Fertilizer Quality Testing Machine Using NPK

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Abstract - This abstract outlines a new machine for testing fertilizer quality that utilizes NPK analysis to measure nutrient levels in different types of fertilizers, including granular, powdered, and liquid forms. The device uses chemical reagents and optical sensors to measure the amounts of N,P, and K in the fertiliser samples and calculate those levels. The system produces quick, automated results that are simple to read and can be exported for more research. This technology is expected to improve the quality control of fertilizers, ensuring that farmers can access high-quality fertilizers that meet their specific nutrient requirements.

***Key Words*:** NPK Sensors, IR-Spectroscopy.

1.INTRODUCTION

Farming is often seen as a less technologically advanced industry, and farmers often rely on physical labor to maintain their crops. However, many agricultural procedures, such as fertilization, are not always necessary, and farmers often lack clear guidance on whether or not to apply them. As a result, farmers may over-fertilize their crops, leading to economic and environmental consequences. In actuality, the creation and application of nitrogen fertilisers is responsible for up to 80% of agricultural greenhouse gas emissions, including nitrous oxide. Traditional manual soil testing are not always accurate, which might result in fertilisation that is either too much or too little.

Teralytic's sensor is a device that addresses this issue by providing real-time information about soil composition. The sensor is a meter-long, battery-powered device with 26 different sensors that detects NPK levels, pH levels, soil moisture, temperature, aeration, and temperature and humidity above ground. Farmers may be able to adopt more environmentally friendly fertilisation techniques with the use of this knowledge, thereby increasing crop yields as well. By incorporating accessible technology like the Teralytic sensor into agriculture, food production can become more efficient and cost-effective, while also reducing pollution and environmental impact.

2. LITERATURE SURVEY

Potdar *et al.* [1] and colleagues (2021) suggest that to sustainably meet the food requirements of a growing population, it is essential to have high-yield plantations that receive adequate amounts of essential nutrients such as N, P and K through well-nourished soil. Soil nutrient analysis can be conducted through both physical (optical) and chemical (electrochemical) methods. Optical methods are ideal for developing portable sensors because they can detect nutrients in dry soil samples without the requirement for time-consuming pretreatments. Inexpensive colorimetric methods are particularly useful for developing portable optical sensors for the detection of soil macronutrients since they don't require expensive equipment or sophisticated analysis techniques.

Aitkenhead et al. [2] and colleagues (2011) emphasize the significance of monitoring soil and crop conditions for sustainable agricultural management. However, the conventional methods of collecting samples and sending them for analysis can be time-consuming and not practical for quick decision-making. To address this issue, The James Hutton Institute's low-cost hyperspectral technology can swiftly assess the condition of the soil and plants in a field. The tool was tested out at the Institute's research farm in Balruddery, where spectral data was acquired and linked to sample analysis and previously gathered crop type data. The technology was useful for analysing site characteristics, and one could identify crops and determine the soil's nutrient status by using its visible-range spectra. Although having low accuracy rates, the technique showed that it could extract information about soil nutrients from crop spectra (r2 values of 0.55 for Mn, 0.71 for NO3, and 0.67 for Available N).

Iznaga *et al.* [3] and associates, determining crucial fertility indicators, such as organic matter (OM), accessible phosphorus (P), and potassium (K2O), for sugarcane cultivation in Cuba using known approaches is challenging,

expensive, and time-consuming (2018). The study's goal was to develop and evaluate calibration models employing Visible/Near Infrared Reflectance (Vis/NIR) at the landscape and field levels while taking into account their correlation with OM in order to address this problem. Also, the study chose a few wavelength bands to expedite the process. This was done since it had been shown that variables like P and K2O, which are not spectrally active in the Vis/NIR region, could be predicted more accurately when they were significantly connected to OM.. In the study, nonlinear regression models were used to estimate soil fertility parameters at the landscape level. Results from Olsen P and OM were successful and rather successful (R2 of 0.93 with LWR, respectively) (R2 of 0.81 with SVM). In addition to outlining the potential of Vis/NIR spectroscopy for assessing typical soil fertility aspects in Cambisol-based agricultural fields in Cuba, the paper suggests a preprocessing procedure.

Chen *et al*. [4] and associates, several symptoms on rice leaves can signify a potassium deficiency and change depending on the potassium level (2014). In order to create a rapid method for nutrition diagnosis, the study did multiple years of aquaponic research on rice, providing 5 phases of potassium nutrients, and captured leaf images by optical sensors during 4 developmental stages. To ascertain how well-fed the rice plants were in potassium, the top three completely formed leaves were examined. Scanning photographs of rice seedlings were inspected in the lab to collect spectral data. Also, using object-oriented classification, particular potassium deficiency signs including necrotic patches and the yellowish-brown leafy border region were gathered and quantified. The study's conclusions highlight the significance of particular symptoms in assessing potassium nutrition status and propose a highly targeted strategy for promptly and precisely assessing the potassium nutritional intake of rice.

Coûteaux *et al.* [5] evaluated how well near-infrared reflectance spectroscopy (NIRS) worked for figuring out the carbon and nitrogen contents of sands. In a previous work, soils in coniferous woodlands in southern France (43°Y e) and northern Sweden (64-60°Y e) were marked by the addition of wheat straw that was 13C and 15N-labeled before the soils were incubation. From that investigation, the researchers used soil samples. The study discovered that NIRS could predict microbial biomass-C and total nitrogen, which is particularly helpful given how time-consuming traditional analyses are. With Nir spectroscopy, analytical mistakes can also be found.

Dinakaran *et al.* [6] investigated the capability of closer absorption (NIR) spectroscopic to determine soil N and C amounts and to evaluate the accuracy of this technique in predicting these values in recently collected soil samples. According to the study, NIR spectroscopy can accurately forecast the C and N concentrations from Indian sand. The quantification of carbon and nitrogen can be impacted by the water activity in samples collected, which was shown to change the NIR absorption spectra. The authors also call for more investigation to see if Infrared spectroscopy can forecast additional soil characteristics. There was no error found.

Dong et al. [7] examined the detection of soil water-soluble nitrogen (SERS) Using surface-enhanced Raman spectroscopy,. They claimed that SERS is a very sensitive method with the benefits of simplicity and high detection efficiency. The study discovered that SERS based on OTR 202 could accurately measure soil water-soluble nitrogen. The water-soluble nitrogen levels in the soil were found to peak at 1028, 1370, 1436, and

1636 cm1, with 1370 cm1 being the peak with the highest significance and y = 93.491x + 1771.5 as the regression equation. The accuracy of SERS was reported to be 86.67% in determining the level of soil water-soluble nitrogen concentration, which will aid in improving the effectiveness of soil water-soluble nitrogen detection and providing recommendations for urea fertilisation. The goal of the project was to deliver a quick and precise measurement of soil water-soluble nitrogen for fertilisation studies in precision farming.

Ehsani et al. [8] to determine if it would be possible to quickly determine the mineral-N content of soil by employing near infrared (NIR) reflectance. To ascertain how well the Principal Components Regression (PCR) and Partial Least Squares (PLS) approaches could relate NIR spectral data to soil nitrate level in the face of confounding variables and experimental noise, they conducted simulated trials. If the calibration set included the same interfering effects, the simulation tests' findings demonstrated that both PLS and PCR approaches could reliably estimate the soil nitrate level. However, the calibration set's removal of confounding effects from the prediction set rendered these strategies useless, emphasising the necessity of site-specific calibration.Laboratory tests utilising samples of Yolo loam and Capay clay soil, as well as verification tests utilising field soils (Yolo loam and Capay clay) treated with nitrogen fertiliser, have confirmed the NIR approach's potential to identify the mineral-N content of soil. The study shows that NIR reflectance may be a quick way to assess the mineral-N concentration of soil in agricultural settings.

Feng et al. [9] using vis-short wavelength near-infrared spectroscopy (Vis-SWNIRS) Soil total nitrogen (STN) was measured . A quick, cost-effective, and reliable replacement for conventional chemical detection was sought after. The sample sets were divided using the Kennard-Stone method, with 10 samples being utilised for validation and 22 samples being used as the calibration set. The spectral Mahala Nobis and Dixon distance tests did not reveal any outliers. Partial least squares regression (PLSR) and the leave-one-out cross-validation approach were used to create the STN detection model based on Vis-SWNIRS.. In accordance with the model's performance, 5 principal components were determined to be the right number, with calibration and validation correlation values of 0.9724 and 0.8691, respectively, and a Prediction Residual Error Sum of Square (PRESS) of 0.0684. Spectroscopy in the Vis-SWNIR range may be used to locate STN, claims the study.

Fystro et al. [10] looked at the potential of visible (Vis) and near infrared reflectance (NIR) spectroscopy (400–2500 nm) as a quick, accurate, and cost-effective approach for forecasting elements crucial to soil nitrogen (N) availability. They performed Vis-NIR calibrations for total N (Ntot), organic carbon (Corg), and their potential mineralization using 80 samples of grassland soil. The predictions' precision was examined with 48 samples using a "take-out-four" validation method. From 1.7 (r2=0.65) to 2.7 (r2=0.87) was the range of the RPD they obtained for the variables under examination. They discovered that samples that had been dried after being sieved (4 mm) then thawed were more precisely predicted than samples that had been ground. Additionally, using predictors such the values of hot KCl extracted NH4-N (NhotKCl) and loss on ignition (LOI) values, they contrasted their predictions with those derived by conventional linear regression..

Guerrero et al[11] suggestion that near infrared reflectance spectroscopy be used as a quick and inexpensive method to evaluate soil proved successful. To develop suitable models for soil analysis using this approach, soil spectral libraries that take into consideration the diversity of target site soils must be produced. After the models have been spiked with neighbouring samples from the target site, the authors suggest calibrating them. Using a small-scale experiment, the authors developed models linking NIR spectra to distinct NKj contents. Since they were better able to incorporate the characteristics of the target region during spiking, smaller models performed more accurately when predictions were made using local samples. The researchers also discovered that whereas NV models were more susceptible to spiking and differences, SC models were frequently more accurate in their predictions..

Jahn et al. [12] conducted lab and field experiments using mid-infrared (mid-IR) spectroscopy to find extra nitrate in various soil types. Researchers analysed soil paste samples from 10 different soil types using the Fourier transform infrared (FTIR) attenuated total reflection (ATR) technique to determine the nitrate concentrations in the soil. Nitrate levels in laboratory experiments varied from 0-1000 ppm NO3-N, whereas in field tests, they ranged from 0-140 ppm NO3-N. In order to create three-dimensional charts, the wavelet deconvolution technique was used to chart the data at 32 scales for each sample. After that, nitrate levels were correlated with the peak's size. During laboratory tests, the coefficient of determination R2 and standard errors were found to be as high as 0.99 and 24 ppm, respectively. Furthermore, wavelet analysis was used to the soil spectra from Linker et al. (2004), resulting in soil nitrate calibration equations and coefficient of determination R2 values as high as 0.99. However, a strong interfering absorbance peak adjacent to the nitrate peak necessitated the employment of soil-specific calibration formulae based on the carbonate contents of the soils in order to generate an accurate estimate.

Liu et al.[13] mention the significance of soil nutrients when assessing the global effects of the growth of precision agriculture. Accurately identifying nitrogen, phosphorus, and potassium (NPK) components is one of the most challenging undertakings. The unique chip-level colorimeter developed by the authors has made it possible to identify the original NPK components. The sandwich design of the colorimeter's light source-microchannel photodetector yields a lower overall size, improved precision, and fewer errors. MEMS (Micro-Electro-Mechanical System) technology serves as its foundation. Monitoring networks can employ our colorimeter since it is far less expensive than a comparable commercial instrument and can be used for low-cost, high-precision sensing tasks. Due to the fact that this colorimeter is based on Beer-law Lambert's and has numerous applications, it has a lot of potential for environmental and biological applications. With prepared calibration solutions and altered codes, the same structure can be used to detect a range of mixed solutions with high absorption rates to blue or red light.

Nie *et al.* [14] emphasized the importance of accurately measuring soil nitrogen content in precision agriculture for optimal fertilization. Near-infrared sensors offer a quick and non-destructive way to provide information about soil nutrients, including nitrogen, without polluting the environment. Using 16 soil samples with different nitrogen concentrations, the researchers examined the effects of various pre-treatments on nitrogen content as detected by near-infrared sensors. Three different sample groups were created. The first group had rigorous pre-treatment to remove negative impacts such soil moisture content, particle size, and surface roughness. The results showed that when forecasting the amount of nitrogen in the soil, the first group outperformed the other two groups in terms of accuracy. The study shown that stringent pre-treatment can improve precision and near-infrared sensors can precisely quantify the amount of nitrogen in soil. The lessons this study provides them will be helpful to precision agricultural practitioners.

Peng et al. [15] underline the necessity of remote sensing technology in soil nutrient content monitoring in order to support sustainable agricultural development and assure food security. Although soil nutrient levels were estimated and mapped using hyper-spectral techniques over a vast area, data accuracy is still an issue. The researchers developed the GA-BPNN technique, which combines a backpropagation neural network and a genetic algorithm optimization, to increase the estimation accuracy of soil nutrient concentrations (BPNN). Hyperspectral data from soil samples collected in Guangdong, China, were used in the study to evaluate the efficiency of the GA-BPNN method for determining the concentrations of TN, TP, and TK. The results were compared to those of PLSR and BPNN, two more frequently used techniques. The study's conclusions were confirmed by applying lab-driven models to map the soil nutrient levels in the Conghua neighborhood of Guangzhou City using HJ-1A HSI pictures.

Ahmed et al[16] emphasis on the value of soil properties in preserving agricultural fertility and raising crop yields. The availability of the nutrient's phosphorus, nitrogen, and potassium, which are crucial for crop development and productivity, may vary from country to country. The scientists suggested an Improved Genetic Algorithm (IGA) technique, which recommends appropriate nutrient levels for various crops and optimizes parameters for maximum performance using time-series sensor data. The system also uses a neighborhood-based approach to managing exploration and exploitation for better results. The proposed approach can help increase agricultural productivity by analyzing seasonal fertility performance and providing nutrient recommendations for appropriate crop growth conditions. Additionally, the study demonstrates the model's usefulness in finding the crops best suited for a given level of nutrients and provides guidance on how to do so in a climate that is changing. Based on testing results, the suggested model might successfully provide optimal strategies and increase annual yield. The approach offers a practical means of tackling the issues of nutrient scarcity and climate change while also raising soil fertility and agricultural productivity.

Sahu *et al.* [17]This article provides an overview of recent scientific research conducted in various regions of India regarding the use of soil testing for achieving targeted crop yields through optimized fertilizer application. Soil testing has become widely recognized as an effective tool for determining the appropriate amount of fertilizer to use in a cost-effective manner. Soil testing enables farmers to assess the fertility status of their soil and make informed decisions regarding nutrient management for different crops and cropping systems. In order to select the most effective rate of nutrient application, Understanding how efficiently the soil can give nutrients and how well fertilisers operate is essential. For a variety of crops and cropping systems, fertiliser recommendations based on soil testing have been created, using post-harvest soil test data to direct nutrient administration.

Saini *et al.* [18]The present paper provides an overview of a recent scientific investigation caried out in multiple locations across India on the utilization of soil test-based fertilizers for achieving crop yield targets. Soil testing refers to the chemical or physical measurement of a soil, with the primary objective of determining the soil's nutrient condition and lime requirements in order to recommend fertiliser and lime for effective farming. It assists in assessing the soil fertility level and recommends suitable chemical fertilisers and organic manures for various crops and cropping systems, thereby offering a nutrient dose at a fair price. The rate of nutrient addition is influenced by knowledge of the soil's capacity to deliver nutrients and the efficiency of the fertiliser. The results of post-harvest soil tests have been used to develop fertiliser recommendations for a number of crops and cropping systems.

Kiruthika *et al.* [19] India is a country that heavily relies on agriculture A successful yield for farmers in each crop cycle has become a significant challenge, nevertheless, for a variety of reasons. It's critical in agriculture to select the proper fertiliser for the crop and soil. Yet, using laboratory apparatus to assess soil nutrient levels can be prohibitively expensive, particularly in developing countries. The techniques used to gauge soil nutrient content and recommend fertilisers are useless. This study makes recommendations about how to measure soil nutrient levels and provide the appropriate fertilisers. The proposed methodology includes four steps: soil analysis, data pre-processing, data analysis, and suggestion. The NPK ratio of the soil nutrient is calculated using an IoT-based device that analyses the soil sample using an NPK sensor with two electrodes. After converting the sensor data into the pertinent dataset for pre-processing, machine learning is utilised to choose the best fertiliser. This study will help farmers choose the optimal fertiliser at the start of the crop cycle in order to maximise yield.

3. CONCLUSIONS

In conclusion, the development of a fertilizer quality testing machine using NPK sensors can provide accurate and efficient measurement of the nutrient content in fertilizers. This technology can improve the quality control process of fertilizer production, ensuring that the correct levels of nutrients are present for optimal plant growth and preventing over-fertilization, which can harm the environment. The machine is user-friendly, portable, and cost-effective, making it accessible for small and large fertilizer producers. The integration of Internet of Things (IoT) technology allows for remote monitoring and real-time data analysis, providing valuable insights for decision-making in agriculture. Overall, this technology can contribute to sustainable agricultural practices, promoting efficient and responsible use of resources to ensure food security for present and future generations.

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