IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES
ISSN PRINT 2319 1775 Online 2320 7876
Research Paper **© 2012 IJFANS. All Rights Reserved**, **UGC CARE Listed (Group -I) Journal Volume 11, Iss 10, 2022**

SOIL NPK DETECTION USING OPTICAL METHOD

Varsha Atul Shukre[1], Supriya Santosh Patil[2] and Tejashree Aher[3]
[1]Dr. Vishwanath Karad MIT World Peace University, Pune, Maharashtra, India
[2,3]Department of Electronic Science MES Abasaheb Garware College (Autonomous), Pune, Maharashtra, India

ABSTRACT

Soil fertility is an important component in determining soil quality since it reflects the amount to which the soil can support plant life.The accurate assessment of soil nutrient content, particularly nitrogen (N), phosphorus (P), and potassium (K), is crucial for optimizing agricultural productivity and sustainable land management.This paper investigates the application of optical methods for the detection of essential soil nutrients - Nitrogen (N), Phosphorus (P), and Potassium (K). Leveraging advancements in optical technology, our study focuses on developing a non-invasive and rapid soil nutrient analysis technique. The methodology involves the use of reflectance patterns to measure the optical properties of soil samples. The optical transducer serves as a detection sensor in this system, comprising three LEDs as light sources and a photodiode as the light detector. The LEDs emit light at specific wavelengths tailored to match the absorption bands of individual nutrients. As the nutrient-rich soil absorbs the light emitted by the LEDs, the remaining light is reflected by a reflector and captured by the photodiode, converting it into an electric current For data acquisition, this system incorporates a microcontroller unit, allowing the conversion of transducer output into a digital display reading. The optical transducer successfully assesses NPK soil concentration after extensive testing on a variety of soil samples. The data illustrate how the detector's output voltage varies with the absorption wavelength of the nutrient concentrations in the soil. This method provides a practical and cost-effective method for evaluating soil nutrients.

Keywords: Beer–Lamberts law Soil Nutrient Detection, Optical Methods, NPK Analysis, Reflectance

I. INTRODUCTION

Though contributing around 18% to India's GDP, agriculture's true essence lies in being the livelihood for over half the workforce. It serves as the financial backbone for countless families, powering rural economies and shaping the landscape of income generation for a significant portion of the country. Science & technology being an inevitable part of everyday life, has proved to be effective in agricultural innovations. Agriculture is undoubtedly the most crucial means of livelihood in India.[1] 58% of the population in India is involved in farming. Agriculture is primarily concerned with growing crops and cultivating the soil. During the cultivation process, it is necessary to preserve the quality of the soil. Because they are so important in providing greater root nourishment to crops, the soil properties have a significant impact on how fertile agricultural production is. In some cases, crops won't give much yield due to soil infertility, planting in the wrong season, and so on.[2] Crop suggestion is a procedure that informs farmers about the precise crop to grow on a certain field. The technological advancement in the field of agriculture has opened that primarily will monitor the health of the plant, climatic factors affecting the crops, soil condition, etc over a complete farm. It is a severe problem when the farmer fails to use the conventional way to select the crops that are best suited for the soil.

Soil nutrients are vital elements for plant growth and development, as they participate in a variety of physiological and metabolic processes.. The availability of these nutrients in the soil directly influences a plant's ability to thrive and produce healthy yields. Nitrogen, phosphorus, potassium, magnesium, sulphur, and other nutrients are taken up by roots and used for a variety of plant functions.. Nitrogen is a vital component of chlorophyll, the green pigment essential for photosynthesis. Phosphorus is crucial for the formation of DNA, RNA, and other nucleic acids, contributing to cell division and growth. Adequate phosphorus ensures the development of strong roots, stems, and overall plant structure. Phosphorus and potassium are involved in energy transfer processes within the plant. Potassium plays a key role in regulating water uptake and loss in plant cells. Adequate potassium levels contribute to improved water use efficiency and drought tolerance. Nutrients are transported within the plant through the vascular system, facilitating their distribution to different plant organs. This nutrient transport is essential for overall plant health and function. Plants deficient in certain nutrients may be more susceptible to infections and stress. In summary, soil nutrients are the foundation of plant

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Iss 10, 2022

nutrition, influencing all aspects of plant growth, development, and health. Understanding and managing soil nutrient levels are essential for sustainable agriculture and achieving optimal crop yields. Traditionally, soil NPK (nitrogen, phosphorus, potassium) nutrient levels are assessed through chemical analysis in a lab, a process often time-consuming and expensive. Fortunately, optical methods offer rapid, non-destructive alternatives for on-site measurement, revolutionizing soil testing. Advantages of Optical Methods are Rapid and on-site measurement, No need for sample preparation, preserving soil integrity. Cost-effective i.e. Portable devices offer lower long-term costs compared to lab analysis. Ulti-parameter analysis can be done using optical methods

Thus, the present paper proposes a method for measuring soil NPK nutrients using reflectance principles.

II. METHODOLOGY

In this research work, three RGB LEDs are used as the light source, each emitting light at a specific wavelength corresponding to the absorption band of one of the soil nutrients (Nitrogen, Phosphorus, and Potassium). A phototransistor is employed as the light detector. When the emitted light from the LEDs passes through the soil, the presence and concentration of nutrients affect the amount of light absorbed. The remaining light is then detected by the phototransistor. The output signal from the phototransistor, which is a current proportional to the intensity of the detected light, is passed through a voltage amplifier. The amplified signal is then fed into a microcontroller unit(MCU). The MCU serves as the brain of the system, responsible for data acquisition and processing. The processed data is displayed on an LCD (Liquid Crystal Display) screen. The LCD provides a visual representation of the NPK levels in the soil, indicating whether the concentrations are High, Medium, or Low.

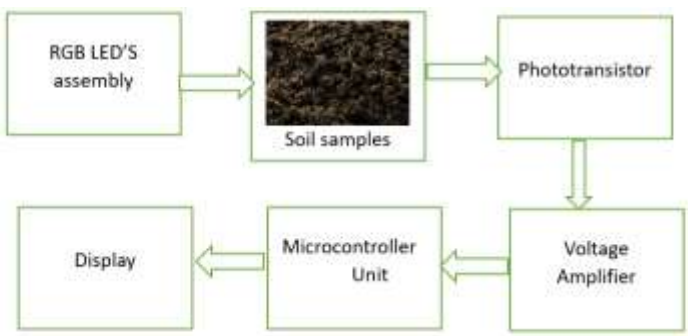


Fig 1: Block diagram

Table 1: Shows the absorption wavelengths for Soil NPK nutrients and respective LEDs used for experimentation.

Table 1: Absorbtion wavelenghs for NPK Nutrients

Nutrient	Absorption wavelength (nm)	LED	Wavelength (nm)
Nitrogen (N)	438-490	LED 1	400-500 nm
Phosphorus (P)	528-579	LED 2	450-600 nm
Potassium (K)	605-650	LED 3	600-700 nm

Source: https://ieeexplore.ieee.org/abstract/document/8312001

III. EXPERIMENTAL SETUP:

Before performing the Soil measurement tests, the transducer was optimized by adjusting the distance between the LED, reflector, and photodiode sensor module, as illustrated in Fig. 3.

IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES
ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Iss 10, 2022

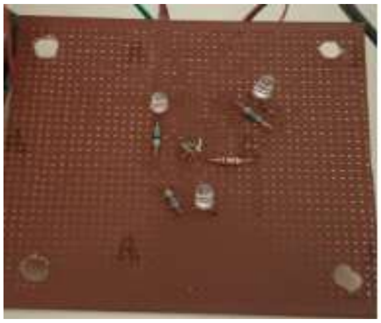


Fig. 2: RGB LED's and Phototransistor arrangements

Fig.3: Distance optimization between optical transducer and reflector

During the measurement, the red, blue and green LEDs are positioned 60°with each other and the photodiode is used at center as a light detector. The soil sample under the test is kept in a black colored tray and the system is protected from the ambient light before taking the measurements. The voltage displayed on the serial monitor depends on the intensity of the light captured by the photodiode sensor. The influence of incident light emitted to the detector was inspected to determine the appropriate optical path length of the transducer. The experiments were carried out and the distance between the transducer and reflector is optimized to 2 cm. The soil test absorption measurement was conducted using the developed optical transducer with two types of soils as illustrated in Fig. . Red soil is obtained from a nursery shop.The sample specification is listed in TABLE II. Under the illumination of an LED light, each soil sample of uniform thickness was placed on top of the reflector. Beer's Law states that absorbance (A) has the following equation.

$A=-\log_{10} I_T/I_0$

where I_T is transmitted light and I_0 is incident light.

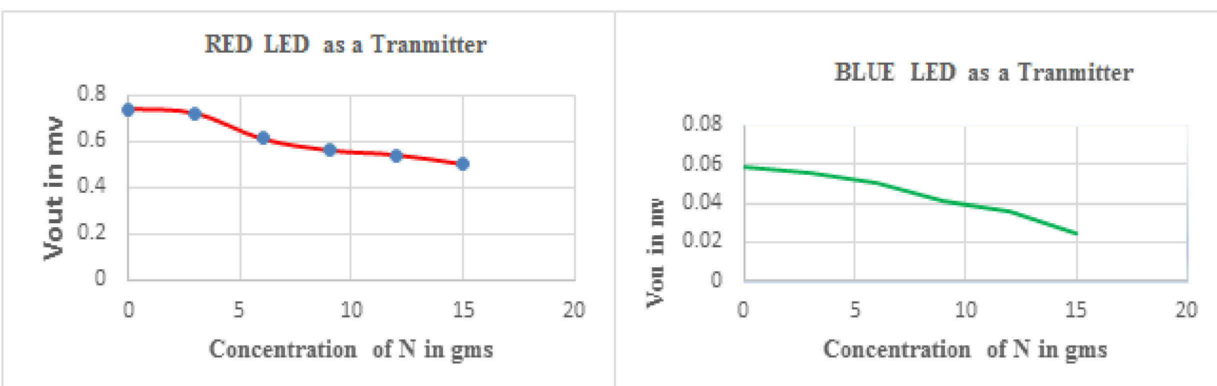
The photodiode evaluated the difference in light intensity level, and the absorption rate was determined using the reflected light recorded by the photodiode sensor module and converted into volts. The observed voltage for each nutrient was compared to a threshold value generated by the microcontroller unit, which was used to divide the nutrient shortage in soil into three voltage levels: High, Medium, and Low. These results were calculated using the rate of absorption of each nutrient during the sample measurement.

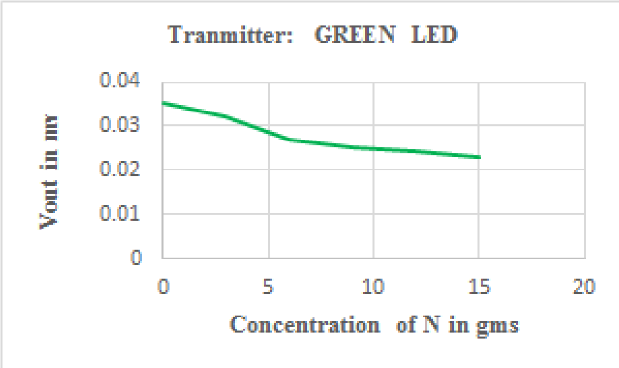
IJFANS International Journal of Food And Nutritional Sciences

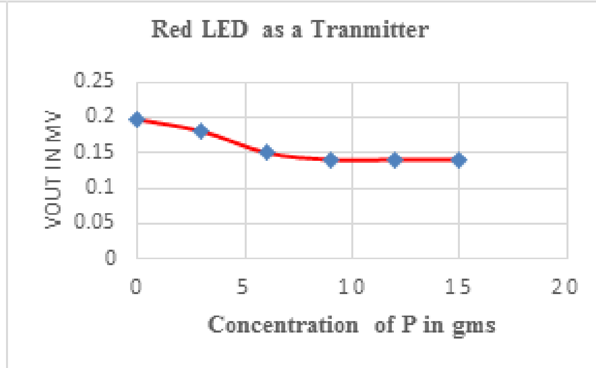
Finally, the optical transducer; LEDs and photodiode with Arduino microcontroller has been successfully constructed and tested as an alternate technique of determining N, P, or K deficit in soil. This research can solve the challenge of determining the amount of nutrients in soil at a lower cost than previous technologies. It can also limit the usage of fertilizers in the soil, which can cause dead plants and lower plant quality and quantity. This can be determined by measuring the light absorption of nutrients by the optical transducer and developing threshold values for each nutrient, which determine the level of nutrients in the display into three voltage levels: Low, Medium, and High.

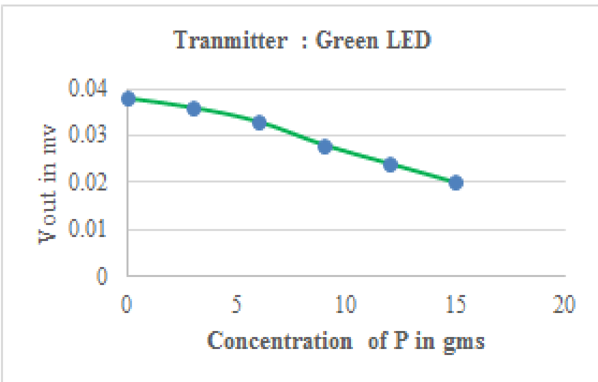
III. RESULTS AND CONCULSION

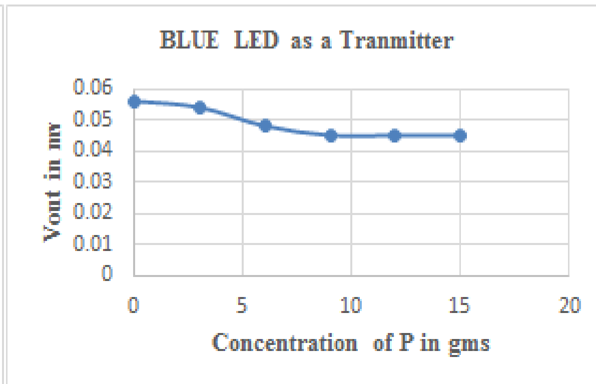
As a conclusion, the optical transducer; LEDs and photodiode with Arduino microcontroller can be used for determination of the deficiency N, P or K in the soil is successfully developed and tested. It is observed that N is absorbed in wavelength ranging from 438-490 nm. P is absorbed in wavelength ranging from 528-569 nm and K is absorbed in wavelength ranging from 605-650 nm. The below graph shows the effect of different lights on concentrations of N,P and K.

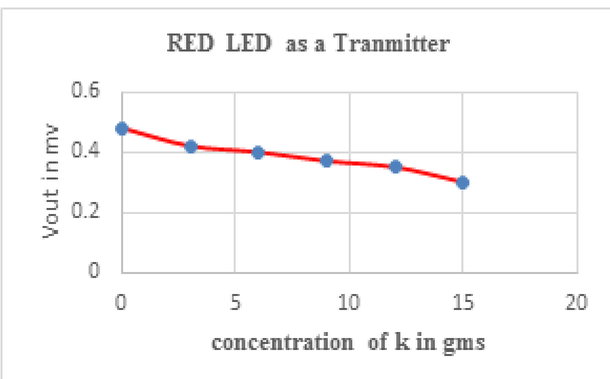


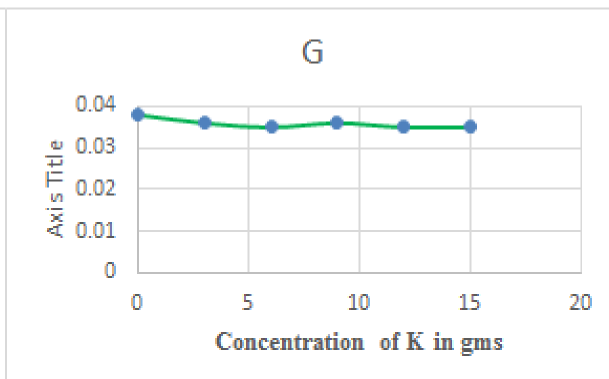


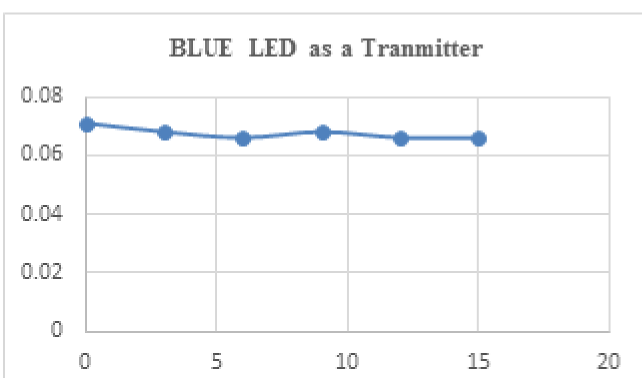












This research can alleviate the challenges associated with determining the amount of nutrients in soil at a lower cost than previous technologies. It can also prevent the unnecessary usage of fertilizers in the soil, which can result in dead plants and decreased plant quality and quantity. This is determined by the optical transducer's light absorption of nutrients and the development of threshold values for each nutrient, which decide the level of nutrients into three voltage levels: Low, Medium, and High in the display. According tothe testing results, the supplied soil sample included a high concentration of NPK soil nutrients.

IV.FUTURE SCOPE

The sensors accuracy can be improved in future prototypes. The integration of cutting-edge technologies like of Things (IoT) connectivity can be implemented for real time data monitoring and Machine learning can be used for fertilizer recommendations. Mobile applications can be developed for Soil Health Monitoring.

CONFLICT OF INTEREST

The authors confirm that there is no conflict of interest to declare for this publication.

ACKNOWLEDGMENTS

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The authors would like to thank the editor and anonymous reviewers for their comments that help improve the quality of this work.

REFERENCES

[1] Islam, M. R., Oliullah, K., Kabir, M. M., Alom, M., & Mridha, M. F. (2023). Machine learning enabled IoT system for soil nutrients monitoring and crop recommendation. Journal of Agriculture and Food Research, 100880.

[2] Fan, W., Kam, K. A., Zhao, H., Culligan, P. J., & Kymissis, I. (2022, June). An Optical Soil Sensor for NPK Nutrient Detection in Smart Cities. In 2022 18th International Conference on Intelligent Environments (IE) (pp. 1-4). IEEE.

[3] Masrie, M., Rosli, A. Z. M., Sam, R., Janin, Z., & Nordin, M. K. (2018, November). Integrated optical sensor for NPK Nutrient of Soil detection. In 2018 IEEE 5th international conference on smart instrumentation, measurement and application (ICSIMA) (pp. 1-4). IEEE.

[4] Tasneem, N., Hasan, M. A., Akther, S. B., & Khan, M. M. (2021, May). An automatic soil testing machine for accurate fertilization. In 2021 IEEE World AI IoT Congress (AIIoT) (pp. 0325-0331). IEEE.

[5] Lincy, C. T., Lenin, F. A., & Jalbin, J. (2023). Deep residual network for soil nutrient assessment using optical sensors. Journal of Plant Nutrition and Soil Science.

[6] Mahadevaswamy, U. B., Pavan Nayak, R., Darshan, M. N., Kumar, T. V., & Gautham Gopi, S. (2021). Automation of Soil Nutrient Measurement System and Irrigation Control. In Proceedings of International Conference on Communication, Circuits, and Systems: IC3S 2020 (pp. 117-125). Springer Singapore.

[7] Masrie, M., Rosman, M. S. A., Sam, R., & Janin, Z. (2017, November). Detection of nitrogen, phosphorus, and potassium (NPK) nutrients of soil using optical transducer. In 2017 IEEE 4th international conference on smart instrumentation, measurement and application (ICSIMA) (pp. 1-4). IEEE.

[8] Ramane, D. V., Patil, S. S., & Shaligram, A. D. (2015, February). Detection of NPK nutrients of soil using Fiber Optic Sensor. In International Journal of Research in Advent Technology Special Issue National Conference ACGT 2015 (pp. 13-14).

[9] Khairnar, H. M., & Kulkarni, S. S. (2018, August). Automated soil macro-nutrient analyzer using embedded systems. In 2018 Fourth International Conference on Computing Communication Control and Automation (ICCUBEA) (pp. 1-3). IEEE.

[10] Amrutha, A., Lekha, R., & Sreedevi, A. (2016, December). Automatic soil nutrient detection and fertilizer dispensary system. In 2016 International Conference on Robotics: Current Trends and Future Challenges (RCTFC) (pp. 1-5). IEEE.

[11] Patokar, A. M., & Gohokar, V. V. (2018, July). Automatic Investigation of Micronutrients and fertilizer

dispense System using Microcontroller. In 2018 International Conference on Recent Innovations in Electrical, Electronics & Communication Engineering (ICRIEECE) (pp. 1737-1739). IEEE.

[12] Kumar, K., Sharma, S., Pandey, P., & Goyal, H. R. (2022, June). IoT Enabled Crop Detection System using Soil Analysis. In 2022 7th International Conference on Communication and Electronics Systems (ICCES) (pp. 323-327). IEEE. Kleinsinger, F. (2018). The unmet challenge of medication nonadherence. The Permanente Journal, 22.

[13] Tejashree Aher,S Patil(2023,June)Design and development of measurement system for gradation of vegetables & Fruits.Journal of Emerging technologies and Innovative research(JETIR)ISSN-2349-5162