ISSN No:-2456-2165

Soil Fertility Analysis using IoT

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Abstract:- Soil is crucial for economic and social development as it provides the foundation for plant growth and life cycle. Agriculture heavily relies on resources like land and fertilizer to produce food. However, the National Academy of Agricultural Sciences (NAAS) reports that the annual soil loss rate in India is about 15.35 tonnes per hectare, which leads to the loss of 5.37 to 8.4 million tonnes of nutrients. This is due to intensive agricultural practices that cause nutrient imbalance and soil depletion, exacerbated by a lack of awareness about soil health. The declining soil health is one of the reasons for stagnant or decreasing crop yields, which will likely worsen in the future.

To address this issue, this project aims to use IoT technology to test different types of soil and determine their macronutrient (NPK) and micronutrient values. The measured nutrient values are compared to a dataset of healthy soil samples' ideal nutrient values using an easy-to-use interface that displays pictorial representations. The farmer receives a detailed soil report that compares the soil's micro and macro nutrient values to the ideal values, much like a soil health report card.

Keywords:- *Agriculture, Arduino UNO, Internet Of Things[IOT], Macronutrient, Micronutrient, Nitrogen Phosphorus Potassium [NPK], Soil Health, Soil HealthReport Card.*

I. INTRODUCTION

For centuries, agriculture has been a crucial part of the Indian economy. Despite being a major contributor to the GDP, traditional farming methods are still widely used, resulting in inefficient and labor- intensive processes that harm soil quality, crop yields, and productivity. With the decline in farmland availability, it is necessary to implement modern farming methods to improve performance and yield.

Plant growth relies on three primary components: nitrogen, phosphorus, and potassium. Nitrogen is crucial for leaf and vegetation growth, phosphorus for root and physical growth, and potassium for regulating water and nutrients in plant cells, flowering, and fruiting. Proper management and maintenance of these components can enhance soil quality and crop growth.

Chemical fertilizers are commonly used in modern agriculture, but overuse can causesoil nutrient depletion, leading to reduced soilfertility and crop yield. By providing accuratesoil nutrient measurements, farmers canoptimize fertilizer use and reduce the risk of nutrient depletion. The project aims to promote sustainable agricultural practices by reducing the excessive use of chemical fertilizers and mitigating soil pollution.

The project will collaborate with farmers, agriculture experts, and researchers to study diverse crop types, soil types, and climatic conditions. Data collection will involvesurveys, interviews, and field observations toevaluate the effectiveness of modern farmingtechniques and provide recommendations for farmers.

The primary objective of this project is to promote responsible and data-driven soil management practices to support the sustainability of modern agriculture. Byreducing the excessive usage of chemicalfertilizers, the project can help ensure soil remains healthy and productive for future generations.

II. LITERATURE SURVEY

Maximizing crop yields by ensuring idealsoil and plant conditions is crucial in India, where the economy is largely based on horticulture. Crop production is dependent on the organic, physical, and chemical properties of the soil due to their interdependence. To maximize crop yield, it is crucial to monitor and manage these factors. The use of sensor systems in agriculture is growing because they have a wide range of applications and can assist farmers in making informed decisions. Thesesystems use sensors to gather information ona variety of factors, including temperature, humidity, soil moisture, nutrient levels, and crop growth. Afterwards, the information is transferred to a computer or mobile device, where it can be analyzed and used to decide on irrigation, fertilization, and other aspects that affect crop yield. Manual data collectionfor some variables can be sporadic and resultin variations from inaccurate estimationtaking, which can make it difficult to control any important factors. This may lead to below-average crop yields and financiallosses for farmers. The time and labor demands of manual data gathering may also be a limit on the amount of data that can beobtained and analyzed.

Comparing sensor systems to manualdata collection, there are several benefits.They can continuously gather data, giving real-time updates on the condition of the soiland crops. This enables farmers to decide onirrigation, fertilization, and other aspects thataffect crop yield in a timely manner. Due to the absence of human error, sensor systems are also more accurate and reliable than manual data collection. Finally, sensor systems can save farmers time and money because they require less labor than manual data collection.

One electrochemical method for determining the amount of nutrients like nitrogen, phosphorus, and potassium (NPK) in soil samples is conductivity measurement. Two or three electrodes made of steel, silver,platinum, graphite, or copper are submerged in the soil sample when using this technique.The conductivity of the electrodes is influenced by the amount of NPK in the soil, which changes the electrical signal that electronic control systems can detect. Although conductivity measurement is a trustworthy technique for analyzing nutrients, it can be time-consuming and expensive due to the need for expensive equipment and trained personnel.

Alternative techniques have emergedin recent years that are less expensive, take less time, and don't require as much expertise, like optical techniques. The foundation of optical methods is the interaction of lightwith the soil sample, and the optical characteristics of the soil change in responseto changes in nutrient concentration. Therefore, even though conductivity measurement is a trustworthy method for analyzing nutrients, it can be costly and time- consuming. In comparison to electrochemical methods, optical techniques are becoming a more affordable and effective substitute for analyzing soil nutrients.

It discusses how widespread deficiencies in secondary (Sulphur) and micronutrients (zinc, boron, manganese, iron) cause even balanced NPK fertilization to perform inefficiently. It also discusses the need toapply soil amendments (gypsum on sodic soils and lime on acid soils) in addition to these deficiencies. Additionally, over fertilization with nitrogen causesproblems for the environment and humanhealth in many areas by nitrate-enriching ground water and depleting soil of other plantnutrients.

A good agronomy package (ideal date of sowing/transplanting, ideal seed rate/plant population, ideal spacing, ideal depth of planting, recommended crop variety/hybrid, good water and weed management) is required to obtain a good fertilizer use efficiency, and it also revealed that the crop yield is the nominator in all terms used to calculate fertilizer use efficiency (recovery efficiency, physiological efficiency, and partial factor productivity).

The right kind and quantity of fertilizer application increases both the quality and yield of food raw materials because fertilizersare essential for plant growth and fertility maintenance, and because soil is a significantsource of food. On the other hand, situationsof both deficiency and excessive use result inissues like low quality and yield, unhealthful crops, higher input costs, or groundwater pollution. The three nutrients known as nitrogen, phosphorus, and potassium are the most significant and deficient. The fertility status of the soil can be determined and the appropriate amounts of fertilizer can be applied with the help of laboratory analyses and soil sampling procedures. Examples of these lab tests include the Dumas method for determining total nitrogen and the Olsen,Bray, or Mehlich methods for plants.

It talks about using an electrochemical sensor and an Arduino to analyse soil nutrients. An electrochemical sensor generates an electrical signal that the Arduino can measure through the use of a chemical reaction. These sensors can also be used to detect the presence of particular nutrients in soil, though they are typically used to detect the presence of various gases and liquids. It is possible to programme the Arduino microcontroller board to read the electrical signals generated by the electrochemical sensor and transform them into useful data. Using a programming designed for this purpose, the Arduino can analyse the data and calculate the amounts of different nutrients in the soil.

To assist farmers with crop selection, boost farm productivity, and increase crop yield, SoilMATTic was created to provide faster and more accurate soil analysis than the traditional method. The Arduino-based prototype automated every step of soil testingprocedures, fertilizer recommendation, andmacronutrient and pH analysis. It contains stepper motors, pumps, and an inbuilt printerthat prints fertilizer suggestions to fully automate the chemical interaction of soil with chemical reagent during testing. It effectivelydetermines (1) Nitrogen, (2) Phosphorus, (3) Potassium, and (4) pH level of Philippine farmlands using digital image processing technique. The system has five stages: automated soil testing, picture acquisition,image processing, training system, and suggestion. For the purpose of processingimages, artificial neural networks performed quickly and precisely. 356 captured images were stored and managed by the system database, of which 70% were used for training, 15% for testing, and 15% for validation. Inbred rice, inbred maize, tobacco, sugarcane, pineapple, mango, coconut, abaca, coffee and banana plants should all use fertilizer, according to the study's results, which showed 96.67 accuracyin detecting soil macronutrients and pH level.

This study aims to put into practice a method that makes transport much more convenient for people who commute every day using the city's public bus system, for efficient time management, and making it trouble-free, not just for the commuters but also for the transport department to develop an effective public transport system. The survey presented here aims to create an application that advances this technology by providing daily commuters with access toinformation about the available seats and thecurrent location of any bus in Real-Time via a state-of-the-art and reasonably priced wireless system. There are currently applications on the market that specify the route and timings and forecast the arrivaltimes of various buses. These techniques givean overview of methods for meeting the public transport needs of different sized citieswhile proposing small adjustments to the bussystem to accommodate different sized cities'capacity needs. They hope to provide a trustworthy, adaptable, comfortable, and accessible bus service that would encourage people to use public transit instead of their own cars.

III. PROPOSED SYSTEM

Utilizing a flow-through soil sensor framework, the suggested system is made to assess the amounts of nitrogen, phosphorous, and potassium in agricultural soil. An Arduino UNO is used to convert the sensor readings into measurable units, which are then displayed on an LCD screen for easy access and interpretation by farmers. In addition to measuring nutrient levels, the proposed framework also provides farmers with a detailed soil health report by comparing the existing soil's micro and macro nutrient values with ideal values. This will help farmers gain a better understanding of the soil's health and condition.

IV. MODULES

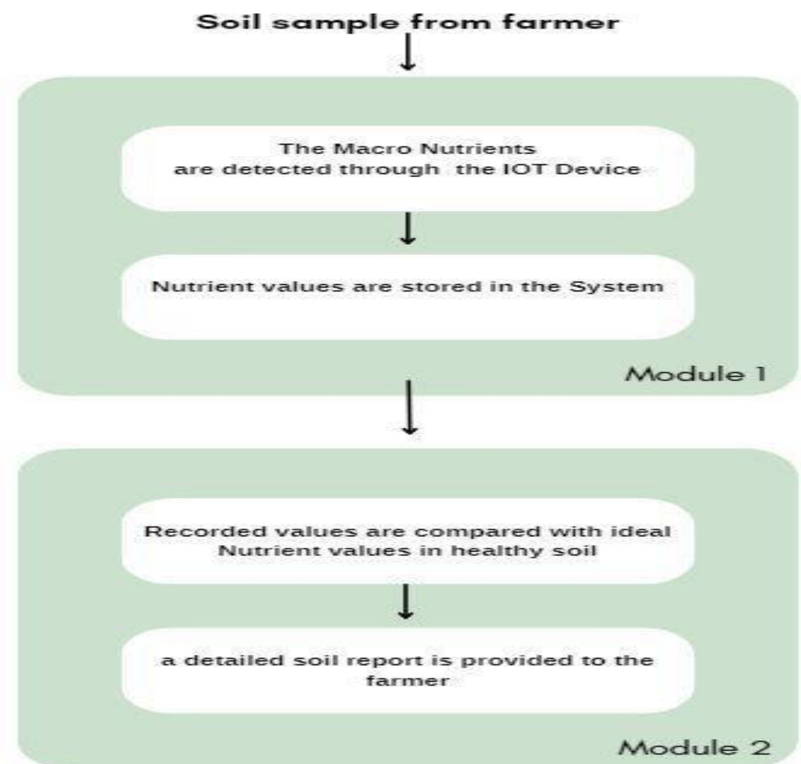


Fig. 1: Architecture of the System

A. Module 1: The Macro NutrientDetection

The Macro Nutrients in soil, which are Nitrogen, Phosphorous and Potassium are detected using the Soil NPK sensor. The values of the macro nutrients are then stored in the system for further evaluations and comparisons.

Fig. 2: Nutrient value detection

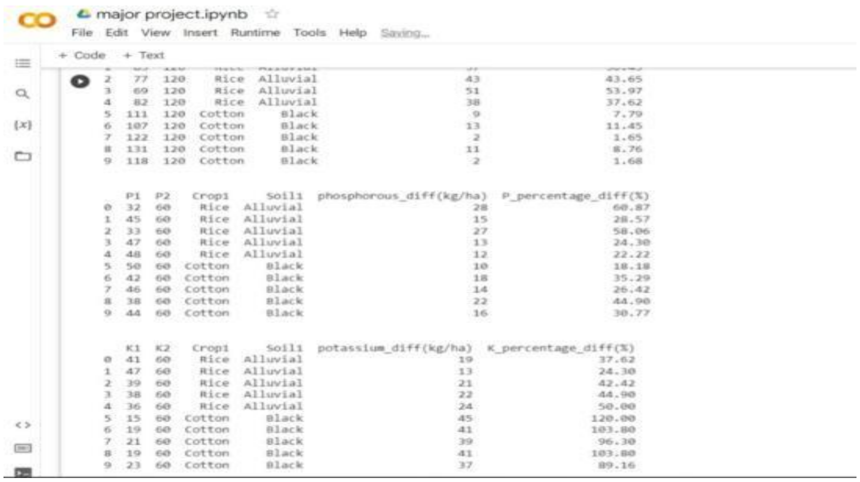
B. Module 2: Recording The Nutrient Values

Through LCD the Macro nutrients values aredisplayed and the values are stored into the system for further processes.

Fig. 3: values displayed by the LCD

C. Module 3: Comparission Of Recorded Values With Ideal Nutrient Values

The data is then obtained and compared with the ideal values of the soil after the determination of the levels of nitrogen, phosphorus, and potassium (NPK) in the soil. The values are compared using different python libraries like Numpy, Pandas and then a Soil Health Card is given to the farmer.



2	77	120	Rice	Alluvial	43	43.65
3	69	120	Rice	Alluvial	51	53.97
4	82	120	Rice	Alluvial	38	37.62
5	111	120	Cotton	Black	9	7.79
6	107	120	Cotton	Black	13	11.45
7	122	120	Cotton	Black	2	1.65
8	131	120	Cotton	Black	11	8.76
9	118	120	Cotton	Black	2	1.68

	P1	P2	Crop1	Soil1	phosphorous_diff(kg/ha)	P_percentage_diff(%)
0	32	60	Rice	Alluvial	28	60.87
1	45	60	Rice	Alluvial	15	28.57
2	33	60	Rice	Alluvial	27	58.06
3	47	60	Rice	Alluvial	13	24.30
4	48	60	Rice	Alluvial	12	22.22
5	50	60	Cotton	Black	10	18.18
6	42	60	Cotton	Black	18	35.29
7	46	60	Cotton	Black	14	26.42
8	38	60	Cotton	Black	22	44.90
9	44	60	Cotton	Black	16	30.77

	K1	K2	Crop1	Soil1	potassium_diff(kg/ha)	K_percentage_diff(%)
0	41	60	Rice	Alluvial	19	37.62
1	47	60	Rice	Alluvial	13	24.30
2	39	60	Rice	Alluvial	21	42.42
3	38	60	Rice	Alluvial	22	44.90
4	36	60	Rice	Alluvial	24	50.00
5	15	60	Cotton	Black	45	120.00
6	19	60	Cotton	Black	41	103.80
7	21	60	Cotton	Black	39	96.30
8	19	60	Cotton	Black	41	103.80
9	23	60	Cotton	Black	37	89.16

Fig. 4: Comparison of NPK values

V. RESULT

In order to gather different soil samples, suchas red and black soil, we conducted research on the different soil types and the ideal nutrient values that correspond with them. We created our own Arduino Soil NPK Metreand successfully implemented the interfacingof the Soil NPK Sensor with Arduino. The code was uploaded to an Arduino UNO board, and the LCD was made available for initialization alongside the NPK sensor.

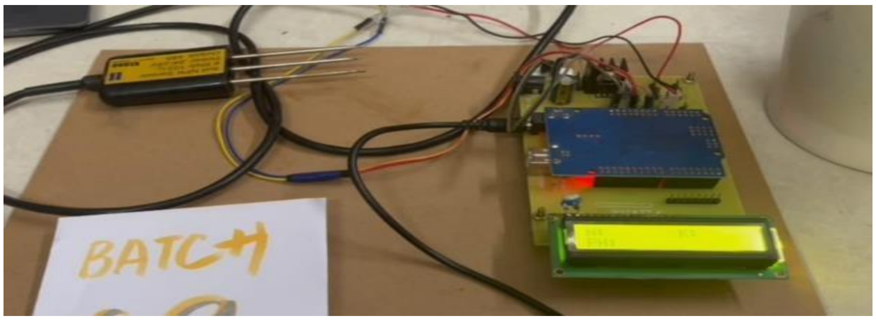


Fig. 5: Implementation of circuit diagram

ISSN No:-2456-2165

Fig. 6: Readings on LCD display

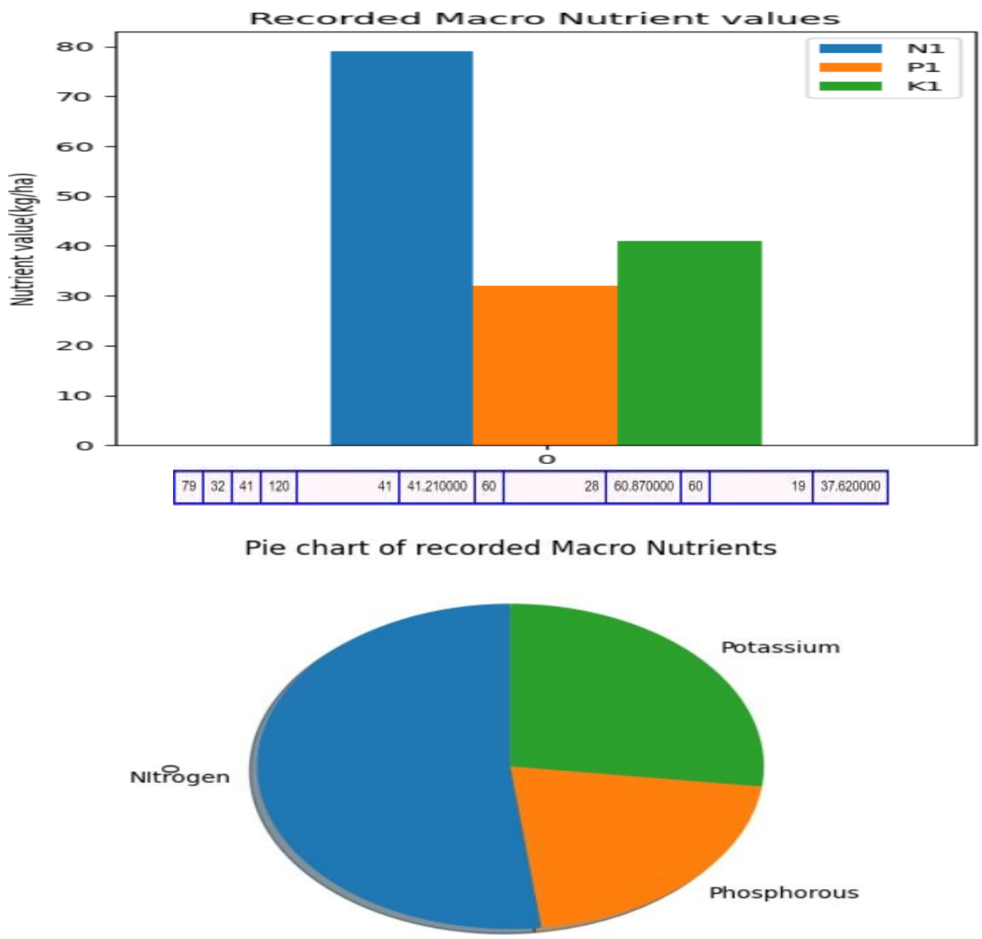


Fig. 7: Detailed analysis of soil samplereceived

Data is gathered and contrasted with ideal values derived from the sources once thequantities of nitrogen, phosphorus, and potassium (NPK) in the soil have been determined(NAAS 2009).[5] "Crop Response and Nutrient Ratio", Policy Paper No. 42, Acharya N.G. Ranga Agricultural University and National Academy ofAgricultural Sciences, New Delhi. These sources provided a detailed analysis of how to increase the nutrient content in the tested soil as well as the ideal values of N, P, and Knutrients in soil, specific to the soil type.

VI. CONCLUSION AND FUTURE SCOPE

The significance of sustainable farming practices and nutrient management in maintaining soil health and increasing crop yields is showcased in this project. By utilizing IoT technology to analyze soil nutrient data, valuable insights have been obtained into the nutrient composition of various types of soils. These insights can assist policymakers and farmers in making data-driven decisions. This initiative lays the groundwork for future precision agricultural research and development.

By analyzing soil nutrient data using IoT technology, this project highlights the importance of sustainable farming practices and nutrient management. The information collected will be utilized to develop a machine learning model that can recommend the appropriate type and amount of fertilizer based on soil nutrient composition. This will help farmers make informed decisions, minimize fertilizer waste, and increase crop yields.

Furthermore, this project endeavors to enhance the IoT prototype used for soil nutrient analysis by integrating micro-nutrient analysis to provide a more comprehensive understanding of soil health.

The future work of this project has the potential to significantly enhance the efficiency and sustainability of agriculture by decreasing resource consumption and improving crop yields while promoting sustainable farming practices..

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