*i*Journals: International Journal of Software & Hardware Research in Engineering (IJSHRE)
ISSN-2347-4890
Volume 10 Issue 9 September 2022

Examination of NPK Values and Their Effects on Soil

Yash Dalal [1]
Jamnabai Narsee School, Mumbai, India

Reetu Jain [2]
Chief-Mentor, On My Own Technology Private Limited reetu.jain@onmyowntechnology.com

Abstract - Soil health and soil quality are defined as the ability of the soil to perform as an essential living system under the restrictions of land use. This activity maintains the biological productivity of the soil, which benefits both the environment and human health. Soil quality is linked to soil function, whereas soil health portrays the soil as a finite, non-renewable, and dynamic living resource. The notion of soil health, which encompasses interactions between plant inputs and soil in creating a healthy environment, is discussed in this paper.

Keywords- *Soil components, Soil nutrients, NPK Values.*

1. Introduction

16 vital elements, including carbon, hydrogen, oxygen, nitrogen, calcium, etc., are present in soil and are necessary for the full completion of the plant life cycle. Three of these macronutrients, Nitrogen (N), Phosphorus (P), and Potassium (K), or NPK, are particularly significant since they are needed in significant amounts and play a significant role in plant development. Nitrogen plays a crucial role in plant growth and is a key component of amino acids and chlorophyll. Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) are vital components of plants, and phosphorus is essential for the growth of roots and the formation of seeds. In contrast, potassium indirectly aids in the development of plants by activating over 80 enzymes.

Thus, for plants to grow properly, these elements must be present in the soil at the optimum level. If necessary, their quantity must be replenished by using NPK fertilizers.

Poor plant yields are the result of insufficient fertilizer use, while contaminated soil is the outcome of excessive fertilizer use. But because of a lack of infrastructure and to increase crop yield, Indian farmers are known to apply fertilizers to the soil carelessly. Due to financial issues and the lack of a soil testing laboratory near the field, it is not practical for farmers to regularly test the nutrient concentration of their soil.

Additionally, it takes many months for farmers to receive the results of soil tests. Therefore, there is a need for quick and mobile soil nutrient assessment. A cheap soil testing probe will assist the farming community in determining the field's nutritional status and promote the prudent application of fertilizers to boost productivity and, consequently, profitability.

Researchers from all over the world are working to develop an in-situ sensor and are continually expanding their understanding of how to assess soil macronutrients (NPK). Current methods include optical sensing, laboratory measurement, ion-selective electrodes, chemical methods, inductively coupled plasma (ICP) spectroscopy, and fluorescence spectroscopy. However, most of these methods are either expensive, require intricate setups, or are inappropriate for in-situ measurement.

2. Literature Review

Analysis of soil NPK, ph value, and electrical conductivity have been widely researched in some areas. Mohammad Adham [8] has proposed the paper to investigate the soil type potentially and to emphasize on macronutrients like phosphorus, nitrogen, and potassium in addition to soil PH and electrical conductivity with random soil and the different depths values.

The fact that the least median squares regression is known to produce better results than the classical linear regression technique, proposed by [9] has also proposed an analysis of the soil data using different algorithms prediction techniques. In spite of the given set of attributes, the most accurately predicted attribute was "P" (Phosphorus content of Algorithm Linear Regression Least Median Square Regression Time taken to build the model 0.16 s 10.84 s Relative Absolute Error 10.77% 10.01% Correlation Coefficient 0.9810 0.9803 the soil) and which was determined using the Linear Regression technique in lesser time as compared to Least Median Squares Regression. Determination of soil nutrients and using the optical methods was proposed by [1] and it has been stated that plants need nutrients and nourishment to grow which has been done by the soil nutrients and fertilizers which consist of different nutrients and components present.

Determination of nutrients using an optical transducer proposed by[4]-An optical transducer is developed to measure and detect the presence of Nitrogen (N), Phosphorus (P), and Potassium (K) in soil. Such a transducer is needed to decide how much extra contents of these nutrients are to be added to the soil to increase soil fertility. This can improve the quality of soil and reduces the undesired use of fertilizers to be added to the soil. The N, P, and K values of the sample are determined by the absorption light of each nutrient. The optical transducer is implemented as a detection sensor which consists of three LEDs as light source and a photodiode as a light detector. The wavelength of LEDs is chosen to fit the absorption band of each nutrient. The nutrient absorbs the light from the LED and the photodiode converts the remaining light that is reflected by the reflector to current. The system utilizes an Arduino microcontroller for data acquisition therefore the output from the transducer is converted into a digital display reading. Testing on various samples of soils showed that the optical transducer can evaluate the amounts of NPK soil content as High, Medium, and Low.

3. Existing Solutions

Bhu Parikshak App, Jayant explains the device's operation by stating that it "works on the notion of near-infrared spectroscopy technology that gives real-time soil analysis data on smartphones connected to a mobile app called Bhu Parikshak, available on Google Play Store. Six important soil parameters, including nitrogen, phosphorus, potassium, organic carbon, clay concentrations, and cation exchange capacity, are determined by the instrument, according to him.

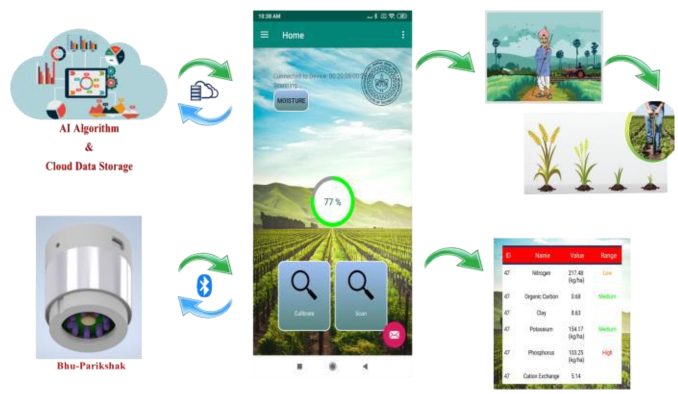

Fig 1. Bhu Parikshak app working

To find macronutrients in the soil, the portable and wireless soil testing instrument required a sample of dry soil weighing 5 grams. The soil sample is placed inside the 5 cm long, cylindrical-shaped gadget, which is Bluetooth-connected to a smartphone. Once activated, it begins a 90-second analysis of the material. The findings of the analysis are displayed on the screen.

Acoustic Sensor, Acoustic sensors are used to gauge soil bulk density (compaction), soil depth variations, and soil texture (sand, silt, and clay) (depth of topsoil, depth to hardpan). When a tool interacts with soil particles, they measure the change in noise level that results.

Digital Soil Testing Kit (STFR Meter), The STFR Meter is a one-of-a-kind device. Unlike other soil test kits, the STFR Meter offers the optimum fertilizer dosage depending on the crop, Sulfur, and micronutrient recommendations based on the important value in soil using an in-built software.

In India, nutrient inadequacy is a big issue, and farmers frequently use fertilizers against expert advice. This raises the cost of production, reduces agricultural earnings, and deteriorates soil health. We have started manufacturing STFR (Soil Test Fertilizer Recommendation) Meter, Digital Soil Testing Kit designed by Indian Agriculture Research Institute, Delhi, based on our wide experience in manufacturing kits and instruments.

The finest features that distinguish our Digital Soil Testing Kit are its dependability, portability, and excellent quality. It is portable and has the capacity of a tiny laboratory. It can test soil, identify principal and secondary nutrients, and perform up to 100 tests for agricultural service departments, agricultural dealers, and fertilizer manufacturers. We are capable of satisfying large-scale demands and providing items at reasonable pricing.

Fig 2. STFR meter

The STFR Meter, designed by the Indian Agricultural Research Institute (IARI), Pusa, New Delhi, is at the heart of our Portable Digital Lab. The STFR Meter helps farmers determine available nutrients in the soil and recommends fertilizer dosage for various crops.

3. Our Solution

Prototype

Here we have created a prototype using the temperature sensor and PH sensor used to measure the temperature of the environment, and this NPK sensor is used to detect the NPK value of the soil, and the value is displayed on an OLED display along with them. Also used python image processing to check the soil particles and find the percentage of soil particles. Working on the data analysis to analyze the soil data that has been collected from the setup.

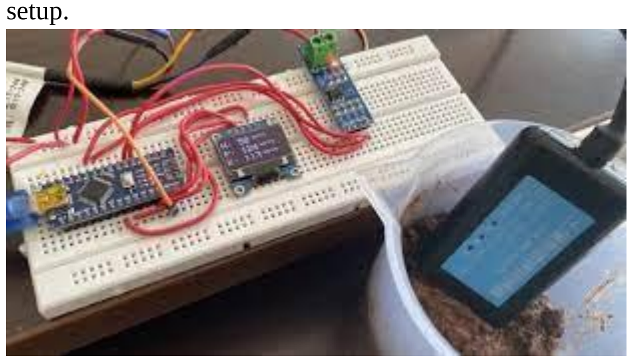

Fig 3. working model of NPK

Image Processing

First we have taken a sample image of the soil shown below. The image processing is done by using the openCV library of python along with the NumPy library. We are reading the sample image in (BGR) format and then converting it into (HSV) format to make it easy to detect the edges and get important details of the image and get the output of the soil particles as shown in Figures 8 and 9.

Fig 4. soil image

Fig 5. Scanning image

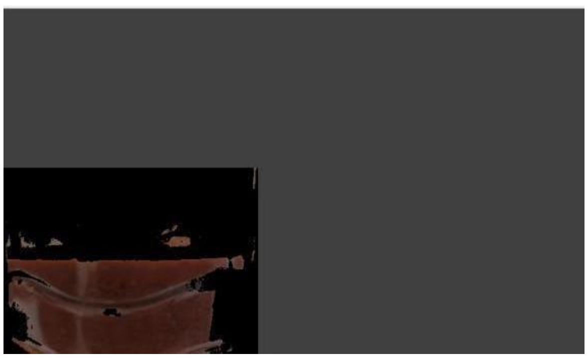

Fig 6. Silt of soil

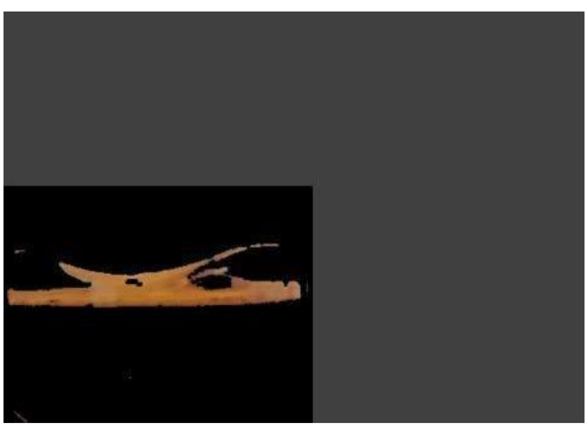

Fig 7. Clay of soil

Soil Particles	**Quality of soil in mm**	**Percentage**
Sand	16mm	50%
Silt	15mm	3.125%
Clay	01mm	46.875%

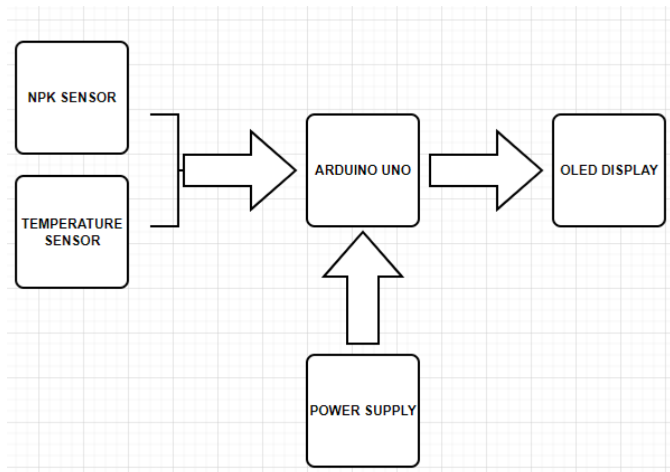

Fig 8. Flow diagram of the Working of the device

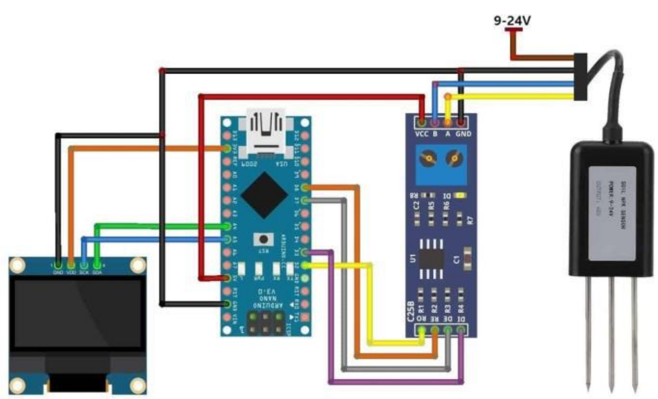

Fig 9. Circuit Diagram

The above fig is a circuit diagram for all the components that were used in our band and their connections. NPK Sensor, which aids in the detection of nitrogen, phosphorus, and potassium as well as the pH level of soil, has been utilized in conjunction with AtMega328 as the device's primary microcontroller. We use an OLED Display to display the values from the NPK sensor and to measure the ambient temperature. The circuit has the power supply module and the battery protection unit and has the following components-

4. 1000mAh Li-ion battery
5. TP4056 Charging circuit
6. 3.7 to 5v Boost circuit

These three are connected to each other and provide consistent power to the device to work continuously.

Component List:
The parts used in the circuit are as follows:

Arduino NANO, The Arduino Nano comes with a variety of features for interacting with computers, other Arduinos, and microcontrollers. UART TTL (5V) serial connection is provided by the ATmega328 and is accessible on digital pins 0 (RX) and 1. (TX). This serial connection is routed through USB by an FTDI FT232RL on the board, and the FTDI drivers (included with the Arduino software) give computer applications access to a virtual com port. Simple textual data can be delivered to and received from the Arduino board using the serial monitor found in the Arduino software. When data is being communicated between the FTDI chip and USB connection to the computer, the RX and TX LEDs on the board will flash (but not for serial communication on pins 0 and 1).

Battery, The circuit is entirely powered by the battery.

Switch: The switch allows the user to toggle the band on and off.

OLED Display, A light-emitting diode (LED) with an organic electroluminescent layer is referred to as an organic light-emitting diode (OLED or organic LED) or an organic electroluminescent (organic EL) diode. This type of LED emits light in response to an electric current. This organic layer is sandwiched between two electrodes, at least one of which is usually transparent. Digital displays are made with OLEDs and can be found in a variety of portable systems, including smartphones, handheld game consoles, and computer monitors. The creation of white OLED devices for use in applications involving solid-state illumination is a significant field of research.

NPK Sensor, the nitrogen, phosphorus, and potassium content of the soil may be found using the soil NPK sensor. It aids in figuring out the soil's fertility, making it easier to conduct an organized evaluation of the soil's state. The sensor may stay in the ground for a very long period. To ensure the long-term functionality of the probe component, it features a high-quality probe that is resistant to rust, electrolysis, salt, and alkali corrosion. It is suited for all types of soil results. Alkaline soil, acidic soil, substrate soil, seedling bed soil, and soil from coconut bran can all be found using this method. Chemical reagents are not necessary for the sensor. It may be used with any microcontroller because of its high measurement precision, quick reaction time, and strong interchangeability. Because it includes a Modbus Communication interface, the microcontroller cannot be used directly with the sensor. As a result, you need to connect the sensor to the microcontroller using any Modbus Module, such as RS485 or MAX485.The sensor uses relatively little power and runs on 9 to 24 volts. When referring to the sensor's accuracy, it is up to within 2%. The measurement resolution for nitrogen, phosphorus, and potassium is up to 1 mg/kg (mg/l).

MAX485 TTL to RS-485 Interface Module, In industrial settings, the MAX485 TTL to RS-485 Interface Module is frequently utilized to leverage RS-485 differential signaling for reliable long-distance serial communications up to 1200 meters or in electrically loud situations. The greatest data rate that can be maintained drops as distance increases, although it still allows data rates of up to 2.5MBit/Sec.

The RS-485 module handles translating the electrical signals between TTL and the differential signaling utilized by RS-485, however, the data initially starts off as a conventional TTL level serial as far as the microcontroller is concerned. The fact that RS-485 permits several devices (up to 32) on a single cable, sometimes known as "multi-drop," is a significant advantage.

Temperature Sensor, The device is used with single power supplies, or with plus and minus supplies. As the

LM35 device draws only 60 µA from the supply, it has very low self-heating of less than 0.1°C in still air. The LM35 device is rated to operate over a −55°C to 150°C temperature range, while the LM35C device is rated for a −40°C to 110°C range (−10° with improved accuracy). The LM35-series devices are available packaged in hermetic TO transistor packages, while the LM35C, LM35CA, and LM35D devices are available in the plastic TO-92 transistor package. The LM35D device is available in an 8-lead surface-mount small-outline package and a plastic TO-220 package.

Soil moisture sensors, Soil moisture sensors measure or estimate the amount of water in the soil. These sensors can be stationary or portable such as handheld probes. Stationary sensors are placed at predetermined locations and depths in the field, whereas portable soil moisture probes can measure soil moisture at several locations. This sensor mainly utilizes capacitance to gauge the water content of the soil (dielectric permittivity). The working of this sensor can be done by inserting this sensor into the earth and the status of the water content in the soil can be reported in the form of a percent. This sensor makes it perfect to execute experiments within science courses like environmental science, agricultural science, biology, soil science, botany, and horticulture.

5. Data Analysis

In this part we are working on data that includes certain parameters that decide whether the soil is fertile or non-fertile.

	pH	EC	OC	OM	N	P	K	Zn	Fe	Cu	Mn	Sand	Silt	Clay	CaCO3	CEC
0	7.74	0.40	0.01	0.01	75	20.0	279	0.48	6.4	0.21	4.7	84.3	6.8	8.9	6.72	7.81
1	9.02	0.31	0.02	0.03	85	15.7	247	0.27	6.4	0.16	5.6	90.4	3.9	5.7	4.61	7.19
2	7.80	0.17	0.02	0.03	77	35.6	265	0.46	6.2	0.51	6.1	84.5	6.9	8.6	1.53	12.32
3	8.36	0.02	0.03	0.05	106	6.4	127	0.50	3.1	0.28	2.3	93.9	1.7	4.4	0.00	1.60
4	8.36	1.08	0.03	0.05	96	10.5	96	0.31	3.2	0.23	4.1	91.5	4.1	4.4	9.08	7.21
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
95	9.21	0.14	0.62	1.06	278	9.8	165	0.18	8.6	0.57	5.8	88.2	2.4	9.4	4.23	8.81
96	7.50	0.22	0.68	1.17	272	9.5	139	0.72	2.6	0.12	1.8	95.4	1.4	3.2	0.00	5.58
97	8.26	0.25	0.71	1.22	277	11.5	264	0.36	7.6	0.07	0.8	90.7	2.5	6.8	3.85	7.26
98	8.12	0.14	0.73	1.25	265	4.6	283	0.38	3.7	0.18	0.8	86.0	6.7	7.3	0.00	3.10
99	7.31	0.46	0.74	1.27	277	32.4	241	0.27	8.2	0.23	4.2	80.5	6.8	12.7	4.86	6.51

Fig 10:- Data Set

The Data Analysis Part is divided into three parts, In the first part we are dividing the data based on the output column into two parts fertile and non-fertile then for each N, P, and K value we are understanding its distribution for each class by doing EDA and Statistical Analysis

1. We are taking the Mean for N, P, and K values and understating the difference between the mean for fertile values and the mean for non-fertile values
2. Plotting this on the graph also helps us to do EDA
3. In the below three graphs the graphs for K and N values the distribution for fertile and non-fertile is almost the same

From the above Statistical observations, the P value will have more impact on deciding the fertility of the soil as compared to N and K Till a certain value P doesn't have much impact on deciding the fertility but after a certain value, it plays an important role

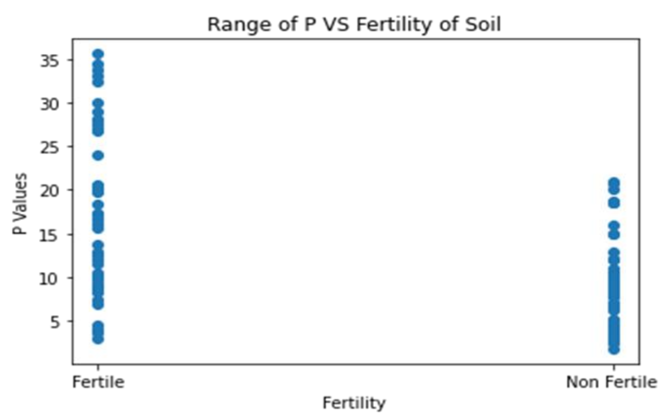

Fig 11:- Range of P vs fertility of soil

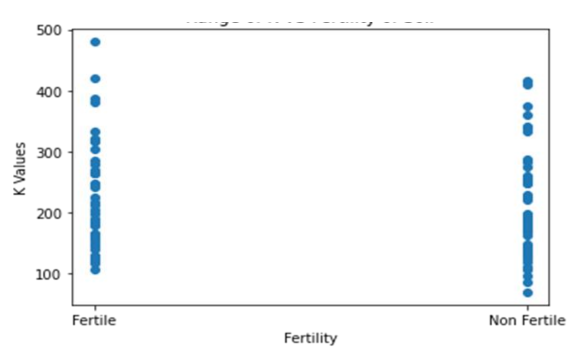

Fig 12:- Range of K vs fertility of soil

*i*Journals: International Journal of Software & Hardware Research in Engineering (IJSHRE)
ISSN-2347-4890
Volume 10 Issue 9 September 2022

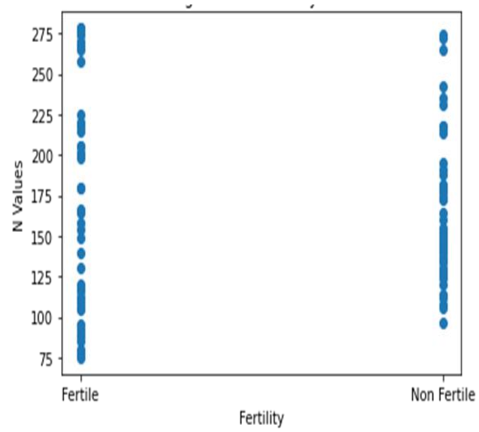

Fig 13:- Range of N vs fertility of soil

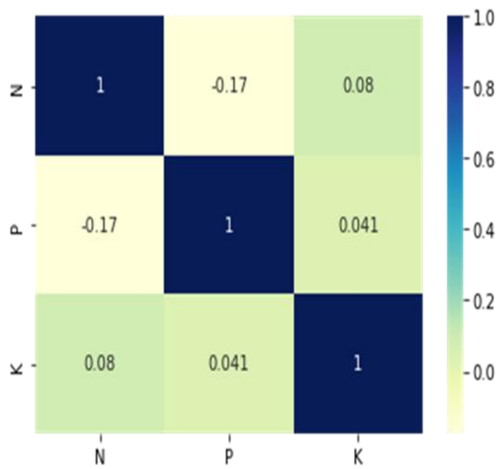

Fig 14:- Correlation between NPK values

Here in the second part, we are understating the correlation between the three N, P, and K values

1. The Heatmap is used to understand the correlation
2. From the below heatmap it is observed that the three N, P, and K values have negligible or No Correlation with each other

In the third part we are dividing the data into train data and test data and standard scaling the data just to make sure that the model doesn't get biased and running a machine learning logistic regression model and understating the weight (importance) associated with each parameter in deciding the fertility of the soil

pH	-0.45839388847394125
EC	-0.09735017857259767
OC	-0.46580990704506575
OM	-0.45895061114710073
N	0.2066311506006423
P	-0.6469367581897076
K	-0.040457127021507715
Zn	-0.2789812346442485
Fe	-0.1757993303883787
Cu	-0.31861177670671675
Mn	-1.335573515230737
Sand	0.8400082826786721
Silt	0.21030959227343696
Clay	-1.811878065740045
CaCO3	-0.3588804390245287
CEC	-0.9558400089603768

The Logistic Model gives more Importance to P value as compared to N and k on deciding the fertility of the soil.

6. Future scope

We plan to put this decision support system in the Android operating system in the future so that farmers may use it and obtain complete soil information on their phones. We are also working on developing this system in other languages. Also getting more data for different N, P, and K values to make sure that the model is more that we get to understand more patterns and seasonality parameters involved can help farmers for better planning and hence get a more accurate model with better output and accuracy and deploy it with the application. As a result, it will be beneficial to all farmers in India.

7. Acknowledgement

I have been supported to complete this project by various subject matter experts whom I would like to acknowledge. Many thanks to OMOTEC coaches and mentors, who provided feedback and direction to arrive at the final research paper. And finally, thanks to my parents who supported me during this long process, always offering support and love.

8. Conclusion:

Precision agriculture has grown to satisfy rising global food demand by utilizing technology that makes it easier and less expensive to collect and apply data, adjust to changing environmental circumstances, and make the most efficient use of resources. Although large farms were the first to adopt these technologies, smaller farms can now benefit as well, thanks to features incorporated into smartphones, related apps, and smaller-sized machinery. Furthermore, these technologies are helping to solve problems that go beyond farms, such as pollution, global warming, and conservation. Talking about the analysis part, the statistical analysis says that the P value will have more impact on deciding the fertility of the soil as compared to N and K. The results from the logistic regression model interpret the same thing also there is no correlation between N, P and K, one is not impacting the Values of others

9. Reference

1. Revati P. Potdar, Mandar M. Shirolka, Alok J. Verma, Pravin S. More & Atul Kulkarni (2021): Determination of soil nutrients (NPK) using optical methods: mini-review, Journal of Plant Nutrition, February 2021.

2. International Journal of Scientific & Technology Research Volume 4, Issue 12, December 2015, Analysis Of Soil NPK, Ph And Electrical Conductivity At Adham Area-Renk, Upper Nile State Abubaker Haroun Mohamed Adam, Ismail Mohamed Fangama Abdalla, Mohammed Abdelkreim, Gammareldain, A. Ibrahim.

3. Jay Gholap, Anurag Ingole, Jayesh Gohil, Shailesh Gargade, Vahida Attar Soil Data Analysis Using Classification Techniques and Soil Attribute Prediction (3 Bibliographic Code: 2012arXiv1206.1557G Abstract Agricultural research has been profited by technical advances such as automation) June 2012

4. M. Masrie, M. S. A. Rosman, R. Sam, and Z. Janin, "Detection of nitrogen, phosphorus, and potassium (NPK) nutrients of soil using an optical transducer," 2017 IEEE 4th International Conference on Smart Instrumentation, Measurement and Application (ICSIMA), 2017, pp. 1-4.