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Characterization and Taxonomy Classification of Soils of Hill Slope Land and Stream Terrace Land Located at North-Eastern Ghat Agro-Climatic Zone of Odisha, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was carried out to study the characterization, fertility status and taxonomic classification of some soils of North-Eastern Ghat Agro-Climatic zone of Odisha. Hill slope (pedon 1) and stream terrace land (pedon 2) two representative pedons of the Nayagarh district located in different topographic positions were studied for their physico-chemical characteristics and taxonomic classification. Results show that in pedon 1, percentage of sand, silt and clay range between 78.4 to 86.4, 3.2 to 3.4 and 10.4 to 17.4 respectively and in pedon 2, sand, silt and clay percentages range between 72 to 84, 3.2 to 7.2 and 10.8 to 18.8 respectively in different horizons. In pedons 1 and 2, pH increases along with depth from 4.80 to 5.82 and 5.80 to 7.60 respectively. Organic carbon content in pedons 1 and 2, ranges from 3.4 to 5.1 and 1.6 to 6.3 g kg^{-1} respectively. Cation exchange capacity decreases in pedon 1 from 13.25 to 8.66 c mol (p+) kg^{-1} and in pedon 2, range 7.66 to 16.65 c mol (p+) kg^{-1}. The exchangeable sodium percentage in pedon 1 and 2, ranges from 4.53 to 9.23, and 2.56 to 6.53 per cent in different horizons respectively. The base saturation percentage in pedon 1, range from 58.11 to 98.15 per cent and in pedon 2, from 59.54 to 97.91 percent. The Hill slope (pedon 1) and stream terrace land (pedon 2) have little or no evidence of development of pedogenic horizons except ochric epipedon, therefore

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these soil are classified under the order *Entisols.* These soils have A-C profile with no distinct horizonation. Pedon 1, are classified under sub order *Orthents,* great group *Ustorthents* and sub group *Typic Ustorthents.* In case of pedon 2 the soils are put under the sub order *Aquents,* great group *Fluvaquents* and sub group *Aeric Fluvaquents.*

Keywords: Pedons; hill slope land; stream terrace land; Entisols.

1. INTRODUCTION

Soil genesis is the study of soil formation on land surface and deals with factors and processes of soil formation. Most import soil forming factor is parent material, topography, time, climate and biosphere. Parent material as such exerts significant influence on soil characteristics during the initial stages of solum development [1]. In the study area soils have developed both from residual (Sedimentary) and transported parent materials. Residuum of biotite gneiss comprises predominant sedentary parent material of the soils in hill slope. In stream terrace land, the parent material consists of alluvial deposits transported by flood plains which are sediments carried by swollen steam and deposited during the flood, with the coarser materials being laid down near the river channel and finer material farther away [2].

Vertical distribution of plant nutrients in soil is useful as roots of most of the crop plants go beyond the surface layer and find their nutrient requirement from the sub surface layers [3]. Studies have been conducted for horizon wise levels of plant nutrients in soil profiles of different parts of India by various research workers. Most of the workers have limited their study on fertility status of surface layers only. Studies of layer wise fertility status of subsurface soils are few which is very important for effective nutrient application. Water retention capacity and nutrient status of soil depend on textural variation together with the physiographic positions.

Though taxonomic classification of representative land types of few districts of Odisha have already been done in recent past, no such work has been done for Nayagarh district in North-Eastern Ghat Agro-Climatic zone of Odisha. Therefore, an attempt has been made in the present investigation to characterization and taxonomic classification of pedons situated in representative land types of Nayagarh district.

2. MATERIALS AND METHOD

The study area is characterized by hot, dry and sub-humid climate with dry summer and mild winter. Average annual rainfall of Nayagarh district is 1243.3 mm in 88 rainy days, out of which 80% rainfall in monsoon season (June to September). The mean maximum temperature is 38.2°C (during summers) and the mean minimum temperature at 17°C (during winters).

2.1 Processing of Soil Samples and Analysis

The soil samples collected from the profiles horizon wise and from soil surface were air dried and passed through 0.5 mm sieve. The samples were then preserved in plastic bottles, labelled and stored for laboratory studies.

The particle size analysis was carried out by Bouyoucos Hydrometer method [4]. Textural classes were determined using USDA Textural Triangular diagram. The bulk densities of the soils were analyzed by clod method as described by Klute [5]. Particle density of the soils was determined by specific gravity bottle or pycnometer bottle [6]. Water Holding Capacity (WHC) (%) was determined by oven dry basis by Keen- Raczkowski box method as described by Piper [4].

The pH of a soil was measured by a glass electrode pH meter. The E.C of soil sample was measured in 1:2 soil: water suspension using the conductivity bridge. The OC of soils was determined by modified Walkley and Black's rapid titration method [7] using Ferroin indicator [6]. The cation exchange capacity (CEC) of soil was determined by centrifuge method by leaching with neutral normal ammonium acetate, as outlined Page et al. [8]. Exchangeable Na and K of the soils present in NH_4OAc leachate collected during CEC determination were determined by "SYSTRONICS" model 128 flame photometer. Exchangeable calcium and magnesium in the above NH_4OAc leachate were determined as per the procedure described by Page et al. [8]. The exchange H^+ and Al^{+3} were determined by following the methods given by Thomas [9].

3. RESULTS AND DISCUSSION

3.1 Depth Wise Vertical Distribution of Soil Physical and Chemical Properties

3.1.1 Particle size distribution

In pedon 1, percentage of sand, silt and clay range between 78.4 to 86.4, 3.2 to 3.4 and 10.4 to 17.4 respectively in different horizons (Table 1). In pedon 2, sand, silt and clay percentages range between 72 to 84, 3.2 to 7.2 and 10.8 to 18.8 respectively in different horizons (Table 2).

In pedon 1, clay content gradually decreased with increasing depth up to 118 and 105 cm (Table 1). In case of pedon 2, clay content irregularly decreases with increase depth of 140 cm (Table 2). Similar types of findings were also obtained by Mishra [10] and Dash et al. [11].

3.1.2 Coarse fragments

The coarse fragments in pedon 1, vary between 2.5 to 32.4 per cent (Table 1). In pedon 2, it ranges from 5.5 to 63.5 per cent (Table 2). In both pedons of the coarse fragments increase along with depth from upper horizon to lower horizon.

3.1.3 Bulk density

The bulk density values of pedon 1, varied between 1.44 to 1.66 Mg m^{-3} (Table 1). In pedon 2, bulk density was in the range from 1.52 to 1.72 Mg m^{-3} (Table 2). Minimum bulk density in the surface horizons due to high amount of clay and organic carbon in the surface horizons. Similar results were also observed by Mishra [12] and Dash et al. [11].

3.1.4 Particle density

The particle density values of pedon 1, varied between 2.40 to 2.55 Mg m^{-3} (Table 1). In pedon 2, bulk density is in the range from 2.46 to 2.63 Mg m^{-3} (Table 2). Particle density increasing from upper horizons towards lower horizons in pedons due to leaching of soil particles. Similar results were also been given by Dash et al. [11].

3.1.5 Total porosity

The percentage of total porosity of pedon 1, range from 34.90 to 40. In pedon 2, total porosity is observed in the range of 34.00 to 38.21. The total porosity lower in the lower most horizons in pedons. Their might be due to lower organic carbon content and higher compactness. Similar results were also been given by Dash et al. [11].

3.2 Water Holding Capacity

The Water Holding Capacity values of pedon 1 and 2, vary from 24.0 to 25.5 and 21.5 to 31.5 per cent in different horizons respectively. In pedon 1and 2, water holding capacity was found to be decreasing with depth due lower organic carbon. Similar results were also found by Dash et al. [11].

3.3 Chemical Characteristics

3.3.1 Soil reaction

In pedons 1 and 2, pH increases along with depth from 4.80 to 5.82 and 5.80 to 7.60 respectively which could be due to leaching of basic cations from upper horizons to lower horizons mostly during intensive rainfall. Similar type of results was also observed by Kumar et al. [13], Rajeswar and Ramulu [14] and Dash et al. [11]. Electrical conductivity which are very low and safe for all the crops.

3.3.2 Organic carbon

In pedons 1 and 2, organic carbon content ranges from 3.4 to 5.1 and 1.6 to 6.3 g kg^{-1} respectively. Organic carbon content of soils in pedons 1, decreases regularly along with depth, in case of pedon 2 it decreases irregularly with depth due to alluviation in stream terrace land. Organic carbon content was maximum in the surface horizons of all the pedons due to fresh accumulation and decomposition of crop residues in the surface horizons. Similar type of results were also found by Dorji et al. [15], Kumar et al. [13] and Khanday et al. [16].

3.3.3 Exchangeable bases

The exchangeable calcium content in pedon 1, increases from 5. 6 c mol (p+) kg^{-1} in the surface horizons along with depth and reaches 6 c mol (p+) kg^{-1} in the lower horizons. In pedon 2, the exchangeable calcium content is 8 c mol (p+) kg^{-1} in the surface horizon which increases irregularly to 11.5 c mol (p+) kg^{-1} in the depth zone of 75-110 cm ($IIIC_2$ horizon).

The exchangeable magnesium content in pedon 1, increases from 1 c mol (p+) kg^{-1} in the surface horizons along with depth and reaches 1.1 c mol (p+) kg^{-1} in the lower horizons. In pedon 2, the exchangeable magnesium content is 0.6 c mol (p+) kg^{-1} in the surface horizon and highest value is 1.2 c mol (p+) kg^{-1} recorded at depth zone of 25-54 cm (A_{13} horizon).

The exchangeable sodium content in pedon 1, increases from 0.6 c mol (p+) kg^{-1} in the surface horizons along with depth and reaches 0.8 c mol (p+) kg^{-1} in the lower horizons. The exchangeable sodium content increases irregularly in pedon 2, from 0.4 c mol (p+) kg^{-1} in the surface horizon to 0.8 c mol (p+) kg^{-1} recorded at depth zone of 75-110 cm ($IIIC_2$ horizon).

The exchangeable potassium content in pedon 1, increases from 0.5 c mol (p+) kg^{-1} in the surface horizons along with depth and reaches 0.6 c mol (p+) kg^{-1} in the lower horizons. The exchangeable potassium content increases irregularly in pedon 2, from 0.3 c mol (p+) kg^{-1} in the surface horizon to 0.5 c mol (p+) kg^{-1} recorded at depth zone of 75-110 cm ($IIIC_2$ horizon).

In both pedons, concentration of exchangeable bases were found to be in order of $Ca^{2+}>Mg^{2+}>Na^{+}>K^{+}$. Exchangeable bases of pedons 1, increases regularly along with depth due to leaching of basic cations from upper horizons to lower horizons mostly during intensive rainfall; in case of pedon 2, they irregularly decrease with depth due to the parent material consists of alluvial deposits transported by flood plains and leaching of basic cations due to floods. Similar type of results was also observed by Giri et al. [17].

3.3.4 Exchangeable acidity

The exchangeable acidity content decreases in pedon 1, from 3.3 c mol (p+) kg^{-1} in the surface horizons to 1.2 c mol (p+) kg^{-1} in the lower horizons. The exchangeable acidity content decreases irregularly in pedon 2, from 2.2 c mol (p+) kg^{-1} in the surface horizon to 0.5 c mol (p+) kg^{-1} recorded at depth zone of 110-150 cm (IVC_3 horizon). The exchangeable acidity decreasing with soil depth in both pedons which could be due to increase in other exchangeable cations saturating the exchange sites down the depth. Similar type of results was also observed by Mishra [12], Pattanayak [18] and Dash et al. [11].

3.3.5 Cation exchange capacity

Cation exchange capacity decreases in pedon 1 from 13.25 to 8.66 c mol (p+) kg^{-1} (Table 1) due to decreases of clay content. In pedon 2, the lowest value of cation exchange capacity is 7.66 c mol (p+) kg^{-1} in the depth zone of 110-150 cm and highest cation exchange capacity is 16.65 c mol (p+) kg^{-1} in the depth zone of 75-110 cm ($IIIC_2$ horizon). This could be attributed to the irregular content of different bases and clay percentage.

3.3.6 Base saturation

The base saturation percentage increases in pedon 1, from 58.11 per cent in the surface horizons to 98.15 per cent in the lower horizons. The base saturation percentage increases irregularly in pedon 2, from 59.54 per cent in the surface horizon to 97.91 percent recorded at depth zone of 110-150 cm (IVC_3 horizon). This could be attributed to content of different bases and clay percentage. Similar type of findings was also obtained by Dash et al. [11].

3.3.7 Exchangeable sodium percentage

The exchangeable sodium percentage in pedon 1 and 2, ranges from 4.53 to 9.23, and 2.56 to 6.53 per cent in different horizons respectively. There was a gradual increase in ESP throughout the profile found in pedon 1which might be attributed to leaching of sodium ions from upper horizons towards lower horizons mostly during intensive rainfall. In pedon 2, ESP irregularly increases due to alluvialization. Similar type of findings was also obtained by Mishra [19].

3.3.8 Soil classification

The soils of pedon 1 and 2, have little or no evidence of development of pedogenic horizons except ochric epipedon, therefore these soil are classified under the order *Entisols.* These soils have A-C profile with no distinct horizonation. The soil do not have cracks as wide as 1 cm at a depth of 50 cm of the soil surface under non irrigated condition nor do they have gilgai micro relief or slickensides. Hence, the soils of pedon 1 and 2, are classified under order of *Entisols*.

In pedon 1, organic carbon content decreases regularly with increasing depth and reaches a level of 2.5 g kg^{-1} or less within a depth of 125 cm (Table 1) and within 50 cm do not have mineral surface horizon and have coarse fragments within a depth of 100 cm and were never saturated with water, therefore soils of pedon 1, are classified under sub order *Orthents*.

Table 1. Physical and Chemical properties of pedon 1 (Hill slope land)

Physical properties											Chemical properties											
Horizon	Depth (cm)	Per cent (%)			Coarse Fragment (Vol. more than 2mm) (%)	Texture class	Mg m^{-3}		Per cent (%)		pH (1:2)	EC (dSm^{-1})	OC (g kg^{-1})	Exchangeable bases [c mol (p+) kg^{-1}] in soil					Exchangeable acidity [c mol (p+) kg^{-1}]	CEC [c mol (p+) kg^{-1}] in Soil	Base Saturation (%)	ESP (%)
		Sand	Silt	Clay			Bulk Density	Particle density	Porosity	WHC				Ca	Mg	Na	K	SUM				
A_1	0-12	78.4	3.2	17.4	2.5	Sandy loam	4.80	0.26	5.1	25.5				5.6	1	0.6	0.5	7.7	3.3	13.2	58.1	4.5
C_1	12-58	83.2	3.4	13.4	8.6	Loamy sand	5.51	0.27	4.1	24.3				5.8	1.1	0.7	0.6	8.2	2.6	10.2	80.0	6.8
C_2	58-118	86.4	3.2	10.4	32.4	Loamy sand	5.82	0.28	3.4	24.0				6	1.1	0.8	Ca	8.5	1.2	8.66	98.1	9.2
C_3	118-140	Partially weathered parent material																				

Table 2. Physical and Chemical properties of pedon 2 (Steam terrace land)

Physical properties											Chemical properties											
Horizon	Depth (cm)	Per cent (%)			Coarse Fragment (Vol. more than 2mm) (%)	Texture class	Mg m^{-3}		Per cent (%)		pH (1:2)	EC (dSm^{-1})	OC (g kg^{-1})	Exchangeable bases [cmol (p+) kg^{-1}] in soil					Exchangeable acidity [c mol (p+) kg^{-1}]	CEC [cmol (p+) kg^{-1}] in Soil	Base Saturation (%)	ESP (%)
		Sand	Silt	Clay			Bulk Density	Particle density	Porosity	WHC	Mg	Na	K	Ca	Mg	Na	K	SUM				
A_1	0-10	76	5.2	18.8	5.5	Sandy loam	5.80	0.05	6.3	8	0.6	0.4	0.3	9.3	2.2	15.62	59.54	2.56	2.2	15.62	59.54	2.56
A_{12}	10-25	78	3.2	18.8	6.5	Sandy loam	6.50	0.09	4.7	9	1	0.5	0.4	10.9	1.4	15.25	71.48	3.28	1.4	15.25	71.48	3.28
A_{13}	25-54	78	3.2	18.8	15.5	Sandy loam	7.26	0.13	3.1	10	1.2	0.7	0.5	12.4	1.0	15.56	79.69	4.50	1.0	15.56	79.69	4.50
IIC_1	54-75	78	7.2	14.8	26.6	Loamy sand	7.36	0.24	3.3	9	0.6	0.4	0.3	10.3	1.2	11.25	91.56	3.56	1.2	11.25	91.56	3.56
$IIIC_2$	75-110	72	7.2	20.8	52.2	Loamy sand	7.48	0.26	2.1	11.5	0.8	0.8	0.5	13.6	0.6	16.65	81.68	4.80	0.6	16.65	81.68	4.80
IVC_3	110-140	84	5.2	10.8	63.5	Loamy sand	7.60	0.25	1.6	8.2	0.6	0.5	0.4	9.7	0.3	7.66	97.91	6.53	0.3	7.66	97.91	6.53

In pedons 1, an *ustic* soil moisture regime and conductivity of less than 2 dSm^{-1} at 25^{0} C in all sub horizons and are therefore classified under great group of *Ustorthents*. They do not have a lithic contact within 50 cm of the surface, hence the soils of pedon 1, are classified under sub group of *Typic Ustorthents.*

The soils are saturated with water at some time throughout the year in all sub horizons within 50 cm of the surface, have texture finer than loamy fine sand and mottling. Therefore, these soils of pedon 2 are classified under sub order *Aquents.* Organic carbon content decreases irregularly with increase in the depth and reaches a level of 2.5 g kg^{-1} or less within a depth of 125 cm (Table 2). Hence, these soils of pedon 5 are classified under great group is *Fluvaquents.* Do not have in 60 per cent or more of the matrix in all sub horizons between a depth of 25cm and 75 cm; therefore these soils of pedon 5 are classified under sub group of *Aeric Fluvaquents.* Similar type of soil classification as of pedon 3 and 4 was also observed by Mishra [19] and Dash et al. [11].

4. CONCLUSION

The bulk density and particle density increases along with depth in pedon I and 2 and total porosity decrease along with depth. The soil pH gradually increases with increasing depth in all pedons. The Electrical Conductivity was found to be less than 1 dS m^{-1} in all the pedons. The organic carbon and exchangeable acidity decreasing along with depth. In pedon 1 cation exchange capacity (CEC) decreased from in the surface horizons to lower horizons; In case of in stream terrace land (pedon 2), irregular decrease. Base saturation increased regularly from surface horizon to the lower most horizons in pedon 1, but in case of pedon 2, base saturation irregularly increases. The exchangeable sodium percentage gradually increase throughout the profile in pedon 1, but in case of pedon 2 irregularly increases.

The hill slope soils of the study area classified under order *Entisols,* sub order *Orthents,* great group *Ustorthents* and sub group *Typic Ustorthents.* The stream terrace land was classified under order *Entisols,* sub order *Aquents,* great group *Fluvaquents* and sub group *Aeric Fluvaquents.*

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Buol SW, Hole FD, Mc Cracken RJ. Soil genesis and classification. The Iowa State University Press, Ames, Iowa; 1973.
2. Mishra A, Das D, Saren S, Dey P. GPS and GIS based soil fertility maps of Nayagarh district, Odisha, Annals of Plant and Soil Research. 2016;**18**(1):23-28.
3. Patil RG, Patel MS. Influence of available nutrients in surface and sub-surface soils on yield and nutrient uptake by Groundnut, Journal of Indian Society of Soil Science. 1983;31:160-161.
4. Piper CS. Soil and plant analysis. University of Adelaide. 1950;368.
5. Klute. Methods of soil analysis. Part I American Society of Agronomy, Soil and Society of America. 1986;371—373.
6. Chopra SL, Kanwar JS. Analytical agricultural chemistry. Kalyani Publishers, New Delhi; 1986.
7. Jackson ML. Soil Chemical Analysis, Prentice Hall of India Private limited, New Delhi; 1973.
8. Page AL, Miller RH, Keeney DR. Methods of soil analysis, Part-2 (edn)., monograph no-9. American Society of Agronomy, Agronomy series ASA SSA. Publishers, Medision, Wisconsin. USA. 1982;621-622.
9. Thomas GW. Soil pH and soil acidity. In Sparks D.L.ed., Methods of Soil Analysis, Part 3, Chemical Methods Madison, WI, Soil Science Society of America, American Society of Agronomy. 1996;475-490.
10. Mishra DP. Morphological studies and classification of soils of Hirakud command area. Ph.D. Thesis, Department of Soil Science and Agricultural Chemistry, OUAT, Bhubaneswar; 1981.

11. Dash PK, Mishra A, Saren S. Characterization and taxonomic classification of soils under a toposequence located in Eastern India, Environment and Ecology. 2019; 37(4):1240-1249.
12. Mishra A. Characterisation, fertility status and taxonomic classification of some soils of West Central Table Land Agro Climatic Zone of Odisha, Ph.D. Thesis, Department of Soil Science and Agricultural Chemistry, OUAT, Bhubaneswar; 2005.
13. Kumar R, Kumar R, Rawat KS, Yadav B. Vertical distribution of physico-chemical properties under different toposequence in soils of Jharkhand, Journal of Agricultural Physics. 2012;12(1): 63-69.
14. Rajeshwar M, Ramulu V. Vertical distribution of available macro and micronutrients in soil profiles of Ganapavaram pilot area of Nagarjuna Sagar left canal command area of Andhra Pradesh, Asian Journal of Soil Science. 2016;11(1):202-206.
15. Dorji T, Odeh IOA, Field DJ. Vertical distribution of soil organic carbon density in relation to land use cover, altitude and slope aspect in the Eastern Himalayas. Land. 2014;3:1232-1250.
16. Khanday M, Wani JA, Ram D, Kumar S. Depth wise distribution of available nutrients of soils of horticulture growing areas of Ganderbal District of Kashmir valley, Journal of Pharmacognosy and Phytochemistry. 2018;7(1):19-22.
17. Giri J, Nilima S, Metkari PM. Status and distribution of available micronutrients along a toposequence at Bazargaon plateau, Maharashtra, An Asian Journal of Soil Science. 2017;12(2):300-306.
18. Pattanayak T. Preparation of GPS based soil fertility maps and identification of soil related crop production constraints for Dhenkanal District, Odisha, Ph. D Thesis, Department of Chemistry, Institute of Technical Education and Research, Siksha 'O' Anusandhan University, Bhubaneswar; 2016.
19. Mishra A, Pradhan NK, Nanda SK, Jena B. Soil test based fertilizer recommendation for targeted yield of Sesamum (*Sesamum indicum*) under rice-sesamum cropping system in an Inceptisol of Orissa, Environment and Ecology. 2008;26 (4A):1756-1758.

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