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Geomorphological Characterization of Soils under Toposequence Located in North-Eastern Ghat Agro-Climatic Zone of Odisha, India

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ABSTRACT

The present investigation has been designed to analyze the landform and soil relationship in Nayagarh district located in North-Eastern Ghat Agro-Climatic zone of Odisha, India. The study area comes under a typical toposequence with varying topography with respect to elevation above mean sea level. The morphological features of soil pedons along the toposequence were studied and soil samples from different genetic horizons were collected from hill slope (4), upland (4), medium land (6), low land (7) and stream terrace land (6). The study area for soil profile study was chosen in such an area which represents almost all the five physiographic position of the district. The depth of soil varied from 140 to 180 cm and color from red to yellow. The parent rock of the study area was found to be Khondalite. The mineralogical composition of the study area to be dominated by quartz and feldspare. 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 (Forest land), upland and midland. In the low land, the parent material chiefly consists of colluvium transported by running water from upslope due to action of gravity and deposited over residuum of biotite-gneiss. 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.

Keywords Landform, Parent rock, Soil formation, Geomorphological characterization.

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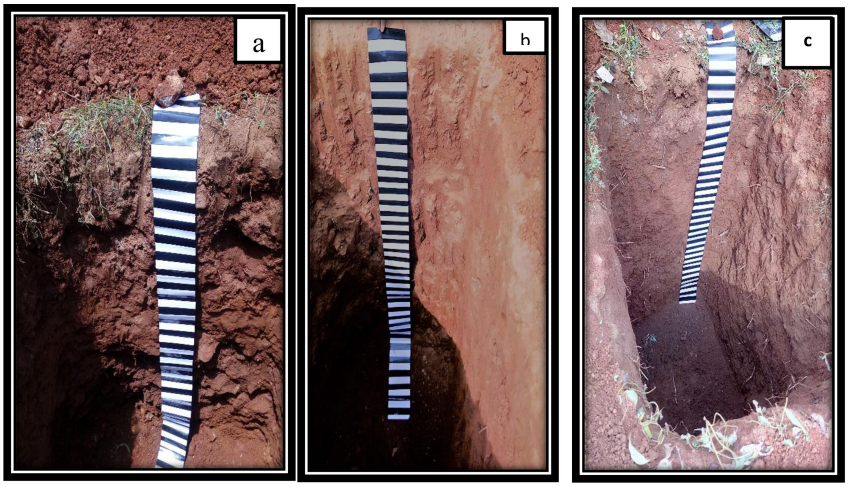
INTRODUCTION

The different hydro-geomorphological units of the Nayagarh district have structural hills, residual hills, denudational hills, lateritic uplands, intermontane valleys, surface water bodies, valley fills, shallow buried pediments, moderate buried pediments, deep buried pediment, alluvial plain and lineaments.

Toposequence is a sequence of related soils, which differ from one another primarily in respect of topography as a soil-forming factor Brady (1995), Sehgal (1997), Catena is a sequence of soils developed from similar parent material, under similar climatic conditions but under varying conditions of relief which also causes difference in drainage where soils of different series have been located. The soils related to a catena are seen to have properties, which could be related to their position on the landscape. It could be due to microclimate, water table, vegetation or erosion deposition relationships, or their combination. Relationships of soil properties with topographic positions do exist which can clearly be observed in many situations Buol *et al*. (1973). Toposequence of the soils is formed on different land form elements in a region of fairly constant parent material, where the different elements are all of same age Milne (1935).



Soil profile in hill slope Soil profile in upland Soil profile in medium land

Soil profile in low land Soil profile in stream terrace land

Photo plate(1a, b, c, d , e). Representing soil profiles of the study area in hill slope land, up land, medium land, low land and steam terrace land respectively.

MATERIALS AND METHODS

Nayagarh is located at 20.13°N 85.1°E with the average elevation of 178 meters (583 feet). 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). Five soil profiles (pedons) representing different physiographic position as found in the district were exposed based on land type located at hill slope (N 20^0 12.207',E 85^0 06.459') has 398 feet above MSL and slope of 5-7%; upland (N 20^0 12.267', E 85^0 06.542') has 332 feet above MSL and slope of 3-5%, medium land (N 20^0 12.348'', E 85^0 06.669') has 360 feet above MSL and slope of 1-3%; low land (N 20^0 12.330', E 85^0 06.644') has 346 feet above MSL and slope of 0-1% and stream terrace land (N 20^0 12.238', E 85^0 06.614' has 348 feet above MSL and slope of 1-3%), of the study area (Photo plates 1a,b,c,d,e). The detailed morphological characteristics of these soil profiles were studied in the field as per the guidelines (All India Soil and Land Use Survey Organization 1970, Soil Survey Staff 2014). The soil samples collected from the profiles horizon wise and from soil surface were air dried and passed through 2mm sieve. The samples were then preserved in plastic bottles, labelled and stored for laboratory studies. The colors of soil samples were determined in the field by matching the color with Munsell Soil Color Chart. The OC of soils was determined by modified Walkley and Black's rapid titration method (Jackson 1973) using Ferroin indicator (Chopra and Kanwar 1986). The cation exchange capacity (CEC) of soil was determined by centrifuge method by leaching with neutral normal ammonium acetate, as outlined Page *et al.* (1982).

RESULTS AND DISCUSSION

Soil genesis

Parent material as such exerts significant influence on soil characteristics during the initial stages of solum development (Buol *et al.* 1973). Khondalite parent rock was found in the study area. It was found that hill slope, upland and steam terrace land soils here formation of immature soil profiles but, in case of both medium and low land soils formation of mature soil profiles were observed due to complete weathering process. Similar type of results was also observed by Moharana (1995), Mishra (2005).

Soils of the hill slope, upland and medium land are affected by the geogenic process of surficial erosion by water as evident from removal of greater part of a horizon. That the effect of such erosion in soils of Panipoila, Balugaon and Sirkharpur series located in hill slope, upland and medium land is evident from thickness of their sola. The cumulization is the predominant geogenic process taking part in formation of soils of Jogiyapalli series (pedon 4) in the lowland, which is evident from accumulation of materials eroded from the soil upslope. The accumulated colluvial materials show clear stratification with abrupt horizon boundary and also from contents of clay and organic carbon along depth. The stratification could also be partly due to human activity in the filling of depression during land preparation. Thus, it is clear from the action of the two geogenic processes that topography serves to alter the influence of the factor parent material and time by the erosional and depositional changes that occur in the lowlands.

Colors of moist soil in different horizons and sub horizons in the matrix of representative pedons are presented in their morphological description. The solum soil colors of different sub horizons along depth in pedon 1, is dark reddish brown, in pedon 3, reddish brown, in pedon 4 yellowish brown and brownish yellow, in pedon 5 it is brown. Thus, brown is the predominant color of soils of Panipoila, Sirkharpur, Jogiyapalli and Gobindapur series located in the hill slope, medium land, low land and stream terrace land of the study area, which could be attributed to the release of iron from primary mineral and dispersion of the particles of iron oxide in increasing amounts and their progressive hydration giving such colors to the soil mass.

Soils of the lowland chiefly comprises of colluvial materials received through slope wash and also deposition of materials by human factor in developing the land for cultivation. Such depositions, through erosion and runoff from the soils upslope and those

Table 1. Weighted average of clay in the control section and within the depth of 100 cm from the soil surface in the representative pedons.

Land type	Soil series	Representative Pedon No.	Control section (cm)	Weighted average of clay in the control section (%)	Particle size class of soil family	Percentage of weighted average of clay (0-100.
Hill slope	Panipoila	1	25-100	10.83	Coarse-loamy	12.62
Upland	Balugaon	2	25-100	12.97	Coarse-loamy	13.58
Medium land	Sikharpur	3	18-68	11.87	Coarse-loamy	12.444
Low land	Jogiyapalli	4	9-59	18.11	Fine –loamy	19.01
Stream terrace land	Gobindapur	5	25-100	18.35	Fine –loamy	18.46

through biotic factor have been made from time to time over the residuum of biotite-gneiss. As has been discussed in course of dealing on the process of leaching, the leached materials from the soils of Panipoila, Balugaon and Sirkharpur series, in the process of enrichment, are regularly added to the body of soils of Jogiyapalli series located in the lowland.

Mineralogy classes

The soils of pedon 1, 2 and 5 have little or no evidence of development of pedogenic horizons except ochric epipedon, therefore this soil are classified under the order *Entisols.* These soils have A-C profile with no distinct horizonation. The soils 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, 2 and 5 are classified under order of *Entisols.*

Pedon 3 and 4, have an orhric epipedon; have an argillic horizon; did not have cracks during any period of the year that are of 1 cm or more wide at a depth of 50 cm from soil surface; hence, classified under soil order of *Alfisols.*

According to the criteria of Soil Survey Staff (1978), control section of particle-size class comprises of the upper 50 cm of the above argillic horizon. Thus, the control sections of the particle-size classes in pedons 3 and 4 are from the depth of 18 to 68 and 9 to 59 cm respectively. The order of *Entisols* the particle-size control section is from a depth of 25 cm to a depth of 100 cm. Thus for pedon 1,2 and 5 representing soils of Panipoila, Balugaon and Gobindapur series located in the hill slope, upland and stream terrace land, the control section comprises of a thickness of 75 cm extending from the depth of 25 to 100 cm (Table 1).

In pedon 1, 2 and 3 within control section of 25 to 100, 25 to 100 and 18 to 68 cm representing the soils of Panipoila, Balugaon and Sikharpur serieses

Table 2. CEC of clay in the control section of the order of *Alfisols* (pedon 3 and 4).

Pedon No.	Depth (cm)	Horizon	CEC of soil (cmol (p+) kg^{-1})	Organic carbon (%)	CEC due to organic carbon (cmol(p+) kg^{-1})	Clay %	CEC due to claying 100 g of soil (cmol(p+) kg^{-1})	CEC of 100 lg clay cmol (p+) kg^{-1})	Weighted average of CEC (cmol (p+) kg^{-1})
3	B_1t	18-60	7.8	0.46	1.98	11.1	5.82	52.41	57.64
	$B_{21}t$	60-104	8.1	0.32	1.38	15.9	6.72	42.27	
	$B_{22}t$	104-137	8.2	0.2	0.86	19.1	7.34	38.42	
4	B_1t	9-20	14.25	0.62	2.67	14.8	11.58	78.23	76.06
	$B_{21}t$	20-51	15.66	0.42	1.81	18.2	13.85	76.10	
	$B_{22}t$	51-100	16.26	0.12	0.52	22.3	15.74	70.60	
	$B_{23}t$	100-124	19	0.1	0.43	26.8	18.57	69.29	

Table 3. CEC of clay in the control section of the order of *Entisols* (pedon 1, 2 and 5).

Pedon No.	Depth (cm)	Horizon	CEC of soil (cmol (p+) kg^{-1})	Organic carbon (%)	CEC due to organic carbon (cmol (p+) kg^{-1})	Clay %	CEC due to clay in 100 g of soil (cmol (p+) kg^{-1})	CEC of 100-g clay (cmol (p+) kg^{-1})	Weighted average of CEC (cmol (p+) kg^{-1})
1		C_1	25-58	10.25	0.34	1.47	13.4	8.78	65.56	61.59
		C_2	58-100	8.66	0.41	1.77	10.4	6.89	66.28	
2		C_1	25-54	5.76	0.2	0.86	14.2	4.90	34.49	35.83
		C_2	54-100	5.25	0.18	0.78	12.2	4.47	36.67	
5		A13	25-54	15.56	0.31	1.34	18.8	14.22	75.66	
		II C_1	54-75	11.25	0.33	1.42	14.8	9.83	66.40	
		III C_2	75-100	16.65	0.21	0.91	20.8	15.74	75.70	73.08

have weighted average of clay in the control section is 10.83, 12.97 and 11.87 % respectively (Table 1) According to Soil Survey Staff (1978), within control section which have particle size less than 18% clay marked under coarse –loamy, therefore the soils of Panipoila, Balugaon and Sikharpur series are marked under particle size class of coarse-loamy. In pedon 4 and 5 within control section of 9 to 59 and 25 to 100 cm representing the soils of Jogiyapalli and Gobindapur serieses have weighted average of clay in the control section is 18.11 and 18.35 % respectively (Table 1). According to Soil Survey Staff (1978) within control section which have particle size 18 to 35% clay marked under fine –loamy.

As per Soil Survey Staff (1978), mineralogy family classes of the soils of the study area have been inferred from the normal physical and chemical characteristics including cation exchange capacity. CEC of clay was calculated after deducting CEC due to organic carbon at the rate of 2.5 c mol (p+) kg^{-1} (Miller *et al.* 1958, Black *et al.* 1965, Housenbuiller 1963 , Mishra 1981).

Cation exchange capacities of kaolinite, illite/chlorite, montmorillonite and vermiculite are in the range of 3-15, 10-40, 80-150 and 100-150 c mol (p+) kg^{-1} respectively (Grim 1953). The CEC of clay in the control section (9-59 cm) of pedon 4 is 76.06 c mol (p+) kg^{-1}(Table 2). It is much beyond the range of even illite and much below the range of vermiculite. It is rather close to the lower range of montmorillonite. The criterion for the mineralogy montmorillonitic requires the soil to contain a mixture that has more montmorillonite than any other mineral. This is applicable to the soils of Jogiyapalli series

Table 4. Morphological characteristics of the soil.

Pedon-1: Latitude- N $20^0$12.377', Longitude- E $85^0$06.749'', Elevation above Mean Sea Level- 398 feet.

Horizon	Depth (cm)	Description
A1	0-12	Yellowish red (5YR 5/6); light reddish brown (5YR 6/4) dry; sandy loam; moderate, medium, sub angular blocky; dry slightly hard, moist friable, wet slightly sticky and plastic; many, very fine to fine, discontinuous, random, imped, simple tubular pores; frequent angular cobbles and pebbles; many, very fine to fine roots; gradual wavy boundary.
C_1	12-58	Dark Reddish brown (2.5YR 3/4);); loamy sand; moderate, medium, sub angular blocky; dry slightly hard, moist friable, wet slightly sticky and slightly plastic; common, very fine to fine, discontinuous, random, imped, simple tubular pores; frequent angular cobbles and pebbles; common, very fine to fine roots; gradual wavy boundary.
C_2	58-118	Dark Reddish brown (2.5YR 3/4);); loamy sand; strong, coarse to medium, angular blocky; dry hard, moist firm, wet slightly sticky and slightly plastic; few, fine to medium, discontinuous, random, imped, simple tubular pores; very frequent angular cobbles and pebbles; few, medium to coarse roots; gradual wavy boundary.
C_3	118-140	Partially weathered compact mass of basic granulite and laterite

Pedon-2: Latitude- N 200 12.267', Longitude- E 850 06.542', Elevation above Mean Sea Level- 384 feet.

Horizon	Depth (cm)	Description
A_P	0-15	Red (2.5 YR 4/6); Light red (2.5YR 6/6) dry; sandy loam; moderate, medium, sub angular blocky; dry soft, moist friable, wet slightly sticky and slightly plastic; many, very fine to fine, discontinuous, random, imped, simple tubular pores; few angular gravels; many, very fine to fine roots; gradual wavy boundary.
C_1	15-54	Red (2.5YR 5/6); sandy loam; moderate, medium, sub angular blocky; dry slightly hard, moist friable, wet slightly sticky and slightly plastic; many, very fine to fine, discontinuous, random, imped, simple tubular pores; few angular gravels; many, very fine to fine roots; gradual wavy boundary
C_2	54-105	Red (2.5YR 5/6); sandy loam; moderate, medium, sub angular blocky; dry hard, moist friable, wet slightly sticky and slightly plastic; common, very fine to fine, discontinuous, random, imped, simple tubular pores; few angular cobble and pebble; common, very fine to fine roots; gradual wavy boundary
C_3	105-152	Partially weathered compact mass of basic granulite and laterite

Pedon-3: Latitude- N 20^0 12.348', Longitude- E 85^0 06.669', Elevation above Mean Sea Level- 360 feet.

Horizon	Depth (cm)	Description
A_P	0-18	Red (2.5YR 4/6); light reddish brown (2.5 YR 6/4) dry; loamy sand; moderate, medium, angular blocky; dry soft, moist friable, wet non sticky and non-plastic; many, very fine to fine, discontinuous, random, imped, simple tubular pores; few, fine, ferruginous concretions; few angular gravels; many, very fine to fine roots; gradual wavy boundary.
B_1t	18-60	Red (2.5YR 4/6); loamy sand; moderate, medium, angular blocky; dry slightly hard, moist friable, wet slightly sticky and slightly plastic; patchy thin clay skins on vertical and horizontal ped faces and in pores; many, very fine to fine, discontinuous, random, imped, simple tubular pores; few angular gravels; many, very fine to fine roots; gradual wavy boundary.
$B_{21}t$	60-104	Reddish brown (2.5YR 4/4); sandy loam; moderate, medium, sub angular blocky; dry slightly hard, moist friable, wet slightly sticky and plastic; patchy thin clay skins on vertical and horizontal ped faces and in pores; many, very fine to fine, discontinuous, random, imped, simple tubular pores; few, medium, hard, ferruginous concretions; few angular gravels; many, very fine to fine roots; gradual wavy boundary.
$B_{22}t$	104-137	Reddish brown (2.5YR 4/4); sandy loam; moderate to strong, medium to coarse, sub angular blocky; dry hard, moist friable, wet sticky and plastic; patchy thin clay skins on vertical and horizontal ped faces and in pores; many, very fine to fine, discontinuous, random, imped, simple tubular pores; plentiful, medium, hard ferruginous concretions; few angular cobbles and pebbles; common, fine to medium roots; gradual wavy boundary.
IIC	137-150	Reddish brown (2.5YR 4/4); loamy sand; moderate to strong, medium to coarse, sub angular blocky; dry hard, moist firm, wet slightly sticky and slightly plastic; many, very fine to fine, discontinuous, random, imped, simple tubular pores; few, fine to medium, ferruginous concretions; few angular cobbles and pebbles; common, fine to medium roots; gradual wavy boundary.
IIIC	>150	Reddish brown (2.5YR 4/4); loamy sand; moderate to strong, medium to coarse, sub angular blocky; dry very hard, moist firm, wet slightly sticky and slightly plastic; many, very fine to fine, discontinuous, random, imped, simple tubular pores; plentiful, fine to medium, ferruginous concretions; strong weathered parent material of quartz and feldspars.

Pedon-4: Latitude- N 20^0 12.330', Longitude- E 85^0 06.644', Elevation above Mean Sea Level- 346 feet.

Horizon (cm)	Depth Description	
AP	0-9	Yellowish brown (10 YR 5/8); brownish yellow (10YR 6/6) dry; loamy sand; week, fine, sub angular blocky; dry hard, moist friable, wet slightly sticky and slightly plastic; many, very fine to fine, discontinuous, random, imped, simple tubular pores; few angular gravels; many, very fine to fine roots; abrupt wavy boundary.
B_1t	9-20	Yellowish brown (10 YR 5/6); sandy clay loam; moderate, medium, angular blocky; dry hard, moist friable, wet slightly sticky and plastic; many, fine, prominent, strong brown (7.5 YR 5/6) mottles; patchy thin clay skins on vertical and horizontal ped faces and in pores; many, very fine to fine, discontinuous, random, imped, simple tubular pores; few, fine to medium, ferruginous concretions; few angular cobbles and pebbles; many, very fine to fine roots; abrupt wavy boundary.

$B_{21}t$	20-51	Brownish yellow (10 YR 6/6); Sandy loam; moderate, medium, angular blocky; dry hard, moist friable, wet very sticky and very plastic; common, medium, prominent, strong brown (7.5 YR 5/6) mottles; patchy thin clay skins on vertical and horizontal ped faces and in pores; common, very fine to fine, discontinuous, random, imped, simple tubular pores; plentiful, medium, hard ferruginous concretions; few angular cobbles and pebbles; common, very fine to fine roots; abrupt wavy boundary.
$B_{22}t$	51-100	Brownish yellow (10 YR 6/6); sandy clay loam; strong, coarse, angular blocky; dry very hard, moist firm, wet very sticky and very plastic; common, medium, prominent, strong brown (7.5 YR 5/6) mottles; patchy thin clay skins on vertical and horizontal ped faces and in pores; few, very fine to fine, discontinuous, random, imped, simple tubular pores; frequent angular cobbles and pebbles; common, very fine to fine roots; abrupt wavy boundary.
$B_{23}t$	100-124	Brownish yellow (10 YR 6/6); sandy clay loam; strong, coarse, sub angular blocky; dry very hard, moist firm, wet very sticky and very plastic; few, fine, prominent, strong brown (7.5 YR 5/6) mottles; patchy thin clay skins on vertical and horizontal ped faces and in pores; few, very fine to fine, discontinuous, random, imped, simple tubular pores; plentiful, medium to coarse, ferruginous concretions; frequent angular cobbles and peb bles; common, fine to medium roots; abrupt wavy boundary.
IIC	124-151	Brownish yellow (10 YR 6/8); sandy clay loam; strong, coarse to very coarse angular blocky; dry very hard, moist firm, wet very sticky and plastic; few, fine, distinct, strong brown (7.5 YR 5/6) mottles; few, very fine to fine, discontinuous, random, imped, irregular pores; plentiful, medium to coarse, ferruginous concretions; very frequent angular cobbles and pebbles; common, fine to medium roots; abrupt wavy boundary.
IIIC	151-180	Brownish yellow (10 YR 6/8); sandy clay loam; strong, coarse to very coarse angular blocky; dry very hard, moist firm, wet slightly sticky and plastic; few, fine, distinct, strong brown (7.5 YR 5/6) mottles; few, very fine to fine, discontinuous, random, imped, irregular pores; very frequent angular cobbles and pebbles; common, fine to medium roots; plentiful, fine to medium, ferruginous concretions; strong weathered parent material chiefly consisting of quartz and feldspars.

Pedon-5: Latitude- N $20^0$12.238', Longitude- E $85^0$06.614',Elevation above Mean Sea Level- 348 feet.

Horizon	Depth (cm)	Description
A_1	0-10	Brown (7.5YR 4/4); brown (7.5 YR 5/4) dry; sandy loam; week, fine, sub angular blocky; dry hard, moist friable, wet sticky and plastic; many, fine, faint, yellowish brown (10YR 5/6) mottles; many, very fine to fine, discontinuous, random, imped, simple tubular pores; few angular cobbles and pebbles; many, very fine to fine roots; clear wavy boundary.
A_{12}	10-25	Brown (7.5YR 4/2); sandy loam; moderate, medium, sub angular blocky; dry hard, moist friable, wet slightly sticky and plastic; many, fine, faint, dark greyish brown (10YR 4/2) mottles; many, fine to medium, discontinuous, random, imped, simple tubular pores; frequent angular cobbles and pebbles; common, very fine to fine roots; abrupt wavy boundary.
A_{13}	25-54	Brown (7.5YR 4/2); loamy sand; moderate, medium, sub angular blocky; dry hard, moist friable, wet slightly sticky and plastic; many, fine, faint, brown to dark brown (7.5YR 4/4) mottles; few, fine to medium, discontinuous, random, imped, simple tubular pores; frequent random cobbles and pebbles; common, very fine to fine roots; abrupt wavy boundary.
IIC_1	54-75	Brown (7.5YR 5/3); loamy sand; moderate to strong, medium to coarse, sub angular blocky; dry very hard, moist firm, wet slightly sticky and slightly plastic; many, medium, faint, brown to dark brown (7.5YR 4/4) mottles; many, very fine to fine, discontinuous, random, imped, simple irregular pores; frequent angular cobbles and pebbles; few very fine to fine roots; abrupt wavy boundary.
$IIIC_2$	75-110	Brown (7.5YR 5/3); loamy sand; massive breaking to week, fine, sub angular blocky; dry hard, moist firm, wet sticky and plastic; many, fine, faint, brown to dark brown (7.5YR 4/4) mottles; many, very fine to fine, discontinuous, random, imped, simple tubular pores; frequent angular cobbles and pebbles; few, fine to medium roots; abrupt wavy boundary.
IVC_3	110-140	Brown (7.5YR 5/3); loamy sand; massive breaking to week, fine, sub angular blocky; dry hard, moist firm, wet slightly sticky and slightly plastic; few, fine, faint, brown to dark brown (7.5YR 4/4) mottles; many, very fine to fine, discontinuous, random, imped, simple irregular pores; very frequent angular cobbles and pebbles; few, fine to medium roots.

represented by pedon 4. Therefore, the soils of this series which marked under the mineralogy class of montmorillonitic. Similarly in pedon 5 representing soils of Gobindapur series CEC of clay in the control section (25-100cm) is 73.08 c mol (p+) kg^{-1}(Table 3) and therefore placed under the mineralogy class of

montmorillonitic. The pedon 1 and 2, have the CEC of clay in control section ranges from 65.56 to 66.28 and 34.49 to 36.67 with the weighted average of 61.59 and 35.83 c mol (p+) kg^{-1} (Table 3). These soils have coarse-loamy particle-size class and mineralogy classes including micaceous and silicious are not applicable, due to their low content, as per the criteria of Soil Survey Staff (1978), soils of Panipoila and Balugaon series represented by pedons 1 and 2 are marked under the mixed mineralogy class. Similarly in pedon 3, representing soils of Sikharpur series marked under the particle-size class coarse-loamy, CEC of clay in the control section (18-68 cm) is 57.64 c mol (p+) kg^{-1} (Table 2) and therefore placed under the mineralogy class of mixed mineralogy.

Morphological characteristics

The surface soil color of pedon 1 (hill slope) was found to be yellowish red (5YR 5/6); in pedon 2 (up land) was red (2.5 YR 4/6); while of pedon 3 (medium land) was also red (2.5YR 4/6); in pedon 4 (low land) it was found to be yellowish brown (10 YR 5/8) and in pedon 5 (stream terrace land), it was found to be brown (7.5 YR 4/4), which might be attributed to the effect of greater moisture regime and impeded drainage condition down the slope (Table 4). The texture became finer and heavier down the slope both in surface and sub soil. Absence of mottling and concretion in the pedon 1, 2 and 3 might be due to well drained condition, because of skeletal nature of the soil never gets saturated to bring about alternate oxidation and reduction condition required for the same.

CONCLUSION

The soils were found to be perfectly developed in a toposequence or Catena. The hill slope and upland soils could not develop the B horizon because washing down of the surface soils from upper ridges of the slope (hill slope) to lower topography. Similarly the stream terrace land soils which were form mostly because of the deposition from the stream and also could not develop the B horizon. Therefore, these three pedons were classified under the order *Entisols.* On the other hand, both medium and low land because there have stable topographic position, leaching of finer particles from the upper horizon to lower horizons resulting in the formation of matured B horizon. Therefore they were classified under the order *Alfisols* having argillic horizon. The mineralogical composition of the study area to be dominated by quartz and feldspare.

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