THE BASIC AGRICULTURE

NUTRISCAN PRO

AGRICORE DYNAMICS

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INDEX

Introduction

Agriculture is the backbone of our country, and soil health plays a crucial role in crop growth and food production. Healthy soil contains the right balance of nutrients, moisture, and pH required for plants to grow properly. However, many farmers today do not have access to fast and affordable methods to test soil health. Traditional soil testing methods require sending samples to laboratories, which takes several days, costs money, and is not practical for frequent testing.

Because of this, farmers often rely on experience or guesswork while applying fertilizers. This can lead to over-fertilization, soil damage, wastage of resources, and reduced crop yield. There is a strong need for a simple, portable, and real-time soil testing system that can be used directly in the field.

NutriScan Pro is designed to solve this problem. It is a smart soil analysis system that measures important soil parameters such as pH, moisture, and nutrient status using sensors and displays the results instantly on a mobile application. By combining principles of Physics, Chemistry and Mathematics, NutriScan Pro helps farmers make informed decisions about crop selection and fertilizer usage.

This project focuses on applying scientific concepts to create a practical solution that improves farming efficiency, reduces dependency on laboratory testing, and promotes sustainable agriculture.

System Overview

NutriScan Pro is an integrated system that combines electronic hardware and intelligent software to analyze soil health in real time. The hardware is responsible for sensing soil parameters, while the software processes, interprets, and presents the data in a simple and useful form.

Hardware Components

- **Soil Sensors:** pH sensor, moisture sensor, and EC sensor to detect soil conditions
- **ESP32 Microcontroller:** Processes sensor signals and manages data communication
- **Probe Assembly:** Allows direct insertion into soil or soil–water slurry
- **Power Supply:** Provides energy for sensor operation and data transmission

Software Components

- **Mobile Application:** Displays soil readings and recommendations
- **Data Processing Logic:** Converts raw sensor values into meaningful units
- **Analysis Module:** Evaluates soil health using predefined scientific ranges
- **Visualization Tools:** Graphs and indicators for easy interpretation

The hardware collects physical and chemical data from soil, while the software transforms this data into actionable insights. Together, they form a complete soil analysis solution that is fast, portable, and farmer-friendly.

Working Of System

The NutriScan Pro system follows a simple step-by-step process to analyze soil health accurately and efficiently.

Step 1: Soil Sampling
The probe is inserted into moist soil or a soil–water slurry at root depth. Moisture helps dissolve nutrients so that sensors can measure soil properties effectively.

Step 2: Sensor Measurement

The sensors measure:

1) pH (acidity or alkalinity)
2) Electrical Conductivity (nutrient and salt presence)
3) Moisture content

These sensors generate electrical signals based on soil conditions.

Step 3: Data Processing by Microcontroller

The ESP32 microcontroller receives raw sensor signals and converts them into digital values. These values are then transmitted wirelessly to the mobile application using Bluetooth.

Step 4: Data Analysis by Software

The application applies mathematical formulas and predefined thresholds to interpret sensor values. Soil condition is classified into ranges such as low, medium, or high.

Step 5: Result Display and Recommendations

The final results are displayed on the screen along with:

- Soil health indicators
- EC trend graph
- Crop and fertilizer recommendations

Physics Integration

1. Role of Physics in Nutriscan Pro

Physics is the foundational science behind the Nutriscan Pro project. The entire system works by applying physical principles to measure soil properties and convert them into meaningful digital information. Traditional soil testing depends on laboratory chemical analysis, which is time-consuming and inaccessible for many farmers. Nutriscan Pro replaces this with a physics-based approach that allows instant measurements directly in the field.

The project uses principles of electricity, electrochemistry, and electromagnetic communication. Soil properties such as moisture content, nutrient availability, and pH influence electrical parameters like voltage, resistance, and conductivity. Physics explains how these changes occur and how they can be measured accurately using sensors and electronic circuits.

The ESP32 microcontroller processes electrical signals obtained from the soil and converts them into usable data. Wireles transmission further applies physics concepts related to electromagnetic waves. Overall, physics enables Nutriscan Pro to provide fast, reliable, and scientific soil analysis.

2. Soil as a Physical System

Soil can be viewed as a physical system consisting of solid particles, water, air, and dissolved salts. From a physics perspective, soil is neither a perfect conductor nor a perfect insulator. Its electrical behavior depends on moisture level, texture, and ionic concentration.

When water is mixed with soil, nutrients dissolve and form charged ions. These ions allow the flow of electric current through the soil solution. Sandy soil, clayey soil, and loamy soil show different electrical behaviors due to differences in structure and composition.

Nutriscan Pro treats soil as a measurable physical medium. Physics helps in understanding why wet soil conducts electricity better than dry soil and why nutrient-rich soil produces different sensor readings. This physical interpretation ensures that soil analysis is scientific and consistent rather than based on assumptions.

3. Electrical Conductivity of Soil

Electrical conductivity represents the ability of soil to allow electric current to pass through it. This property mainly depends on the concentration of dissolved salts and nutrients, as well as soil moisture. In Nutriscan Pro, soil is mixed with water so that nutrients dissolve into ions.

When the probe is dipped into the soil solution, an electrical signal is applied. The ease with which current flows indicates the conductivity of the soil. Higher conductivity generally suggests higher nutrient availability, while lower conductivity indicates poor soil fertility.

Physics explains this relationship through the movement of charged particles in an electric field. Conductivity measurement allows Nutriscan Pro to estimate soil condition quickly and effectively.

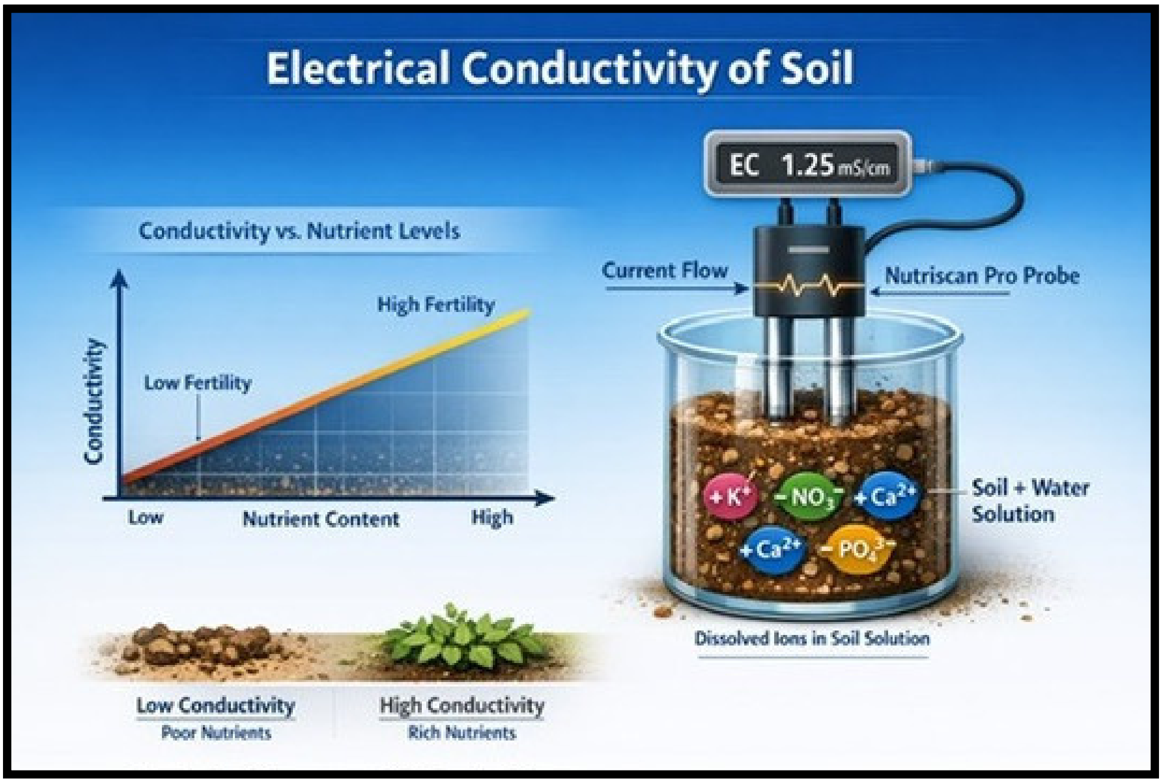

Figure :- Representation of measurement of soil conductivity

The image clearly shows how the increased conductivity of the soil helps us determine that the nutrient content of the soil is higher/has increased.

4. Resistance Measurement in Soil

Resistance is the opposition offered by a material to the flow of electric current. In soil, resistance depends on moisture content, nutrient concentration, and soil structure. Nutriscan Pro measures soil resistance using metallic electrodes placed in the soil-water mixture.

When voltage is applied across the electrodes, current flows through the soil solution. Moist and nutrient-rich soil offers lower resistance, while dry or nutrient-deficient soil offers higher resistance. These resistance values are sent from the sensor to the ESP32 Microcontroller.

Physics ensures that resistance measurements are accurate and repeatable. By comparing resistance values across samples, Nutriscan Pro can differentiate between healthy and poor soil conditions.

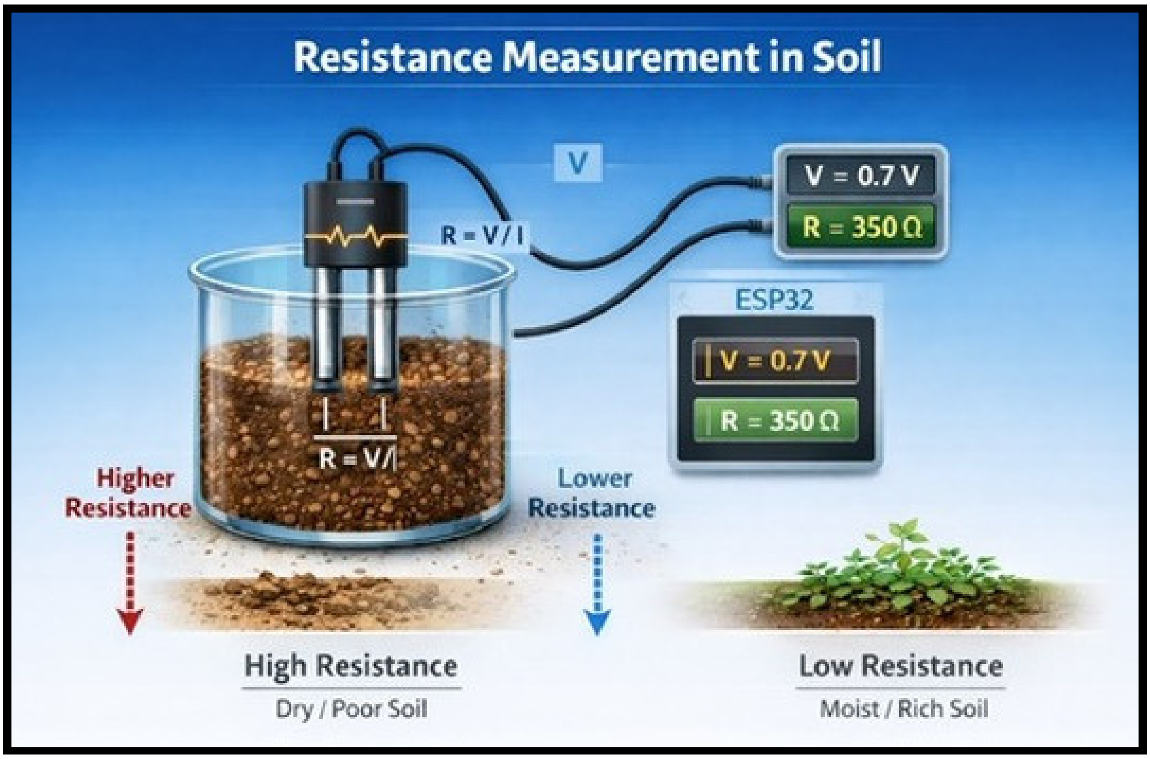

Figure :- Representation of measurement of resistance in soil

The image shows how the device can determine the difference between a healthy soil sample and a poor one by measuring the resistance across the electrodes of the sensor dipped in soil slurry.

$$\text{Conductivity } (\sigma) = 1 \div R$$

where, R = resistance of soil solution

5. Application of Ohm’s Law

Ohm’s Law defines the relationship between voltage, current, and resistance. Nutriscan Pro directly applies this fundamental law of physics in its measurement process. When a known current passes through the soil solution, the voltage drop across the probe changes according to soil resistance.

The ESP32 measures this voltage and uses Ohm’s Law to calculate resistance accurately. This calculated resistance is then used to analyze soil properties such as moisture and nutrient availability.

Applying Ohm’s Law ensures that all electrical measurements are based on established scientific principles. This makes the system reliable and suitable for real-world agricultural applications.

$$V = I \times R$$

where,

- V = voltage across soil probe
- I = current through soil
- R = resistance of soil

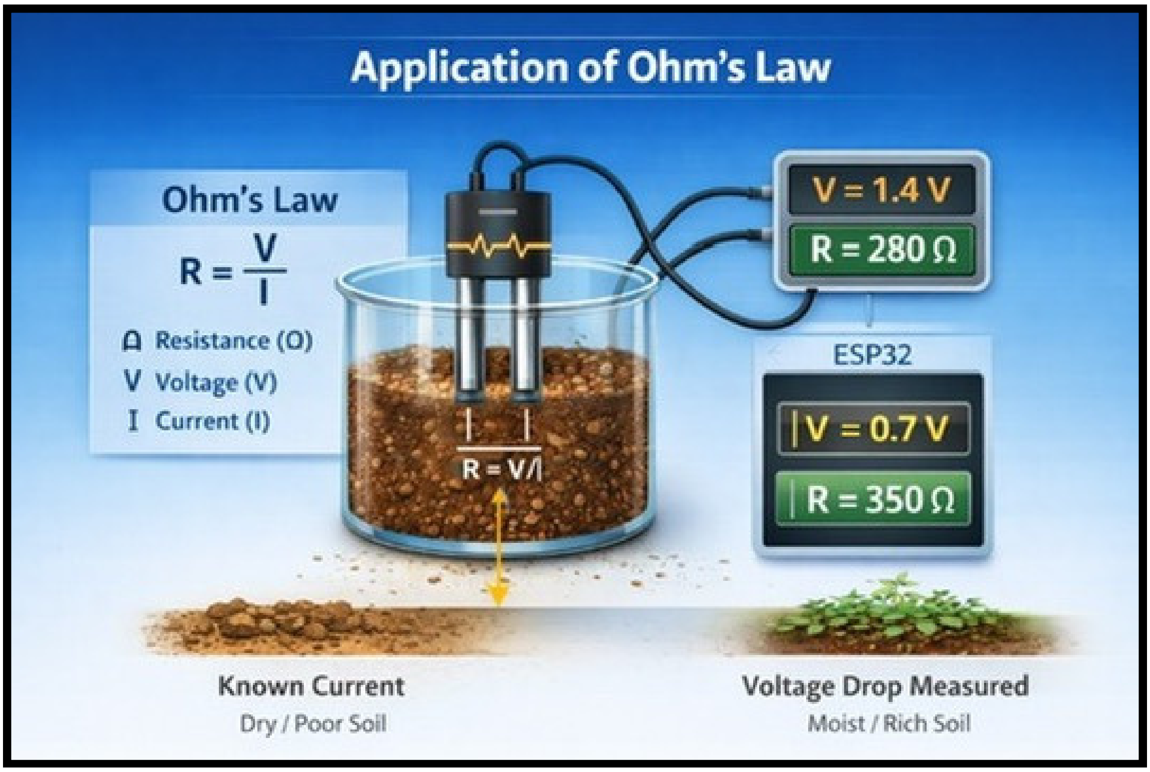

Figure :- Showing how Ohm's law helps calculate resstance

The image shows how with known voltage and current, our device can calculate the resistance which allows to identify the conductivity which is the indicator of how fertile the soil is

6. Physics-Based Estimation of NPK Levels

Nutriscan Pro estimates Nitrogen, Phosphorus, and Potassium levels using indirect physics-based techniques. The nutrients dissolve in water and form ions that influence electrical conductivity and resistance.

Instead of performing chemical reactions, the Electric Conductivity (EC) sensor uses Ohm's Law to calculate the resistance (R) across the electrodes which helps it find the conductivity (σ) across the rods as well.

These measured values in the range of (0-100) helps the system identify the N,P and K concentrations indirectly.

7. Measurement of Soil Moisture

Soil moisture significantly affects crop growth and nutrient absorption. Nutriscan Pro measures soil moisture using changes in electrical resistance and conductivity caused by water content.

As moisture increases, water fills the gaps between soil particles, allowing electric current to flow more easily. The sensor detects this change and generates an electrical output corresponding to moisture level.

Physics explains how water reduces resistance and increases conductivity. Accurate moisture measurement helps farmers plan irrigation efficiently and avoid water wastage.

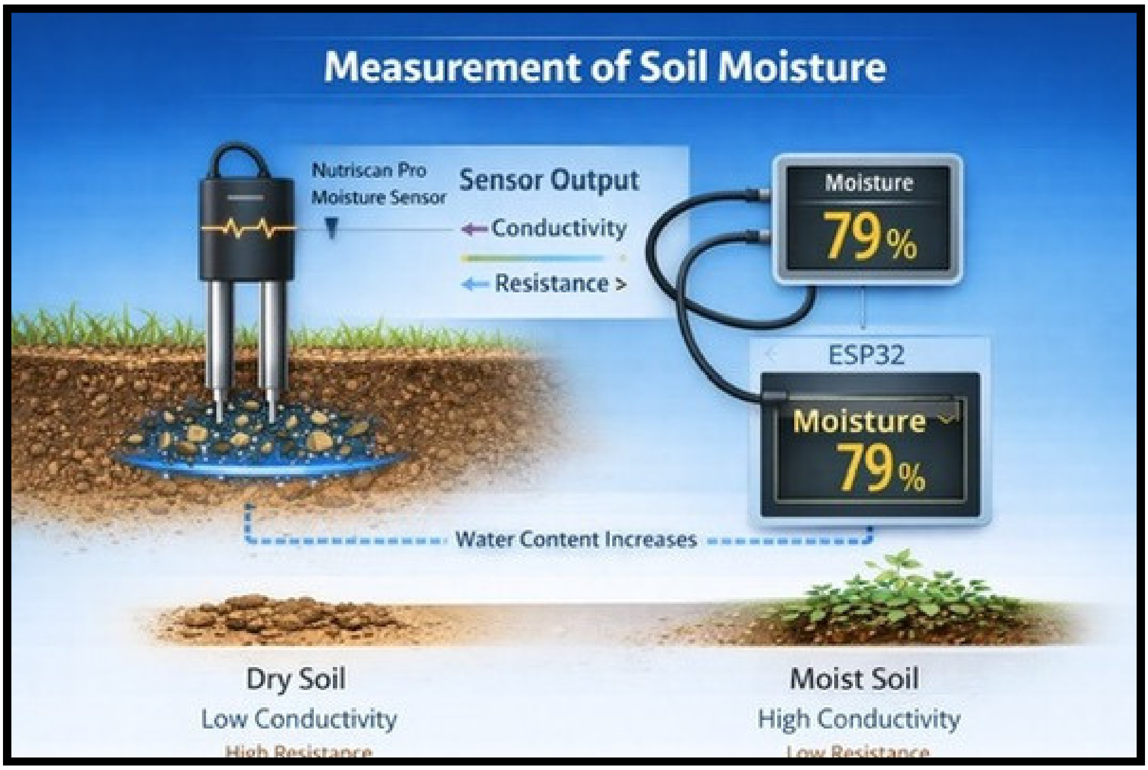

Figure :- Image showing how soil moisture content is measured

The image represents how the device can identify the moisture content of the soil by calculating the conductivity of the soil.

Resistance ∝ 1/Moisture Content

8. Capacitance Effects in Moist Soil

Capacitance is the ability of a system to store electric charge.Water has a high dielectric constant (measure of material's ability to store electrical energy in an electric field) , which significantly affects the capacitance of soil. In Nutriscan Pro, changes in soil moisture alter the capacitance between sensor electrodes.

As water content increases, the dielectric property of soil changes, increasing capacitance. Physics explains how electric fields interact with water molecules.Using capacitance improves measurement sensitivity and stability.

This allows Nutriscan Pro to provide reliable moisture readings under varying field conditions.

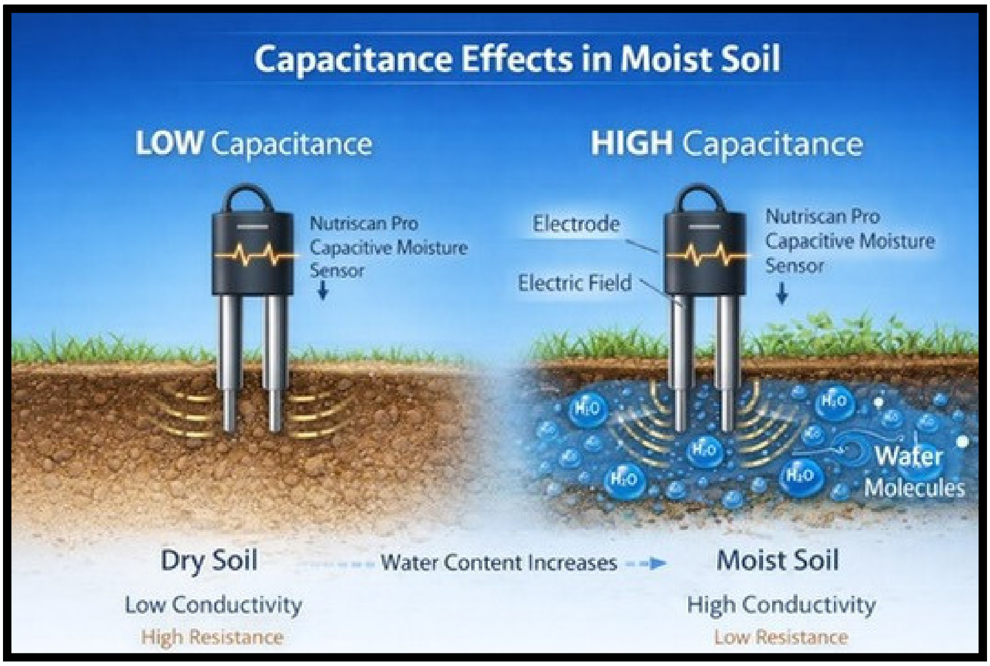

Figure :- How capacitance helps identify soil moistue content

The image represents how the soil moisture determines the moisture content by measuring the capacitance between both the electrodes.

9. Electrochemical Principle of pH Measurement

Soil pH determines whether soil is acidic or alkaline and directly affects crop suitability. Nutriscan Pro measures pH using electrochemical principles.

The pH sensor produces a voltage based on hydrogen ion concentration in the soil solution.Acidic and alkaline soils generate different voltage levels.

These voltages are measured and converted into pH values using calibration data.

Physics ensures accurate interpretation of electrochemical signals. This allows farmers to understand soil suitability for different crops.

Figure :- Showing how pH is determined by the produced voltage
The image shows how the voltage produced by the sensor in different solutions helps the system

10. Temperature Effects on Sensor Readings

Temperature plays a crucial role in the accuracy and reliability of electronic sensors used in Nutriscan Pro. From a physics perspective, temperature directly affects electrical resistance, voltage stability, and electrochemical reactions occurring inside the soil-water mixture.

As temperature increases, ions in the soil solution move more rapidly, which increases electrical conductivity and decreases resistance. If this effect is not considered, soil moisture or nutrient readings can appear higher than their actual values.

Similarly, pH sensors are sensitive to temperature because the voltage generated at the sensing electrode depends on thermal energy. According to electrochemical principles, higher temperatures can slightly increase electrode potential, causing small shifts in pH readings. Nutriscan Pro accounts for this by stabilizing readings through calibration and averaging multiple sensor values.

Understanding temperature effects ensures that readings remain consistent across different times of the day and varying field conditions.

This physics-based awareness allows the system to provide more dependable soil analysis, even in hot or cool agricultural environments.

11. Signal Conditioning and Noise Reduction

Raw electrical signals generated by soil sensors are often weak and susceptible to noise. Noise may originate from surrounding electrical devices, fluctuations in supply voltage, or natural electromagnetic interference. Physics principles related to wave behavior, electromagnetic induction, and circuit theory are applied to reduce this noise and improve signal quality.

In Nutriscan Pro, signal conditioning circuits such as resistors, capacitors, and filters are used to smoothen voltage fluctuations. Capacitors help block unwanted high-frequency noise, while resistive networks stabilize current flow.

These components ensure that the ESP32 microcontroller receives a clean and accurate analog signal.

Without proper signal conditioning, minor disturbances could lead to large errors in soil readings. By applying physics-based filtering and stabilization techniques, Nutriscan Pro ensures that the sensor output reflects true soil conditions rather than random electrical disturbances.

12. Analog-to-Digital Conversion (ADC)

Soil sensors naturally produce analog signals, meaning their output voltage changes continuously. However, digital systems like the ESP32 cannot directly process analog values. Physics principles of sampling and quantization are applied through Analog-to-Digital Conversion.

The ADC converts varying voltage levels into discrete digital values by comparing the input voltage with reference levels. This process relies on precise timing and voltage resolution, both governed by electronic physics. Higher resolution ADCs can detect smaller changes in voltage, allowing Nutriscan Pro to measure subtle differences in soil moisture, conductivity, and pH.

Accurate ADC conversion is essential because even a small voltage change may represent a significant variation in soil health. Physics ensures that this conversion process retains maximum information while minimizing error, enabling the software to interpret sensor data correctly.

13. Power Management and Energy Efficiency

Nutriscan Pro is designed to operate efficiently in field conditions where power availability may be limited. Physics principles related to electrical power, energy conservation, and efficiency guide the system's power management strategy.

The ESP32 operates at low voltage and uses sleep modes to reduce power consumption when measurements are not being taken. Sensors are powered only during active readings, minimizing unnecessary energy loss. This approach follows the principle that electrical power equals voltage multiplied bycurrent, so reducing either component lowers overall energy usage.

Efficient power management ensures longer battery life and reliable operation during extended field use. Applying physics- based energy optimization allows Nutriscan Pro to function as a practical and portable agricultural tool rather than a lab- dependent system.

14. Wireless Data Transmission Physics

Nutriscan Pro communicates with a mobile application using wireless signals, which rely on electromagnetic wave propagation. Physics principles governing radio waves, frequency, wavelength, and signal attenuation are applied in this process.

The ESP32 transmits data using Wi-Fi or Bluetooth, where information is encoded into electromagnetic waves. These waves travel through air and are affected by distance, obstacles, and interference. Understanding signal strength and attenuation helps ensure stable data transfer between the device and the smartphone.

By selecting appropriate transmission power and frequency, Nutriscan Pro maintains a balance between energy efficiency and communication reliability. Physics enables real-time data delivery, transforming raw sensor readings into instantly accessible information for farmers.

15. Calibration and Error Correction

Calibration is a critical physics-based process that ensures sensor readings match real-world values. Sensors may drift over time due to environmental exposure, electrode aging, or temperature changes. Calibration involves comparing sensor output with known reference values and adjusting the system accordingly.

Physics principles of measurement accuracy, systematic error, and repeatability are applied during calibration. For example, known pH buffer solutions or standard conductivity values are used to align sensor output with accepted standards. Mathematical correction factors are then applied within the microcontroller software.

This process ensures that Nutriscan Pro provides consistent and trustworthy readings. Without calibration, even advanced sensors would gradually lose accuracy, reducing the usefulness of the system in agricultural decision-making.

16. Physics Behind Data Interpretation and Decision Making

The final stage of Nutriscan Pro involves interpreting sensor data to generate meaningful recommendations. Physics transforms raw electrical measurements into physical quantities such as moisture percentage, pH level, and nutrient availability.

Mathematical models based on experimental observations relate resistance, capacitance, and voltage values to soil properties. These models rely on physical laws and empirical relationships developed through testing. Once processed, the data is displayed in a simplified form that farmers can easily understand.

Physics thus acts as the bridge between invisible electrical signals and practical agricultural guidance. By converting complex physical interactions into actionable insights, Nutriscan Pro enables faster, evidence-based decisions that improve crop planning and fertilizer usage.

Chemistry Integration

Soil chemistry helps us understand what is happening inside the soil. Soil is not just dirt. It is a living place where tiny soil particles, water, air, and plant food are always mixing together. These things react with each other all the time. Because of these reactions, plants either grow healthy or grow weak. Even if soil looks good from outside, plants may not grow well if the chemical conditions inside the soil are not correct. That is why chemistry is very important in studying soil health and soil fertility.

1. Soil pH and Its Role in Chemical Reactions

1.1 Meaning and Importance of Soil pH

Soil pH simply tells us how sour or how soapy the soil is. If soil is very sour, it is called acidic. If soil is very soapy, it is called alkaline. If it is in between, it is called neutral. Soil pH is measured on a scale from 0 to 14.

A lower number means more sour soil, and a higher number means more soapy soil. Most plants do not like extreme conditions. They grow best when soil is close to neutral.

Soil pH is very important because it controls how soil behaves. It decides which nutrients are free and which nutrients get stuck.

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Soil pH is very important because it controls how soil behaves. It decides which nutrients are free and which nutrients get stuck. It also affects how fast chemical reactions happen in soil and how active helpful soil organisms are. Because soil pH controls so many things, it is often called the most important factor in soil chemistry.

$$pH = -\log[H+]$$

Where,

- *[H^+] = concentration of hydrogen ions*

1.2 What Happens in Acidic Soil

In acidic soil, there are too many sour particles. Because of this, some nutrients stop working properly. Phosphorus, which helps roots grow and plants become strong, gets stuck in acidic soil. It sticks to iron and aluminium that are already present in soil.

Once phosphorus gets stuck, plants cannot take it, even though it is still inside the soil.

Acidic soil can also release harmful substances that hurt plant roots. When roots are damaged, plants cannot take enough water or nutrients. This makes plants weak and small.

Real-World Example:

In places where it rains a lot, rain washes away good nutrients from soil and makes it acidic. This happens in areas like Assam and Kerala. Farmers there add lime to the soil. Lime reduces sourness and helps nutrients become free again.

1.3 What Happens in Alkaline Soil

In alkaline soil, the soil has too much calcium. Here, phosphorus sticks to calcium and becomes hard. When this happens, plants cannot absorb phosphorus easily. Alkaline soil also causes problems with small nutrients like iron and zinc. These nutrients are needed in very small amounts, but they are very important for plant health. When plants do not get them, leaves turn yellow and growth becomes slow.

Real-World Example:

In dry areas like Rajasthan and Gujarat, soil is often alkaline. Farmers notice yellow leaves in crops like wheat. To solve this problem, farmers add organic manure or special fertilizers that help nutrients become available.

1.4 Best Soil pH for Plant Growth

Most plants grow best when soil pH is between 6 and 7. In this range, nutrients are not stuck and are easy for plants to take. Helpful soil bacteria also work best in this condition. Roots grow well, and plants become healthy. This is why soil testing is done before farming, so farmers know whether soil pH needs correction.

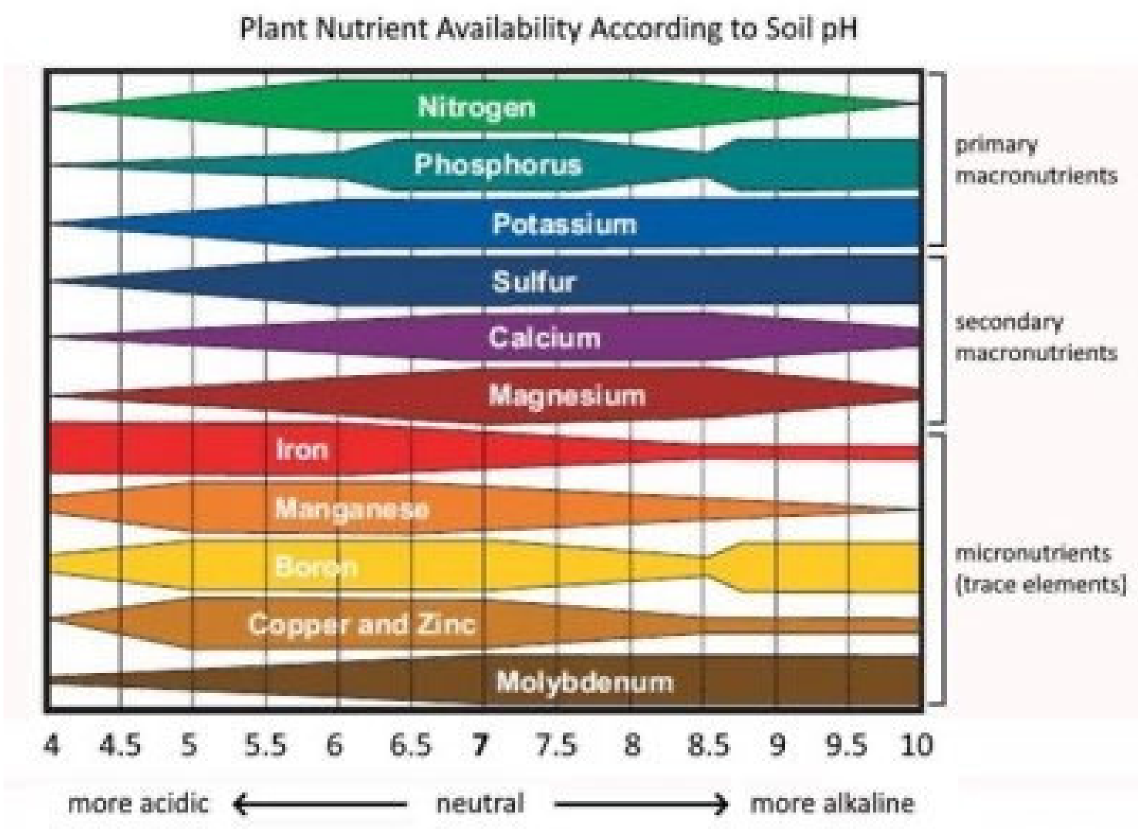

Figure: Effect of soil pH on nutrient availability.
The chart shows how the availability of essential plant nutrients varies with soil pH. Most nutrients are most available in the pH range of 6 to 7, while extreme acidic or alkaline conditions reduce nutrient uptake. This explains why maintaining optimal soil pH is crucial for healthy plant growth and efficient fertilizer use.

2. Nutrient Behavior and Ionic Forms in Soil

2.1 Nutrients Exist as Tiny Charged Particles

Plants cannot eat solid nutrients. They drink nutrients mixed in water. When nutrients mix with oil water, they break into very tiny pieces called ions.

These ions are so small that plant roots can easily take them in. Only nutrients in this form can be used by plants.

- Nitrogen → NO_3^-, NH_4^+
- Potassium → K^+
- Phosphorus → $H_2PO_4^-$

2.2 Nitrogen in Soil

Nitrogen helps plants grow tall and green. Plants absorb nitrogen mainly in two forms. One form moves very fast in soil and can easily wash away with water. The other form sticks to soil and stays longer. Both forms are useful, but they behave differently in soil.

Real-World Example:

In rice fields, soil stays flooded with water. In such conditions, farmers prefer nitrogen that stays in soil longer, so plants can use it slowly and properly.

2.3 Potassium in Soil

Potassium helps plants stay strong and healthy. It helps control water inside plants and protects them from diseases. Potassium exists as tiny charged particles in soil water. Soil holds potassium like a storage box and releases it when plants need it.

Real-World Example:

Crops like sugarcane need a lot of potassium. Farmers add potash fertilizer to increase yield and improve quality.

2.4 Phosphorus in Soil

Phosphorus helps roots grow deep and strong. It also helps in flowering and fruit formation. Phosphorus does not move easily in soil and often gets stuck. That is why soil pH plays a very important role in phosphorus use.

3. Electrical Conductivity (EC) and Soil Salinity

3.1 What is EC in Simple Words

Electrical Conductivity, or EC, tells us how many dissolved particles are present in soil water. When there are more dissolved nutrients or salts, soil water can carry more electricity. When there are fewer dissolved particles, electricity flow is low.

$$EC \propto \text{Total Dissolved Ion Concentration}$$

3.2 EC and Plant Growth

Normal EC means soil has enough nutrients. Very high EC means soil has too much salt. Too much salt makes it difficult for plants to drink water, even if water is present in the soil.

4. Soil–Water Interaction and Chemical Processes

4.1 Why Water Is Very Important in Soil

Water is needed for almost everything in soil. It dissolves nutrients, helps them move, and allows chemical reactions to happen. Without water, nutrients remain locked and useless.

4.2 Soil Holds Nutrients Like a Magnet

Soil particles have a small negative charge. Many nutrients have a positive charge. Because of this, soil attracts and holds nutrients like a magnet. This stops nutrients from washing away too fast and allows plants to take them slowly.

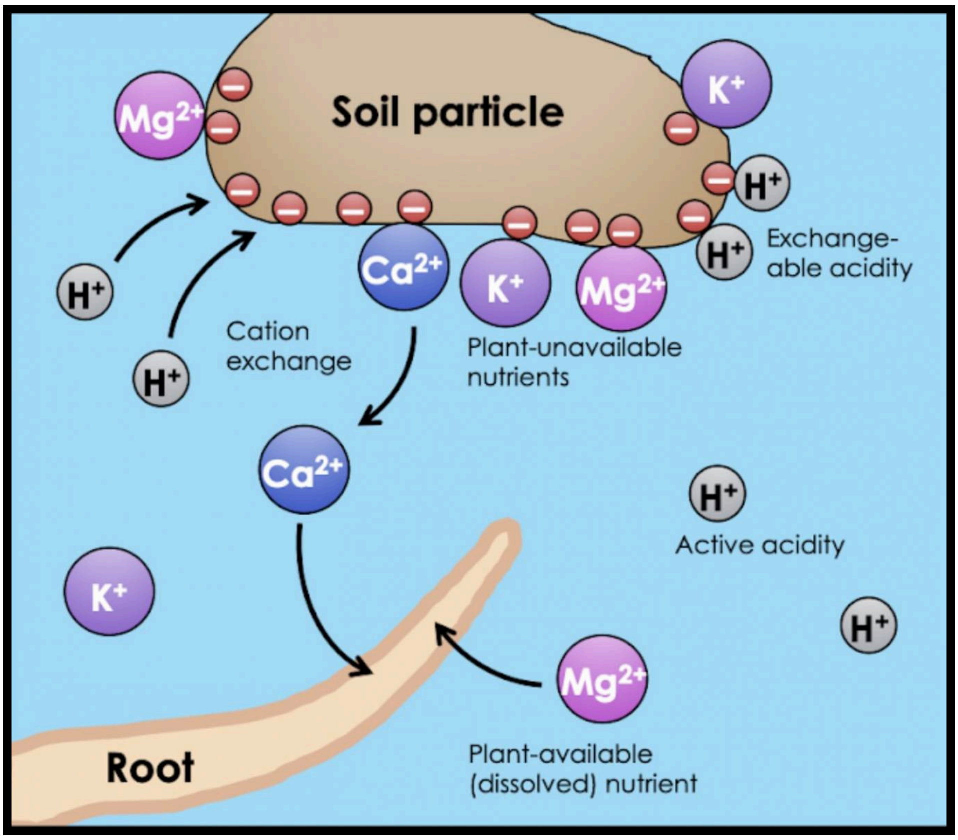

Figure: Cation exchange process in soil.
Positively charged nutrient ions such as calcium, potassium, and magnesium are held on negatively charged soil particles and released into soil water, where they become available for plant uptake. Hydrogen ions influence this exchange and soil acidity.

4.3 Why Soil Is Mixed with Water for Testing

Soil testing is done by mixing soil with water because plant roots also absorb nutrients from wet soil. This method shows real conditions and gives accurate results.

5. Importance of Soil Chemistry in Farming

Understanding soil chemistry helps farmers choose the right fertilizers, correct soil problems, save money, and grow healthy crops. It also helps protect soil for future use.

Conclusion

In conclusion, soil chemistry helps us understand how soil works. Soil pH decides whether nutrients are free or stuck. Nutrients exist as tiny particles that plants can drink. Water helps nutrients move and react. EC tells us how much nutrient or salt is present in soil. All farming practices depend on these simple chemical ideas. Therefore, chemistry is the backbone of soil health and successful agriculture.

Math Integration

Mathematics is used everywhere in this system, even when we do not notice it directly. Whenever the system reads data from sensors, changes that data into useful values, compares different numbers, or makes a decision, mathematics is working in the background. Numbers help the system understand what the soil condition really is and help it decide what action or suggestion should be given. Without mathematics, the data collected from sensors would just be meaningless numbers. Mathematics turns those numbers into useful information.

1. Sensor Calibration & Conversion

1.1 Why Sensor Data Needs Conversion

Sensors do not directly give values like pH, moisture percentage, or EC. Instead, sensors give raw values, usually in the form of voltage or simple numbers. These raw numbers do not make sense to humans or farmers. Mathematics is used to convert these raw values into meaningful units that we can understand easily.

For example, when a pH sensor is placed in soil, it does not directly say “pH is 6.5”. It gives a small electrical value.Mathematics helps convert that value into a number between 0 and 14, which is the pH scale. In the same way, moisture sensors give raw readings that are converted into percentages between 0% and 100%, showing how wet or dry the soil is.EC sensors also give raw values, which are converted into relative EC units that tell us about salt and nutrient presence.

1.2 How Mathematics Is Used in Conversion

To convert sensor values, simple mathematical ideas are used. Linear equations are used to draw a straight relationship between raw sensor value and real-world value. Scaling is used to stretch or shrink numbers so that they fit into a proper range. Offset correction is used to adjust errors so that the sensor gives accurate results. In simple words, mathematics helps the system say, “If the sensor gives this number, the real soil value must be this much.” Without these calculations, the sensor readings would be confusing and unreliable.

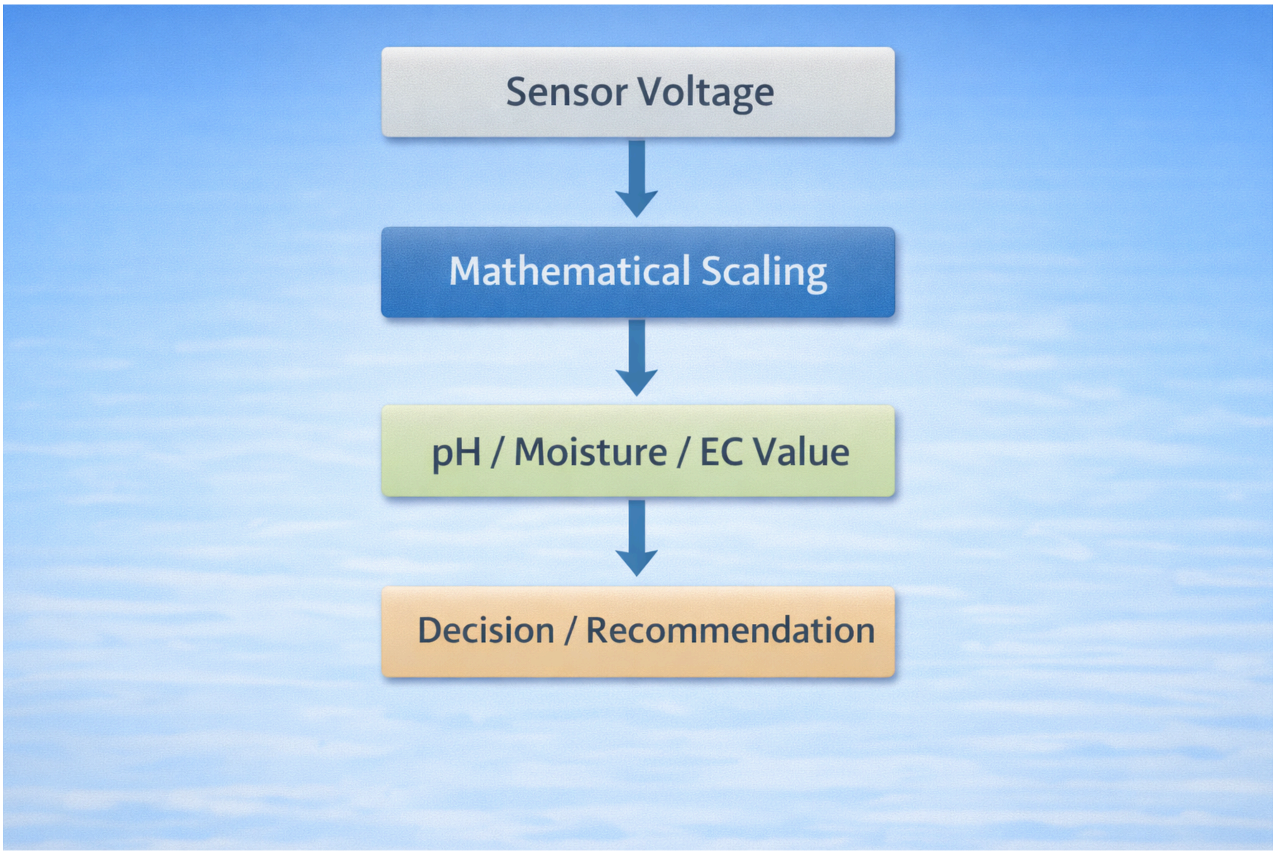

Figure :- Mathematical Processing of Sensor Data in NutriScan Pro

This diagram illustrates how raw sensor readings are mathematically converted into meaningful soil parameters. Electrical signals from sensors are scaled, normalized, and processed using mathematical formulas to obtain values such as pH, moisture percentage, and electrical conductivity. These processed values are then used for soil fertility analysis and crop suitability calculations.

Actual Value = m x Raw Sensor Reading + c

where,

- *m = scaling factor*
- *c = offset*
-

2. Derived NPK (Soil Fertility) Index

2.1 Why Direct NPK Is Not Measured

Measuring nitrogen, phosphorus, and potassium directly requires expensive and complex equipment. Instead of measuring N, P, and K separately, the system uses mathematics to calculate a Soil Fertility Index. This index gives a general idea of how fertile the soil is. Mathematics combines information from EC, moisture, and pH to estimate soil fertility. This makes the system simpler, cheaper, and faster while still giving useful results.

2.2 Soil Fertility Index Formula (Simple Understanding)

The Soil Fertility Index is calculated using a mathematical formula where EC, moisture, and pH are added together in a balanced way. Each value is multiplied by a constant number, which decides how important that value is.

In simple terms:

- EC tells us about nutrient and salt level
- Moisture tells us if soil has enough water
- pH tells us if soil conditions are suitable

Before adding them, each value is normalized. Normalizing means bringing different values to the same scale so that no single value becomes too powerful. This makes the calculation fair and balanced.

Normalization formula:

$$X(norm) = (X - X(min)) \div (X(max) - X(min))$$

, this is how all three indexes are brought to same scale before comparission

where,

X = actual measured value
X(min) = Minimum expected value
X(max) = Maximum expected value

Fertility Index = a(EC_norm) + b(Moisture_norm) + c(pH_norm)

Where,

- *a, b, c are weighting constants*

2.3 Fertility Classification Using Mathematics

After calculating the Soil Fertility Index, mathematics is again used to compare the number with fixed ranges. Based on this comparison, soil is classified into three groups:

- Low fertility
- Moderate fertility
- High fertility

This classification helps users understand soil quality easily without reading complex numbers. Instead of saying “your fertility index is 0.63”, the system simply says “moderate fertility”.

3. Crop Suitability Scoring

3.1 Why Crop Scoring Is Needed

Different crops need different soil conditions. Some crops like acidic soil, some like neutral soil, and some need more water than others. Mathematics is used to check how well a crop matches the current soil condition.

Each crop is given a suitability score. This score tells how suitable that crop is for the given soil.

3.2 How Suitability Score Is Calculated

The suitability score is calculated using simple mathematical comparisons. The system checks:

- How close the soil pH is to the crop's preferred pH
- Whether soil fertility is enough for the crop
- Whether moisture level is suitable

Each factor gives some points. These points are added together using mathematics. The crop with the highest total score is selected as the best option.

In simple words, mathematics helps the system say, "This crop matches soil conditions better than others."

3.3 Final Crop Recommendation

After calculating scores for all crops, mathematics is used to compare them. The crop with the highest score is chosen and recommended. This removes guesswork and makes the decision logical and data-based.

4. Graphs & Trend Analysis

4.1 Why Graphs Are Used

Graphs help us see changes clearly. Numbers in a table can be confusing, but graphs make it easy to understand what is happening over time. Mathematics is used to create graphs from sensor data.

4.2 Mathematical Ideas Used in Graphs

Simple mathematical ideas like averages, differences, and rate of change are used. Averages show the general condition of soil over time. Differences show how much soil condition has changed. Rate of change shows how fast soil conditions are improving or worsening.

4.3 Understanding Soil Changes Over Time

Using graphs, we can see how soil condition changes after rainfall, irrigation, or fertilizer application. For example, moisture increases after rain, EC may increase after fertilizer use, and pH may slowly change over time. Mathematics helps track these changes clearly and accurately.

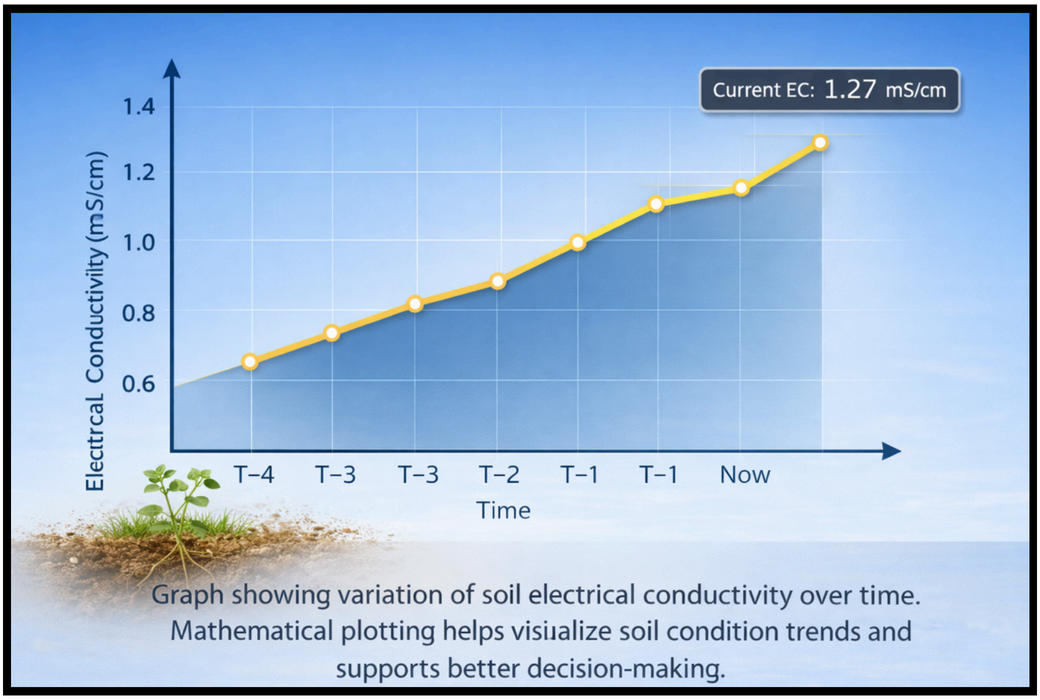

Figure :- Graph showing EC trend

Graph showing variation of soil electrical conductivity over time. Mathematical plotting helps visualize soil condition trends and supports better decision-making.

Conclusion

In conclusion, mathematics plays a very important role in data processing and decision making. It helps convert raw sensor values into meaningful numbers, calculate soil fertility, compare crop suitability, and display data in the form of graphs. Mathematics makes sure that decisions are logical, fair, and based on data. Without mathematics, the system would not be able to understand soil conditions or give useful recommendations. Therefore, mathematics is the backbone of data analysis, soil evaluation, and smart decision making in this system.

Conclusion

NutriScan Pro successfully demonstrates how scientific principles can be applied to solve real-world agricultural problems. By integrating Physics, Chemistry, Mathematics, and Software Technology, the project provides a fast, affordable, and user-friendly solution for soil health monitoring.

The system replaces slow and expensive laboratory testing with instant field-level analysis. It helps farmers understand soil conditions, choose suitable crops, and apply fertilizers efficiently. This reduces resource wastage, improves crop yield, and supports sustainable farming practices.

Although the current version is a prototype, it shows strong potential for future development. With improved sensor accuracy, better calibration, and advanced software features, NutriScan Pro can become a powerful tool for precision agriculture.

Overall, this project proves that interdisciplinary science, when applied thoughtfully, can create impactful solutions that benefit society and the environment.

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Remarks