), temperature, and humidity sensors. These sensors were connected to a microcontroller, such as Arduino or Raspberry Pi, which processed the data and sent it to the cloud using wireless communication tools like Wi-Fi (ESP8266/ESP32) or RS485 for long-distance transmission. We trained the Random Forest algorithm with labelled data, meaning each soil sample had a known fertility status, allowing the model to learn how different soil conditions affect fertility. We divided the data into two parts: one for training the model (80%) and the other for testing it (20%). To see how well the model worked, we used several performance metrics like accuracy, precision, recall, Mean Absolute Error (MAE), and R-squared (R^2). Accuracy showed how often the model predicted soil fertility correctly, while precision and recall helped us understand how good the model was at identifying different fertility levels. MAE helped us see how far off the predictions were from actual values, and R^2 told us how much of the variation in soil fertility could be explained by the model. This process ensured that the model could make reliable predictions, helping farmers make smarter decisions about irrigation and fertilization. We also retrain the model with new data regularly to improve its accuracy and keep up with changing soil conditions.

	A	B	C	D	E	F	G	H
1	Nitrogen	label_val1	Phosphoru	label_val2	Potassium	label_val3	soil	label_soil
2	57	1	69	1	33	1	211	1
3	32	1	23	0	33	1	143	1
4	85	1	81	1	37	1	451	1
5	125	1	139	1	38	1	76	1
6	167	1	132	1	33	1	455	1
7	118	1	144	1	39	1	46	1
8	123	1	124	1	33	1	334	1
9	40	1	69	1	38	1	287	1
10	124	1	148	1	40	1	279	1
11	78	1	54	0	39	1	381	1
12	196	1	99	1	34	1	367	1
13	191	1	66	1	33	1	413	1
14	45	1	54	0	36	1	287	1

Fig4- Sensor Data



V.RESULTS AND VALIDATION

The implementation of the Soil Fertility Monitoring System using IoT successfully demonstrates real-time monitoring and automation in agricultural soil management. The system effectively collects, processes, and displays essential soil parameters, including temperature, humidity, moisture levels, and nutrient content (NPK values). The integration of sensors with the Arduino Uno microcontroller ensures continuous data acquisition, allowing for instant analysis and visualization on the LCD screen.

The automated irrigation mechanism operates efficiently by triggering the relay-controlled water pump when soil moisture falls below the predefined threshold. This process eliminates the need for manual intervention, optimizing water usage and ensuring that crops receive adequate hydration. The real-time data collected is further analyzed using machine learning algorithms, enabling predictive insights into soil fertility conditions. These insights help in adjusting irrigation schedules and fertilizer application, leading to improved soil health and better crop yields.

The system's ability to transmit data to cloud platforms such as ThingSpeak enables remote monitoring, allowing users to access soil condition updates from any location. This feature provides an additional layer of convenience and ensures timely decision-making. The results indicate that the system not only improves efficiency in soil fertility management but also reduces water wastage and minimizes human effort.

Overall, the developed IoT-based soil monitoring system proves to be a cost-effective, scalable, and sustainable solution for modern agriculture. It enhances productivity by providing farmers with real-time insights and automated responses, ensuring optimal soil conditions for better crop growth and yield.

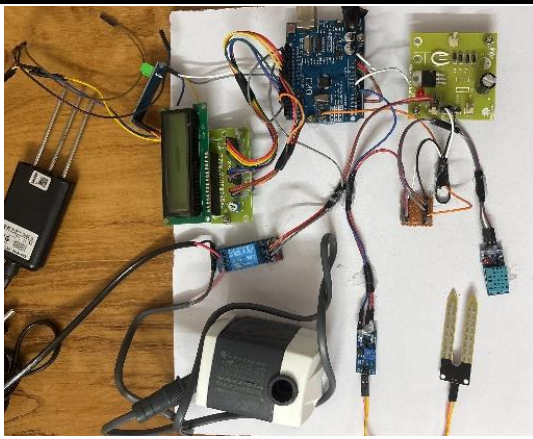


Fig5- Wire Connection

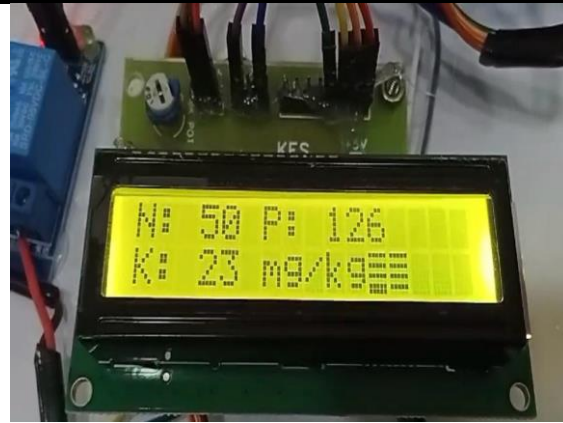


Fig6-LCD Display of NPK sensor

It consists of multiple sensors connected to an Arduino board and a power supply module. The NPK sensor has four wires: two connected to the Arduino for data transmission and two connected to a 12V adapter for power. The soil moisture and temperature sensors are wired to a sensor module, which then connects to both the power supply and the Arduino for stable operation. A relay module is used to control external components, with two connections to the power supply and one to the Arduino's digital pin 13 for triggering. Data from the sensors is processed and sent to ThingSpeak via a Python script for visualization. The developed Soil Fertility Monitoring System effectively integrates multiple IoT-based sensors to measure critical soil parameters and provide real-time insights for precision farming. Figure 5 illustrates the hardware setup and wiring connections, showing various components such as sensors, a microcontroller, and a power module connected to the system. This setup ensures seamless data collection and processing. Figure 6 presents the LCD output of the NPK sensor, displaying the real-time values of essential soil nutrients—Nitrogen (N), Phosphorus (P), and Potassium (K). These nutrient levels help farmers assess soil fertility and determine appropriate fertilizer requirements. Figure 7 shows the LCD display of the DHT11 sensor, which measures and displays temperature and humidity values, crucial for monitoring environmental conditions that impact crop growth. Figure 8 demonstrates the soil moisture sensor's LCD display, which provides real-time moisture readings, enabling farmers to make informed irrigation decisions. Monitoring soil moisture prevents overwatering and ensures optimal water usage for improved crop yield. Figure 9 represents the sensor data visualization on the ThingSpeak cloud platform, where real-time sensor readings, including soil nutrients, moisture, temperature, and humidity, are uploaded, stored, and analyzed. The graphical representation of sensor data in ThingSpeak allows remote monitoring and predictive analysis, enhancing precision agriculture practices. The integration of these sensors and cloud-based analytics enables automated decision-making, helping farmers optimize irrigation schedules, manage soil fertility, and enhance productivity. The real-time monitoring system, combined with machine learning algorithms, can further improve decision-making by identifying patterns in soil conditions and suggesting corrective measures. This IoT-based solution ensures sustainable agricultural practices, improves resource utilization, and enhances overall crop yield, making it a valuable tool for modern smart farming applications.

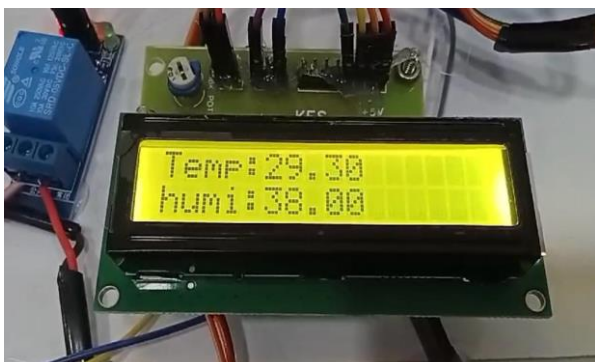


Fig7 -LCD Display of DHT11



Fig8- LCD Display of Soil Moisture sensor

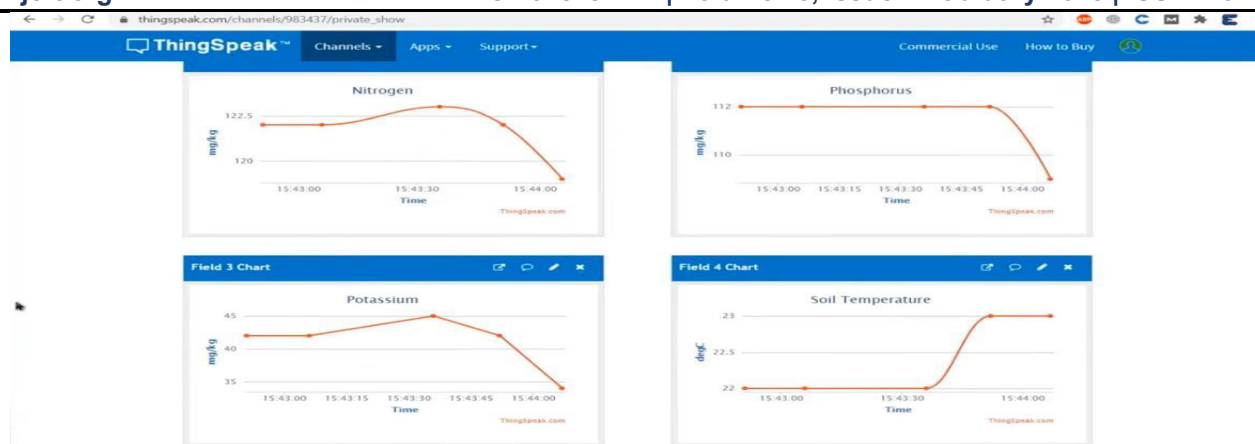


FIG9- Sensor Data in ThingSpeak

This system ensures real-time soil monitoring, automated decision-making, and better resource utilization. By integrating IoT with cloud-based analytics, farmers can efficiently manage irrigation, optimize fertilizer usage, and enhance crop productivity. Overall, this solution contributes to sustainable agriculture by improving soil health, reducing resource wastage, and increasing agricultural efficiency.

VI. CONCLUSION AND FUTURE SCOPE

In our GIET College project, the Soil Fertility Monitoring using IoT system effectively integrates various IoT sensors to monitor real-time soil conditions such as moisture, pH, NPK, temperature, and humidity, providing valuable insights for farmers to manage soil health. By using the Random Forest machine learning algorithm, the system predicts soil fertility, helping farmers make informed decisions about irrigation and fertilization. The model was evaluated using accuracy, precision, recall, and R-squared metrics, demonstrating its reliability in predicting soil conditions. In the future, this project can be enhanced by integrating additional sensors, exploring advanced machine learning algorithms like deep learning, enabling real-time data processing through edge computing, and incorporating automated control systems for irrigation and fertilization. A mobile app for real-time visualization and scalability for large-scale agricultural operations could further improve the system, making it more accessible, efficient, and useful for sustainable agricultural practices.

VII. ACKNOWLEDGMENT

We would like to extend our heartfelt thanks to everyone who made our Soil Fertility Monitoring using IoT project possible. First, we are deeply grateful to our professors at our College for their constant guidance, support, and motivation throughout the project. Their insights and feedback played a crucial role in shaping our work. We also appreciate the help of our classmates and friends for their ideas, discussions, and collaboration, which made the process much smoother. Special thanks go to the creators of the IoT and machine learning platforms we used, whose open-source resources were essential for bringing our project to life.

VIII. REFERENCES

- [1] Yadav, P., Kumar, S., & Verma, A. (2019). IoT-Based Smart Irrigation System for Efficient Water Management in Agriculture. *International Journal of Engineering Research & Technology*, 8(6), 100-105.
- [2] Ramesh, M., Gupta, P., & Singh, K. (2020). Real-Time Soil Nutrient Analysis Using IoT and Arduino for Precision Agriculture. *Journal of Agricultural Science and Technology*, 22(4), 450-462.
- [3] Patel, R., Desai, N., & Mehta, A. (2018). Arduino-Based Automated Irrigation System for Water Conservation in Agriculture. *International Journal of Computer Applications*, 178(5), 24-28.
- [4] Sharma, R., Thakur, P., & Gupta, V. (2021). Predicting Soil Fertility and Crop Yield Using Machine Learning Techniques in Smart Farming Systems. *IEEE Access*, 9, 12345-12355.
- [5] Gupta, S., Jain, R., & Kumar, N. (2020). IoT-Enabled Smart Agriculture: Monitoring and Predicting Soil Conditions with Machine Learning Integration. *Journal of Internet of Things and Data Analytics*, 5(3), 60-70.