Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

# Physicochemical Characterization of Rhizospheric Soils of Banana (Musa spp.) in Uttar Dinajpur District, West Bengal, India

**Papan Chowhan**
Raiganj University
**Oindrila Chakraborty**
Raiganj University
**Arka Pratim Chakraborty**
arka.botanyrgu@gmail.com
Raiganj University

**Short Report**

**Keywords:**

**Posted Date:** October 8th, 2026

**DOI:** https://doi.org/10.21203/rs.3.rs-10836148/v1

**License:** This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License

**Additional Declarations:** No competing interests reported.

## Abstract

Between December 2021 and January 2022, a survey-based soil analysis was done in different parts of Uttar Dinajpur district, West Bengal, India, to look at the physicochemical properties of rhizospheric soils that are linked to banana (*Musa* spp.). We took 57 soil samples and tested them for pH, electrical conductivity (EC), organic carbon, organic matter, nitrogen (N), phosphorus ($P_2O_5$), potassium ($K_2O$), sulfur (S), C:N ratio, and moisture content. The pH of the soils ranged from 3.82 to 8.13, which means they were either very acidic or moderately alkaline. The amount of organic carbon ranged from 1.26% to 3.54%, which means the soil was moderately to very fertile. The EC values were very different, which means that the amount of soluble salt in the water was different at each site. An analysis of the nutrients showed that the macronutrients were not always available, which is a sign of uneven soil fertility. The results show that the region's banana farming is affected by a wide range of soil conditions, which shows that nutrient management needs to be done on a site-by-site basis.


## Introduction

Banana (Musa spp.) is a vital fruit crop grown in tropical and subtropical areas. For the best growth, the soil must be rich in nutrients and well-balanced. The physicochemical properties of soil are very important for plant health, yield, and microbial interactions in the rhizosphere (Reddy et al. 2016). The rhizospheric soil is especially important because it has a direct effect on how plants take up nutrients and how microbes work (Philippot et al. 2013). In West Bengal, particularly in Uttar Dinajpur, banana cultivation is prevalent; however, comprehensive soil fertility evaluations are scarce. To improve crop yields and make farming more sustainable, it's important to understand how soil changes.

## Materials and Methods

Soil samples (n = 57) were obtained from the rhizosphere of banana plants in various locations within Uttar Dinajpur district from December 2021 to January 2022 (Fig. 1). We got a total of 48 samples by following standard soil sampling procedures. All analyses were performed in accordance with established soil testing protocols (Jackson 1973; Anderson and Ingram 1993). The samples were dried in the air, sifted, and analyzed according to standard procedures:

- pH and EC were measured using digital meters
- Organic carbon was determined by Walkley and Black method
- Nitrogen by Kjeldahl method
- Available phosphorus by Olsen method
- Potassium by flame photometry
- Sulfur by turbidimetric method

## Results and Discussion

The soil pH varied a lot, from 3.82 to 8.13, showing that the soils could be very acidic or very alkaline (Fig. 2). Most of the samples were acidic, which is normal for places with a lot of rain and alluvial soil (Brady and Weil,

2016). The electrical conductivity ranged from 119 to 5960 µS/cm, which means that the amount of soluble salt built up was different (Fig. 3). Some samples with higher EC values may show that there is salt or fertilizer buildup in a certain area. The organic carbon content varied from 1.26% to 3.54%, indicating moderate to high levels of organic matter, which are good for soil fertility and microbial activity. Similar results have been observed in tropical agricultural soils (Lal 2004). The nitrogen content ranged from 0.11% to 0.30%, which means that the nutrients were moderately available. There was also a lot of variation in phosphorus and potassium, which suggests that the soil was not evenly fertilized and that the soil was not uniform (Fig. 4). The C:N ratio stayed pretty stable (about 11:1), which means that microbes were actively breaking down things and nutrients were moving around in a balanced way (Fig. 5). The moisture content of the samples varied because the soil texture and environmental conditions were different. A one-way analysis of variance (ANOVA) was performed to evaluate the effect of soil pH on nitrogen content across different soil groups (acidic, neutral, and alkaline). The results indicated that there was no statistically significant difference in nitrogen content among the different pH groups ($F = 2.52$, $p = 0.089$). However, a marginal trend was observed, suggesting that soil pH may influence nitrogen availability to some extent.Although the differences were not statistically significant, the observed trend suggests that soil pH may indirectly influence nitrogen dynamics through its effect on microbial activity and nutrient mineralization.Linear regression analysis revealed a strong positive relationship between organic carbon and nitrogen content ($R^2 = 0.99$), indicating that nitrogen availability is largely dependent on organic matter content in the soil.Principal Component Analysis (PCA) revealed that the first principal component (PC1) explained 84.2% of the total variance, while the second component (PC2) accounted for 15.8%. This indicates that the majority of soil variability is driven by key physicochemical parameters such as organic carbon and pH (Fig. 6).The combined ANOVA, regression, and PCA results demonstrate that organic carbon is the primary factor controlling nitrogen availability, while soil pH plays a secondary regulatory role. These findings highlight the importance of organic matter management in sustaining soil fertility in banana cultivation systems.The differences in soil properties show that banana farming needs nutrient management plans that are specific to each location.

| Sample code | pH | E.C (µS/cm) | Org. Carbon (%) | Org. Matter (%) | N (%) | $K_2O$ (ppm) | $P_2O_5$ (ppm) | S (ppm) | C:N | Moisture (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| MRH-01 | 5.18 | 177 | 1.71 | 2.94 | 0.15 | 30 | 35 | 40 | 11.4:1 | 10.30 |
| MRH-1A | 5.40 | 210 | 1.67 | 2.87 | 0.14 | 32 | 40 | 35 | 11.9:1 | 8.93 |
| MRH-02 | 5.64 | 301 | 1.58 | 2.72 | 0.13 | 250 | 45 | 40 | 12.1:1 | 10.88 |
| MRH-2A | 4.98 | 160 | 1.69 | 2.91 | 0.15 | 65 | 30 | 35 | 11.2:1 | 10.35 |
| MRH-03 | 5.70 | 459 | 1.83 | 3.15 | 0.16 | 90 | 35 | 30 | 11.4:1 | 7.95 |
| MRH-04 | 4.26 | 129 | 1.71 | 2.94 | 0.15 | 65 | 20 | 35 | 11.4:1 | 8.83 |
| MRH-05 | 6.48 | 198 | 2.83 | 4.87 | 0.24 | 325 | 40 | 45 | 11.7:1 | 5.63 |
| MRH-06 | 5.76 | 208 | 1.59 | 2.73 | 0.14 | 175 | 30 | 30 | 11.3:1 | 3.88 |
| MRH-07 | 6.50 | 378 | 1.89 | 3.25 | 0.16 | 72 | 25 | 35 | 11.8:1 | 5.78 |
| MRH-08 | 6.28 | 270 | 1.77 | 3.04 | 0.15 | 98 | 30 | 40 | 11.8:1 | 4.59 |
| MRH-09 | 4.65 | 179 | 1.78 | 3.06 | 0.15 | 54 | 30 | 30 | 11.8:1 | 5.63 |
| MRH-10 | 8.13 | 485 | 3.54 | 6.08 | 0.30 | 188 | 35 | 45 | 11.8:1 | 5.10 |
| MRH-11 | 5.42 | 235 | 1.97 | 3.39 | 0.17 | 230 | 40 | 35 | 11.5:1 | 8.80 |
| MRH-12 | 7.46 | 312 | 1.49 | 2.56 | 0.13 | 210 | 30 | 35 | 11.4:1 | 7.98 |
| MRH-13 | 7.66 | 235 | 2.48 | 4.27 | 0.21 | 355 | 25 | 30 | 11.8:1 | 6.75 |
| MRH-14 | 7.60 | 418 | 1.88 | 3.23 | 0.16 | 235 | 25 | 30 | 11.5:1 | 8.91 |
| MRH-15 | 6.99 | 179 | 1.73 | 2.98 | 0.15 | 77 | 20 | 35 | 11.5:1 | 8.00 |
| MRH-16 | 7.32 | 230 | 1.58 | 4.35 | 0.14 | 741 | 35 | 30 | 11.2:1 | 6.74 |

| Sample code | pH | E.C (µS/cm) | Org. Carbon (%) | Org. Matter (%) | N (%) | $K_2O$ (ppm) | $P_2O_5$ (ppm) | S (ppm) | C:N | Moisture (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| MRH-17 | 5.76 | 432 | 2.31 | 2.73 | 0.20 | 245 | 20 | 30 | 11.5:1 | 4.78 |
| MRH-18 | 6.23 | 376 | 1.76 | 2.81 | 0.15 | 67 | 30 | 35 | 11.7:1 | 5.94 |
| MRH-19 | 6.39 | 173 | 2.78 | 3.08 | 0.25 | 78 | 35 | 40 | 11.1:1 | 5.89 |
| MRH-20 | 5.74 | 273 | 3.34 | 3.46 | 0.30 | 182 | 30 | 35 | 11.1:1 | 7.47 |
| KMRH-1 | 3.82 | 379 | 1.26 | 2.17 | 0.11 | 35 | 15 | 45 | 11.4:1 | 7.7 |
| KMRH-2 | 4.52 | 178 | 1.57 | 2.70 | 0.14 | 55 | 15 | 30 | 11.2:1 | 8.9 |
| KMRH-3 | 4.18 | 263 | 1.78 | 3.06 | 0.15 | 37 | 15 | 30 | 11.8:1 | 8.10 |
| KBR-1 | 4.82 | 188 | 1.87 | 3.22 | 0.16 | 59 | 15 | 30 | 11.6:1 | 8.91 |
| MRH-21 | 6.08 | 1424 | 2.09 | 3.59 | 0.18 | 53 | 41 | 35 | 11.6:1 | 11.5 |
| MRH-22 | 5.88 | 119 | 1.90 | 3.27 | 0.16 | 25 | 20 | 30 | 11.8:1 | 8.75 |
| MRH-23 | 6.30 | 5910 | 2.19 | 3.77 | 0.19 | 450 | 39 | 29.2 | 11.5:1 | 8.93 |
| MRH-24 | 5.25 | 813 | 1.69 | 2.91 | 0.15 | 81 | 35 | 30 | 11.2:1 | 6.89 |
| MRH-25 | 6.40 | 5717 | 1.80 | 3.10 | 0.15 | 275 | 44 | 35 | 12:1 | 12.33 |
| MRH-26 | 5.72 | 370 | 1.93 | 3.32 | 0.17 | 49 | 37 | 38 | 11.3:1 | 5.80 |
| MRH-27 | 5.67 | 5811 | 1.83 | 3.15 | 0.16 | 215 | 37 | 35 | 11.4:1 | 9.17 |
| MRH-28 | 6.85 | 5909 | 1.90 | 3.27 | 0.16 | 825 | 44 | 35 | 11.8:1 | 13.52 |
| MRH-29 | 6.30 | 5848 | 2.29 | 3.94 | 0.20 | 96 | 39 | 41.7 | 11.4:1 | 10.58 |
| MRH-30 | 6.20 | 5918 | 1.69 | 2.91 | 0.15 | 230 | 35 | 35.4 | 11.2:1 | 9.77 |
| MRH-31 | 6.33 | 5907 | 2.29 | 3.94 | 0.20 | 175 | 36 | 35.4 | 11.4:1 | 8.99 |

| Sample code | pH | E.C (µS/cm) | Org. Carbon (%) | Org. Matter (%) | N (%) | $K_2O$ (ppm) | $P_2O_5$ (ppm) | S (ppm) | C:N | Moisture (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| MRH-32 | 5.70 | 5960 | 1.88 | 3.23 | 0.16 | 245 | 40 | 30 | 11.7:1 | 10.08 |
| MRH-33 | 6.60 | 5767 | 2.33 | 4.01 | 0.20 | 160 | 42 | 32 | 11.7:1 | 11.07 |
| MRH-34 | 6.16 | 177 | 1.79 | 3.08 | 0.15 | 65 | 30 | 32.3 | 11.9:1 | 6.75 |
| MRH-35 | 5.40 | 710 | 1.71 | 2.94 | 0.15 | 42 | 40 | 35 | 11.4:1 | 5.72 |
| MRH-36 | 6.20 | 5892 | 1.83 | 3.15 | 0.16 | 160 | 37 | 38.5 | 11.4:1 | 11.78 |
| MRH-37 | 6.20 | 202 | 1.77 | 3.04 | 0.15 | 97 | 25 | 29.2 | 11.8:1 | 4.88 |
| MRH-38 | 5.90 | 5893 | 2.33 | 4.01 | 0.20 | 85 | 40 | 38.5 | 11.7:1 | 10.25 |
| MRH-39 | 6.32 | 180 | 1.63 | 2.80 | 0.14 | 42 | 25 | 22.9 | 11.6:1 | 3.83 |
| MRH-40 | 6.55 | 5799 | 1.97 | 3.38 | 0.17 | 200 | 44 | 32.3 | 11.5:1 | 10.07 |
| MRH-41 | 5.43 | 258 | 2.33 | 4.01 | 0.20 | 48 | 30 | 35.4 | 11.7:1 | 5.89 |
| MRH-42 | 5.80 | 175 | 1.83 | 2.93 | 0.16 | 30 | 35 | 30 | 11.4:1 | 8.62 |
| MRH-43 | 6.43 | 210 | 1.78 | 3.23 | 0.16 | 35 | 30 | 35 | 11.1:1 | 9.03 |
| MRH-44 | 5.78 | 279 | 2.21 | 3.95 | 0.19 | 43 | 34 | 30 | 11.6:1 | 10.42 |
| MRH-45 | 6.20 | 305 | 1.79 | 2.38 | 0.15 | 30 | 25 | 32.2 | 11.9:1 | 8.63 |
| MRH-46 | 5.92 | 245 | 1.72 | 2.78 | 0.15 | 43 | 30 | 35 | 11.4:1 | 10.04 |
| MRH-47 | 6.32 | 186 | 2.32 | 2.86 | 0.20 | 30 | 25 | 30 | 11.6:1 | 8.98 |
| MRH-48 | 5.80 | 176 | 1.83 | 2.93 | 0.16 | 32 | 28 | 34 | 11.4:1 | 9.63 |
| MRH-49 | 5.76 | 253 | 1.68 | 3.41 | 0.15 | 35 | 30 | 32 | 11.2 | 9.76 |

| Sample code | pH | E.C (µS/cm) | Org. Carbon (%) | Org. Matter (%) | N (%) | $K_2O$ (ppm) | $P_2O_5$ (ppm) | S (ppm) | C:N | Moisture (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| MRH-50 | 4.63 | 283 | 1.87 | 3.37 | 0.16 | 67 | 39 | 30 | 11.6:1 | 8.79 |
| KBR-02 | 5.67 | 265 | 1.72 | 3.42 | 0.15 | 48 | 26 | 31 | 11.4 | 8.78 |

| Parameter | Minimum | Maximum | Mean (Approx.) |
|---|---|---|---|
| pH | 3.82 | 8.13 | 5.94 |
| EC (µS/cm) | 119 | 5960 | 1473.44 |
| Organic Carbon (%) | 1.26 | 3.54 | 1.95 |
| Organic Matter (%) | 2.17 | 6.08 | 3.27 |
| Nitrogen (%) | 0.11 | 0.30 | 0.17 |
| $K_2O$ (ppm) | 25 | 825 | 141.42 |
| $P_2O_5$ (ppm) | 15 | 45 | 31.70 |
| Sulfur (ppm) | 22.9 | 45 | 33.95 |
| C:N ratio | 11.1 | 12.1 | 11.54 |
| Moisture (%) | 3.83 | 13.52 | 8.28 |

# Conclusion

The research indicates considerable spatial variability in the physicochemical properties of soil within the banana cultivation areas of Uttar Dinajpur. Most soils are acidic and have average levels of fertility. To make the land more productive and sustainable, it is suggested to manage nutrients and add things to the soil that are specific to each site (for example, liming acidic soils).

# Declarations


### Acknowledgement

All soil analyses were done by the Department of Tea Science at the University of North Bengal.


### Consent for publication

I, PapanChowhan, hereby declare that this manuscript is an original work that has not been published previously, and is not under consideration for publication elsewhere in any form.

### Data availability statement

All data generated or analysed during this study are included in this published article.

**Ethics and consent to participate**

*Musa spp*. are cultivated one.

**Funding**

No funding support was taken.

**Consent to participate**

Not applicable

**Conflict of Interest**

The authors have no competing interests.

**Consent to Publish**

Not applicable

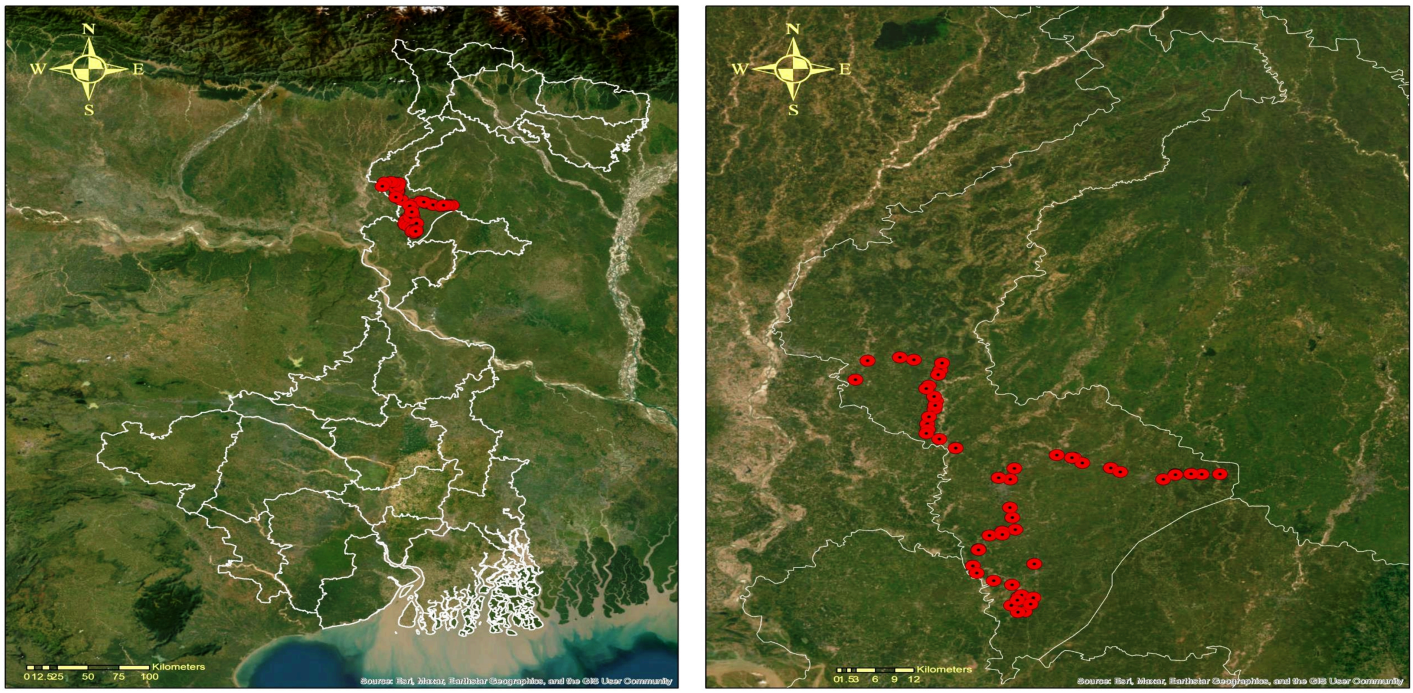
# Author Contribution

Papan Chowhan and Oindrila Chakraborty wrote the article and prepared the figures. Dr. Arka Pratim Chakraborty reviewed the article before communication.

# References

1. Anderson JM,  Ingram JS (1994) Tropical soil biology and fertility: a handbook of methods Soil Science 157(4): 265
2. Brady NCand  Weil RR (2016). *The nature and properties of soils*. Pearson
3. Jackson ML (1973) *Soil chemical analysis*. Prentice Hall
4. Lal R (2004) Soil carbon sequestration impacts on global climate change and food security. *Science* 304(5677): 1623–1627
5. Philippot L, Raaijmakers JM, LemanceauP,  Van Der Putten WH (2013) Going back to the roots: the microbial ecology of the rhizosphere. Nature reviews microbiology11(11): 789-799
6. Reddy PP (2016) Sustainable intensification of crop production. Singapore: Springer Singapore

# Figures




A B

**Figure 1**

Google Earth map view of different locations of soil sample collection (A) in West Bengal and (B) in Uttar Dinajpur District.

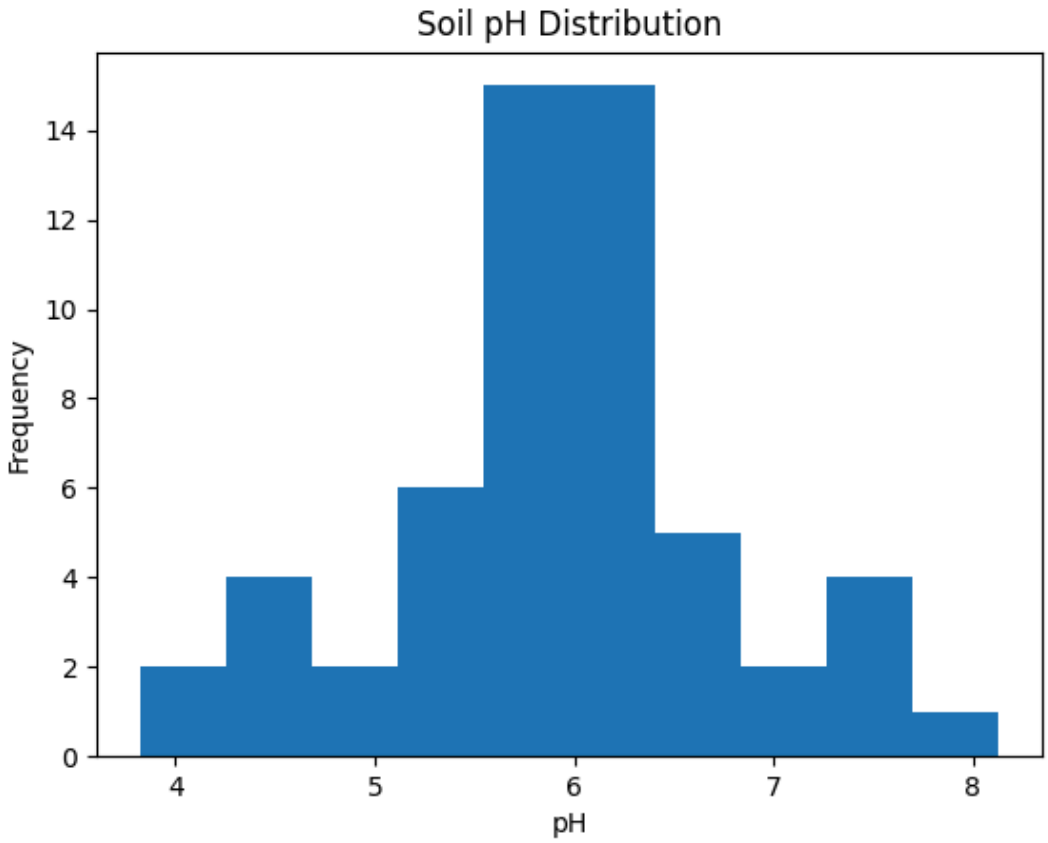



**Figure 2**

Soil pH distribution.

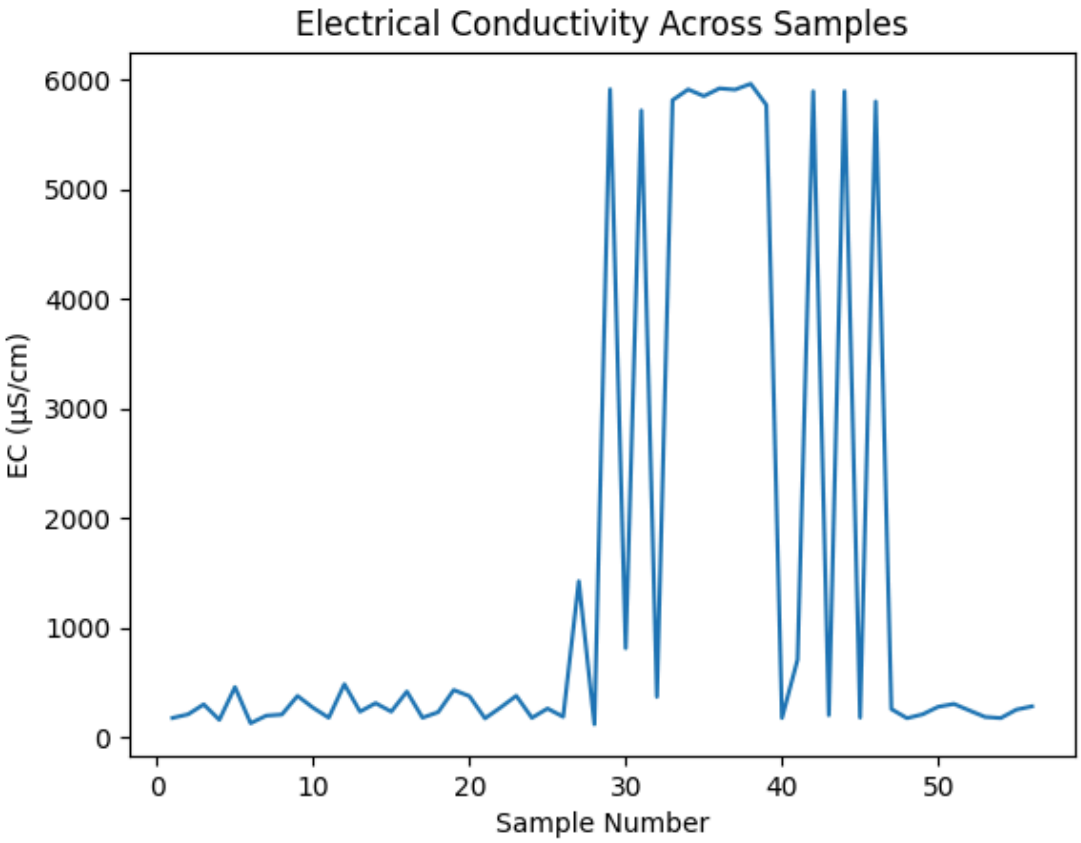



**Figure 3**

Electrical Conductivity across soil samples.

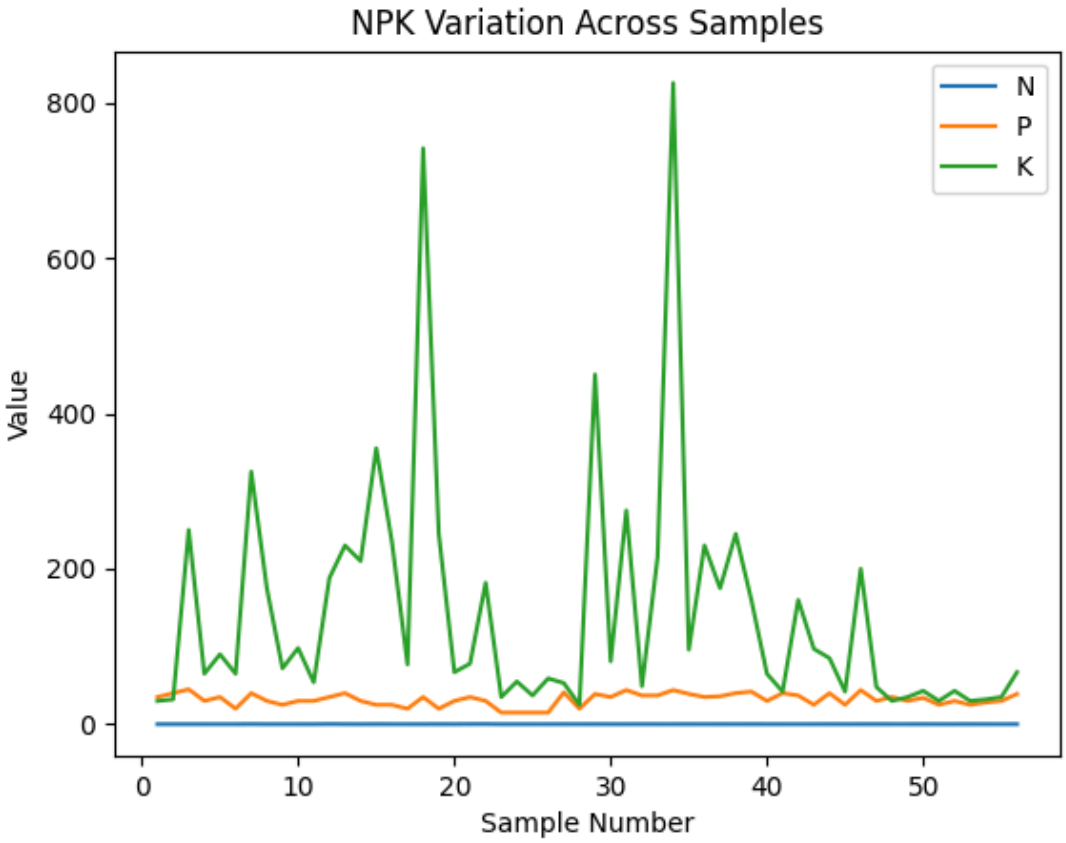



**Figure 4**

NPK variation across soil samples

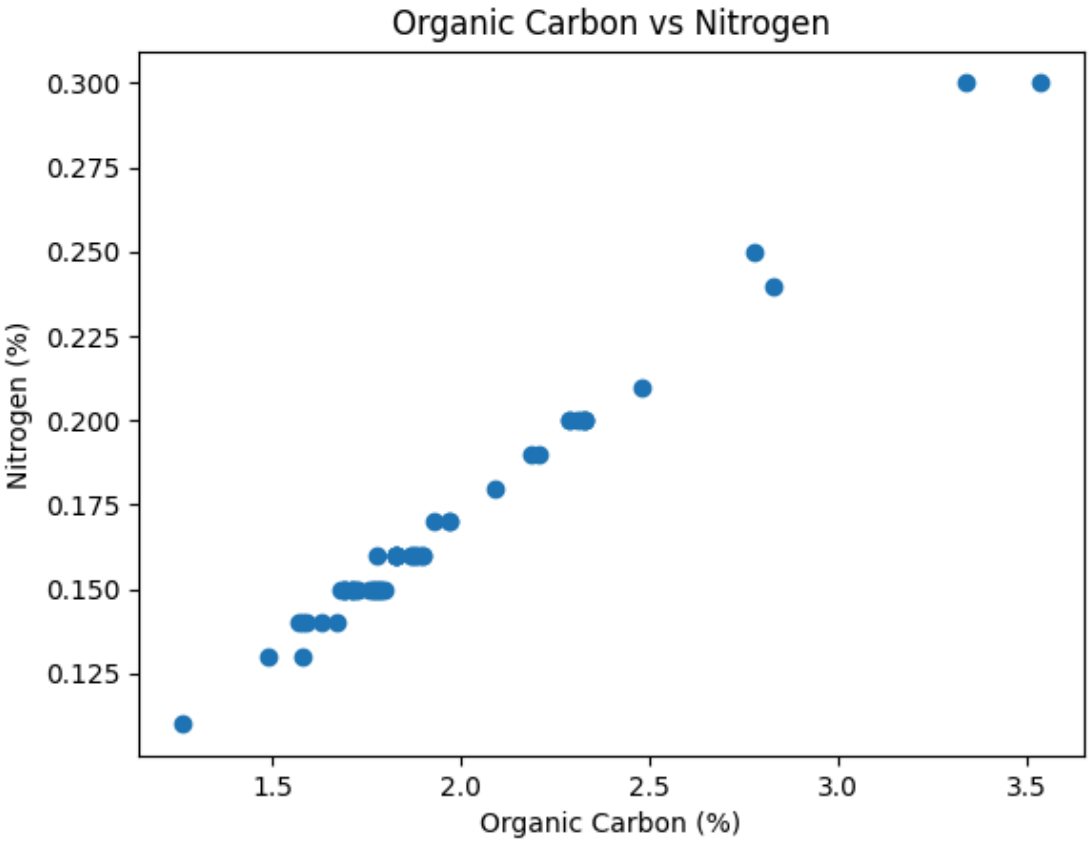



**Figure 5**

Graph plot showing data of organic carbon vs. nitrogen

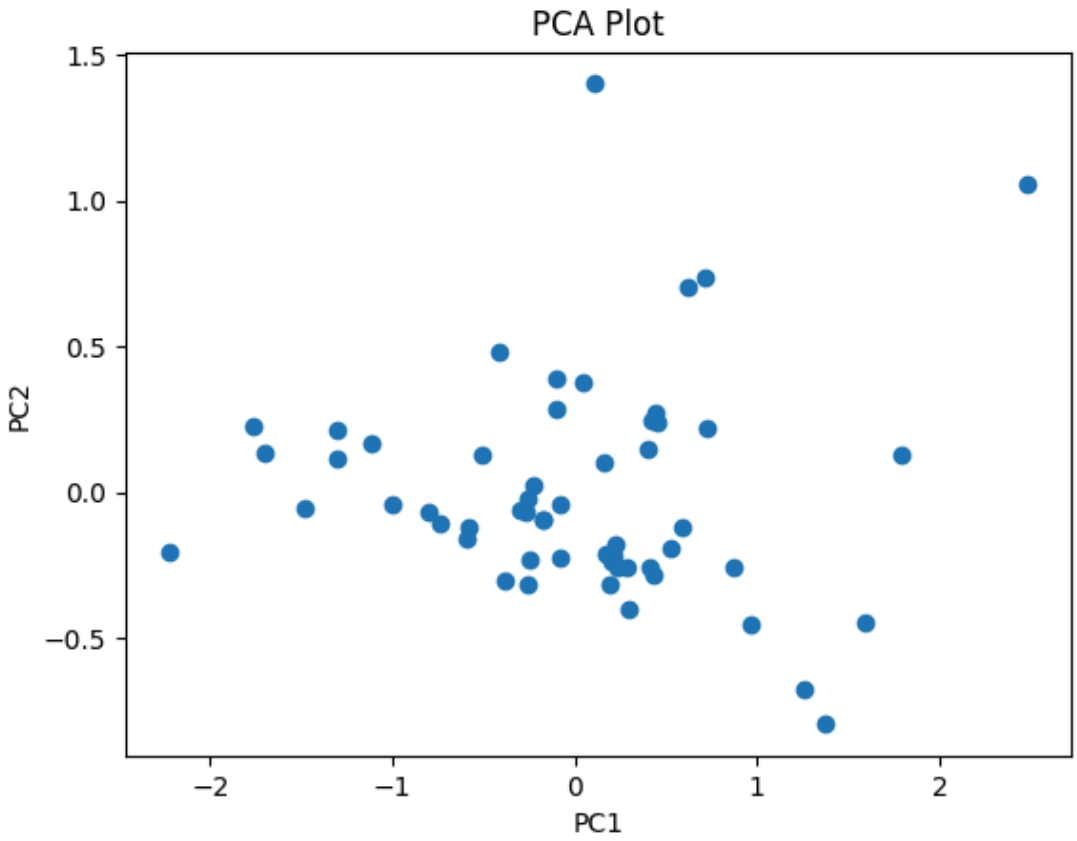



**Figure 6**

PCA plot