

Original Research Article

INFLUENCE OF PARENT MATERIAL AND LAND USE TYPES ON SOIL PROPERTIES OF TAMIL NADU

ABSTRACT

A Study was conducted to study the impact of parent materials and land use on soil physical and chemical properties in soils of Tamil Nadu. The aim of this study is to evaluate the impact of parent materials and land use systems on soil properties. 15 parent materials (Lime, Marl shell, Sandstone with clay interaction, Granite (Gr2), Fuchsite quartzite, Fissile hornblende biotite gneiss, Limestone and Calcareous Shale, Sand/Clay admixture, Teri sand, Sand (Medium), Sand (Grey Brown Medium), Amphibolite, Gabbro, Hornblende biotite gneiss, Chamockite and Sandy Clay) and their respective major land use were selected for the study. In each landuse type per parent material, six composite soil samples were collected from the representative location within the land use types at 0 - 30 cm soil depth and all soil samples were generated for laboratory analysis. Results showed that among the parent materials, Sandy clay had the highest silt + clay fractions, Sandy/Clay admixture had the higher organic carbon content and Fissile hornblende biotite gneiss have higher exchangeable Calcium whereas Granite (Gr2) had the higher exchangeable Magnesium. The Cation exchange capacity (CEC) was significantly highest in Limestone and Calcareous shale whereas the base saturation was significantly higher in Granite (Gr2) in the study area. This shows that land use and parent material highly influence the soil properties. The application of more organic and less inorganic fertilizers will alter the Soil properties of the study area.

Keywords: *Parent material; Land use; Soil physical and chemical properties; Tamil Nadu*

1. INTRODUCCION

Soils are considered as the "Earth's Critical Zone" which is defined as the surface layer from treetop to the underlying bedrock enrolled in life-sustaining life ecosystem and services. Globally, a number of poor agricultural management practices have caused decline in soil fertility and deteriorated the environment making it vital to secure sustainable agricultural production systems. Despite, it is expected that the world still grapples with food production on a sustainable manner due to rising sea levels, climatic change, soil and land degradation and rapid shrinking of agricultural lands amidst the projected population increase by 2050 and 2100 respectively (Camponiet al., 2023).

There are serious doubts about the sustainability of soil formation and the provision of soil ecosystem services due to human pressures such as population growth, land use change, and intensifying human involvement. Therefore, understanding the lifecycle of soil formation to soil degradation is crucial to formulate strategies for restoration, sustainable landuse practices and

Comment [PATLE1]: Change 'Study' to 'study'

Comment [PATLE2]: In this sentence, study word is repeated. It should be changed into 'examine'.

Comment [PATLE3]: Space between land use

protection of soil functions (Feiznia *et al.*, 2007). Further studies on the influence of parent material and land use change on the soil properties is vital for environmental management to ensure sustainable use of land.

The ability of the soil to perform ecosystem function depends on the integrated actions of different soil properties called soil quality indicators. Simple qualities or properties of the soil that can be assessed to evaluate soil physio – chemical properties in relation to a particular function are known as soil quality indices or indicators (Parsley *et al.*, 2008).

Parent material is one of the important passive factors of soil forming process upon which soil development depends. Parent materials would result in differential weathering products based on different elemental composition which influence the physico – chemical and morphological properties under same agro – ecological conditions (Akpan *et al.*, 2018). The number of cations and sesquioxides contained in the parent materials, which have an impact on the soil structure, nutrient status, and soil pH, control the rooting depth. Many researchers have reported that various land use such as agricultural land, crop land, plantation, continuous cultivation, fallow land, grazing, deforestation as well as parent materials can cause depletion or addition of nutrients to the soil and eventually, inflation or reduction in output (Deng *et al.*, 2015). It is well known that turning forest into agriculture degrades the soil's physical qualities and makes the area more prone to erosion because macroaggregates are disrupted. Further, climate change, parent material and wide land use types have diverse impacts on the soil attributes. While other land use strategies enrich the soil with nutrients, some frequently cause the loss of soil nutrients.

2. MATERIALS AND METHODS

2.1. STUDY AREA

The study was conducted in Tamil Nadu state which extends from 8°4'N to 13°35'N latitudes and from 76°18'E to 80°20'E longitudes (Fig 1.). The most common parent materials in Tamil Nadu are clay, hornblende, quartzite, limestone respectively. Tamil Nadu gets an average annual rainfall of 96 cm. The most common land uses followed in the state are Agricultural and horticultural crop land, agricultural and horticultural plantation, Fallow lands, water bodies. In addition, the crop lands are diversified with variety of crops like food crops, cash crops, plantation crops etc.

Fifteen Parent materials and land use types were selected for the study. In each land use type per parent material, composite soil samples were collected from the representative location in 0-30cm soil depth. Undisturbed soil samples were selectively collected for saturated hydraulic conductivity and bulk density determinations.

2.3. LABORATORY ANALYSIS

The soil samples were air-dried, sieved through a 2 mm size-sieve, and the following analyses were performed in accordance with the necessary standard protocols. Soil pH was determined using pH meter in a ratio of 1:2.5 soils and water. Soil Electrical Conductivity (EC) was determined using EC meter. The measurement of organic carbon followed Nelson and Sommer's recommendations. As explained by Udo *et al.*, the Bray-1 method was used to assess the amount of available phosphorus. Exchangeable cations were extracted using 1 M NH₄ OAC (pH 7.0),

Comment [PATLE4]: Add space between

Comment [PATLE5]: Add average annual rainfall of the study area.

Comment [PATLE6]: Add 3-4 lines about the geology of the study area.

and Ca and Mg concentrations were assessed using the EDTA titration method and K and Na concentrations using a flame photometer. Base saturation was estimated as the portion of the total ECEC that Ca, Mg, K, and Na occupied and Exchangeable Sodium Percentage (ESP) was derived using standard formula. The cation exchange capacity (CEC) was obtained by the summation of exchangeable bases (Ca^{2+} , Mg^{2+} , K^+ , Na^+).

3. RESULTS AND DISCUSSION

The major parent material occupied larger area and the major land use followed in the soil formed from the particular parent material was enlisted in the Table 1 and Fig 2 (both the table and Fig are below). The series under which the soil formed from the respective parent material was also given. According to the table, it was evident that Lime, Marl Shell occupied larger area followed by Sandstone with clay interaction, Granite, Fuchsite quartzite, Schistose quartzite, Sillimani, Fissile hornblende biotite gneiss, Limestone and calcareous shale, Sand/Clay admixture, Teri sand, Sand (Medium), Sand (Grey Brown Medium), Amphibolite, Gabbro, Hornblende biotite gneiss whereas least area occupied by Chamockite and Sandy Clay.

The influence of parent material and land use on soil physical properties is presented in Table 2. There were textural variations among all parent materials taken under consideration. The mean sand fraction was significantly higher in Fuchsite quartzite, Schistose quartzite, Sillimani (87.8%) followed by chamocklite (79.7%) which was in on par with Teri Sand (79.7%) and Sand (Grey Brown Medium) (79.7%) followed by Amphibolite (76.5%) and Lime Marl Shell (68.7%) which was on par with Fissile Hornblende Biotite gneiss (68.7%) and Limestone and Calcareous Shale (68.7%) respectively (Huotet *et al.*, 2015). The mean Silt fraction was significantly higher in Sandstone with Clay intercalation (25%) which was on par with Sand/ Clay admixture followed by Sandy Clay (16.5%). The mean Clay fraction was significantly higher in Gabbro (38.3%) which was on par with Sandy clay (38.3%). The higher clay and silt fractions in Sandy Clay parent material could be attributed to more binding effect due to higher organic matter content.

The influence of parent material and land use on soil chemical properties is presented in Table 3. The pH of the soil was acidic in Sandstone with clay interaction, Fuchsite quartzite, Schistose quartzite, Sillimani and Sand/Clay admixture and neutral in Granite (Gr2), Amphibolite and Gabbro and basic pH is prominent in Sand (Grey Brown Medium), Limestone and Calcareous Shale, Teri sand, Fissile hornblende and Lime, Marl Shell. The EC of all combinations lies in the range between 0 – 0.3. The organic carbon content was higher in Sandy/Clay admixture and Sandstone with clay interaction. The available phosphorous content was significantly higher in Sandy clay followed by Amphibolite.

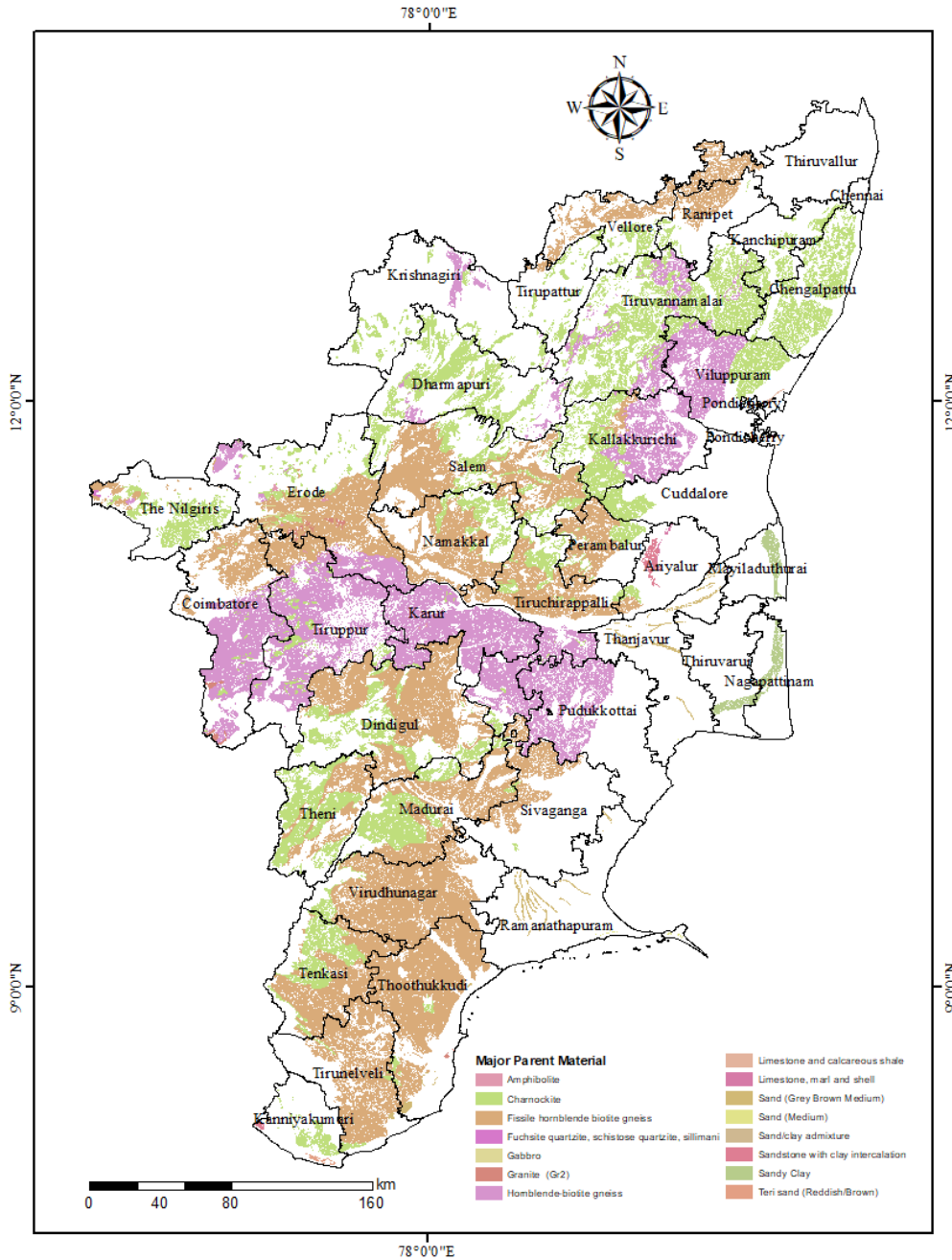
The available potassium was significantly higher in Sandy clay and gabbro and further exchangeable bases like exchangeable Ca was higher in Fissile hornblende biotite gneiss and Limestone calcareous shale and exchangeable Mg was higher in Granite (Gr2) and exchangeable potassium was in higher concentrations in Amphibolite whereas Lime, Marl Shell, Fissile hornblende biotite gneiss and Limestone and calcareous shale had higher concentrations of exchangeable Sodium. The cation exchange capacity of the soil was eventually higher in parent materials such as Lime, Marl Shell, Fissile hornblende biotite gneiss and limestone and calcareous shale respectively. The total exchangeable sites occupied by basic cations were significantly higher in Granite (Gr2) followed by Sandy clay.

Comment [PATLE7]: Lithology map and soil texture map of the study area may be included in this section.

CONCLUSION

The study revealed that among the parent materials and land use combinations, Sandy clay parent material had the highest silt + clay fractions and most of the soil had the textural variations within sandy clay, Sandy loam and Sandyclayloam respectively. Sandy/Clay admixture had the highest organic carbon content followed by Sandstone. The available phosphorous and potassium was significantly higher in Sandy clay followed amphibolites and gabbro (Wilson *et al.*,2019). The combination of parent material and land use types indicated that the major parent material under the given major land use had the highest water and nutrient holding capacity, high rooting volume, good aeration status, higher exchange sites, more available nutrients for plant uptake, less erosion threats, more biological activity, etc., followed by other parent materials in the study area. The results also revealed that the soil physical and chemical properties were influenced by appropriate land use types and parent materials respectively in the study area.

UNDER PEEL



Comment [PATLE8]: In the map, increase the font size of legend, so that it can be visible properly.

Figure 2. Distribution of major parent material in Tamil Nadu

Table 1. Major Parent material and Land use Combinations

| S. No. | Parent Material | Land Use | Area (in Ha.) | Series |
|--------|--|---|---------------|-----------------|
| 1 | Sand/Clay admixture | Agricultural Plantation | 1447306297.40 | Kombuthuki |
| 2 | Sandstone with Clay intercalation | Agricultural Plantation | 1447306297.00 | Kombuthuki |
| 3 | Teri Sand | Agricultural Plantation | 696086309.32 | Peravurani |
| 4 | Sand -Grey Brown Medium | Agricultural Land -2 Crop Area | 696086309.32 | Peravurani |
| 5 | Chamockite | Agricultural Land-More than 2 Crop Area | 696086309.32 | Peravurani |
| 6 | Granite -Gr2 | Agricultural Land-Current Fallow | 487839594.79 | Thengampudur |
| 7 | Gabbro | Agricultural Land-Zaid Crop | 269947918.14 | Ambasamudram |
| 8 | Lime, Marl Shell | Agricultural Plantation | 266041423.34 | Kallivalasu |
| 9 | Fissile Hornblende Biotite gneiss | Agricultural Land-Current Fallow | 266041423.34 | Kallivalasu |
| 10 | Limestone and Calcareous Shale | Agricultural Plantation | 266041423.34 | Kallivalasu |
| 11 | Sand - Medium | Agricultural Plantation | 185166835.04 | Habitation |
| 12 | Hornblende Biotite gneiss | Agricultural Land-More than 2 Crop Area | 185166835.04 | Habitation |
| 13 | Fuchsite quartzite, Schistose quartzite, Sillimani | Agricultural Plantation | 106429175.82 | Puvattihalli |
| 14 | Amphibolite | Agricultural Land-2 Crop Area | 93824480.47 | Chokkanpatti |
| 15 | Sandy clay | Agricultural Land-Rabi Crop | 36451945.73 | Nalladevanpatti |

Comment [PATLE9]: Ha should be written as ha.

Table 2. Influence of parent material and land use on physical properties

| S. No. | Parent Material | Land Use | Sand (%) | Silt (%) | Clay (%) | Texture | Bulk Density |
|--------|--|---|----------|----------|----------|---------------|--------------|
| 1 | Sand/Clay admixture | Agricultural Plantation | 54.50 | 25.00 | 20.50 | Loam | 1.43 |
| 2 | Sandstone with Clay intercalation | Agricultural Plantation | 54.50 | 25.00 | 20.50 | Loam | 1.43 |
| 3 | Teri Sand | Agricultural Plantation | 79.72 | 9.78 | 10.50 | Sandyloam | 1.58 |
| 4 | SAND -Grey Brown Medium | Agricultural Land-2 Crop Area | 79.72 | 9.78 | 10.50 | Sandyloam | 1.58 |
| 5 | Chamockite | Agricultural Land-More than 2 Crop Area | 79.72 | 9.78 | 10.50 | Sandyloam | 1.58 |
| 6 | Granite - Gr2 | Agricultural Land-Current Fallow | 65.66 | 7.45 | 26.89 | Sandyclayloam | 1.41 |
| 7 | Gabbro | Agricultural Land-Zaid Crop | 52.90 | 8.80 | 38.30 | Sandyclay | 1.34 |
| 8 | Lime, Marl Shell | Agricultural Plantation | 68.78 | 11.53 | 19.69 | Sandyclayloam | 1.46 |
| 9 | Fissile Hornblende Biotite gneiss | Agricultural Land-Current Fallow | 68.78 | 11.53 | 19.69 | Sandyclayloam | 1.46 |
| 10 | Limestone and Calcareous Shale | Agricultural Plantation | 68.78 | 11.53 | 19.69 | Sandyclayloam | 1.46 |
| 11 | Sand -Medium | Agricultural Plantation | 0.00 | 0.00 | 0.00 | - | 0.00 |
| 12 | Hornblende Biotite gneiss | Agricultural Land-More than 2 Crop Area | 0.00 | 0.00 | 0.00 | - | 0.00 |
| 13 | Fuchsite quartzite, Schistose quartzite, Sillimani | Agricultural Plantation | 87.75 | 2.05 | 10.20 | Loamysand | 1.60 |
| 14 | Amphibolite | Agricultural Land-2 Crop Area | 76.54 | 13.24 | 10.22 | Loamysand | 1.58 |
| 15 | Sandy clay | Agricultural Land-Rabi Crop | 45.26 | 16.48 | 38.26 | Sandyclay | 1.32 |

Table 3. Influence of parent material and land use on Soil chemical properties

| S. No. | Parent Material | Land Use | pH | EC | OC (%) | P ₂ O ₅ (mg/kg) | K ₂ O (mg/kg) | Ex.Ca (cmol/ kg) | Ex. Mg (cmol/ kg) | Ex.Na (cmol/ kg) | Ex.K (cmol/ kg) | CEC (meq/ 100g) | Base Saturation(%) | ESP(%) |
|--------|--|--|------|------|--------|--|-----------------------------|------------------------|----------------------------|------------------------|-----------------------|-----------------------|-----------------------|--------|
| 1 | Sandy clay | Agricultural Plantation | 7.00 | 0.14 | 0.34 | 10.20 | 342.00 | 4.00 | 5.50 | 0.48 | 0.10 | 10.40 | 96.92 | 4.62 |
| 2 | Amphibolite | Agricultural Plantation | 7.10 | 0.06 | 0.23 | 10.00 | 86.00 | 2.49 | 2.18 | 0.22 | 0.84 | 9.80 | 58.47 | 2.24 |
| 3 | Fuchsite quartzite, Schistose quartzite, Sillimani | Agricultural Plantation | 6.30 | 0.02 | 0.26 | 7.24 | 92.40 | 2.24 | 1.80 | 0.05 | 0.11 | 5.25 | 80.00 | 0.95 |
| 4 | Sand –Medium | Agricultural Land-2 Crop Area | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | Hornblende Biotite gneiss | Agricultural Land-More than 2 Crop Area | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6 | Lime, Marl Shell | Agricultural Land- Current Fallow | 8.20 | 0.30 | 0.48 | 0.80 | 242.00 | 17.85 | 9.69 | 0.66 | 0.30 | 29.70 | 95.96 | 2.22 |
| 7 | Fissile Hornblende Biotite gneiss | Agricultural Land-Zaid Crop | 8.20 | 0.30 | 0.48 | 0.80 | 242.00 | 17.85 | 9.69 | 0.66 | 0.30 | 29.70 | 95.96 | 2.22 |
| 8 | Limestone and Calcareous Shale | Agricultural Plantation | 8.20 | 0.30 | 0.48 | 0.80 | 242.00 | 17.85 | 9.69 | 0.66 | 0.30 | 29.70 | 95.96 | 2.22 |
| 9 | Gabbro | Agricultural Land- Current Fallow | 6.90 | 0.10 | 0.42 | 4.80 | 308.00 | 7.50 | 6.00 | 0.25 | 0.25 | 15.50 | 90.32 | 1.61 |
| 10 | Granite - Gr2 | Agricultural Plantation | 7.10 | 0.20 | 0.33 | 5.12 | 105.70 | 6.60 | 17.00 | 0.12 | 0.41 | 11.60 | 208.02 | 1.03 |
| 11 | Teri Sand | Agricultural | 8.10 | 0.30 | 0.67 | 6.22 | 82.70 | 1.62 | 0.52 | 0.26 | 0.15 | 4.22 | 60.45 | 6.18 |

| | | Plantation | | | | | | | | | | | | |
|----|-----------------------------------|---|------|------|------|------|-------|------|------|------|------|-------|-------|------|
| 12 | SAND - Grey Brown Medium | Agricultural Land-More than 2 Crop Area | 8.10 | 0.30 | 0.67 | 6.22 | 82.70 | 1.62 | 0.52 | 0.26 | 0.15 | 4.22 | 60.45 | 6.18 |
| 13 | Chamockite | Agricultural Plantation | 8.10 | 0.30 | 0.67 | 6.22 | 82.70 | 1.62 | 0.52 | 0.26 | 0.15 | 4.22 | 60.45 | 6.18 |
| 14 | Sandstone with Clay intercalation | Agricultural Land-2 Crop Area | 6.00 | 0.01 | 0.79 | 4.00 | 40.00 | 6.40 | 1.20 | 0.34 | 0.06 | 19.20 | 41.67 | 1.77 |
| 15 | Sand/Clay admixture | Agricultural Land-Rabi Crop | 6.00 | 0.01 | 0.79 | 4.00 | 40.00 | 6.40 | 1.20 | 0.34 | 0.06 | 19.20 | 41.67 | 1.77 |

UNDER PEER REVIEW

REFERENCE

- Akpan, U. S. (2018). Impact of Land Use Systems and Parent Materials on Soil Quality Indicators in Soils of Akwalbom State, Nigeria. *Agriculture Extension Journals* (2018).
- Olowolafe, E. A. (2002). Soil parent materials and soil properties in two separate catchment areas on the Jos Plateau, Nigeria. *GeoJournal*, 56, 201-212.
- Orobator, P., & Odjugo, P. (2015). Influence of parent materials and land use on exchangeable cations in a tropical environment. *Journal of Geography, Environment and Earth Science International*, 3(4), 1-12.
- Feiznia, S. A. D. A. T., & Nosrati, K. A. Z. E. M. (2007). The effect of parent material and land use on soil erosion: a case study of the Taleghan drainage basin, Iran. *IAHS PUBLICATION*, 314, 300.
- Deng, H., Yu, Y. J., Sun, J. E., Zhang, J. B., Cai, Z. C., Guo, G. X., & Zhong, W. H. (2015). Parent materials have stronger effects than land use types on microbial biomass, activity and diversity in red soil in subtropical China. *Pedobiologia*, 58(2-3), 73-79.
- Xiao, K., Lu, L., Tang, J., Chen, H., Li, D., & Liu, Y. (2020). Parent material modulates land use effects on soil selenium bioavailability in a selenium-enriched region of southwest China. *Geoderma*, 376, 114554.
- Camponi, L., Cardelli, V., Cocco, S., Serrani, D., Salvucci, A., Cutini, A., ...& Corti, G. (2023). Holm oak (*Quercus ilex* L.) cover: A key soil-forming force in controlling C and nutrient stocks in long-time coppice-managed forests. *Journal of Environmental Management*, 330, 117181.
- Nenkam, A. M., Wadoux, A. M. C., Minasny, B., McBratney, A. B., Traore, P. C., & Whitbread, A. M. (2023). Using homosols to enrich sparse soil data infrastructure: An example from Mali. *Catena*, 223, 106862.
- Pierce, F. J., Dowdy, R. H., & Grigal, D. F. (1982). Concentrations of six trace metals in some major Minnesota soil series. *Journal of Environmental Quality*, 11(3), 416-422.
- Abindaw, T., Hanyabui, E., Atiah, K., Akwasi, E. A., & Ziblim, I. A. (2023). Influence of land use types on the distribution of selected soil properties in tropical soils of the Coastal Savanna zone. *Heliyon*, 9(3).
- Kalaiselvi, B., Hegde, R., Kumar, K. A., Dharumarajan, S., Srinivasan, R., Lalitha, M., ...& Maddileti, N. Influence of Parent Material on Soil Characteristics in a Topo-sequence of Tamil Nadu Uplands.
- Parsley, J. J. (2008). Influence of parent material on the genesis of the Miles soil series.
- Massey, H. F., Lowe, R. H., & Bailey, H. H. (1967). Relation of extractable molybdenum to soil series and parent rock in Kentucky. *Soil Science Society of America Journal*, 31(2), 200-202.

- Dengiz, O., Gol, C., Karaca, S., &Yuksel, M. (2006). Effects of different landscape position and parent material on soil variability and land use in both sides of Acicay River-Çankiri. In *Proceedings of the International Soil Meeting on Soil Sustaining Life on Earth, Managing Soil and Technology. Sanliurfa, Turkey* (Vol. 2, pp. 745-751).
- Liu, Y. L., Yao, S. H., Han, X. Z., Zhang, B., &Banwart, S. A. (2017). Soil mineralogy changes with different agricultural practices during 8-year soil development from the parent material of a Mollisol. *Advances in Agronomy*, *142*, 143-179.
- Kosmas, C., Gerontidis, S., &Marathianou, M. (2000). The effect of land use change on soils and vegetation over various lithological formations on Lesvos (Greece). *Catena*, *40*(1), 51-68.
- Chesworth, W. (1973). The parent rock effect in the genesis of soil. *Geoderma*, *10*(3), 215-225.
- Candra, I. N., Gerzabek, M. H., Ottner, F., Wriessnig, K., Tintner, J., Schmidt, G., ...&Zehetner, F. (2023). Soil formation and mineralogical changes on basaltic lava vs scoria along a hydroclimatic gradient on Santa Cruz Island, Galapagos. *Catena*, *220*, 106696.
- Huot, H., Simonnot, M. O., & Morel, J. L. (2015). Pedogenetic trends in soils formed in technogenic parent materials. *Soil Science*, *180*(4/5), 182-192.
- Wilson, M. J. (2019). The importance of parent material in soil classification: A review in a historical context. *Catena*, *182*, 104131.

Comment [PATLE10]: Add more 2-3 latest references related to the study.

UNDER PEE