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Properties, genesis and classification of soils developed on diversified parent materials in selected area of Budhihal micro-watershed (4D7A312F) in Yadgir district, Karnataka, India

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Abstract
Conspicuous differences in both particle size classes, morphological and chemical properties of soils was attributed to the underlying diversified geological materials which were the parent materials of the soils as it was confirmed by the total elemental analysis of soils, molar ratio and CEC/Clay ratio. Intermediately siliceous grey shale and pink shale derived pedon-2 and 3 registered moderately deeper solum depth, finer texture and well developed soil structure as compared to the high siliceous sandstone derived pedon-7. The soil reaction, CEC, total exchangeable basic cations as well as percent base saturation were comparatively low in highly siliceous sandstone derived pedon-7 than in the soils derived from intermediately siliceous grey shale and pink shale. Soil depth of calcareous limestone derived pedon-4 was shallow, while soil texture and structure and CEC were in between shale and sand stone derived pedons. Pedon-4 was calcareous unlike other pedons. Positive correlation of SiO_2 with sand (0.015), coarse fragments (0.045) and negative correlation with clay (-0.134) suggested the influence of parent materials on soil properties. Soils under study were keyed out at subgroup level as Vertic Haplustepts (Pedon-2), Typic Haplustepts (Pedon-3), Lithic Usthorthent (Pedon-4) and Lithic Haplustalf (Pedon-7).

Keywords: Highly siliceous parent material, intermediately siliceous parent material, calcareous parent material, soil properties, genesis, taxonomy

1. Introduction
Soil diversity, complexity and heterogeneity is more common than uniqueness, simplicity and homogeneity respectively and thus existence of diversified soils developed on diversified lithology at a shorter interval is also not uncommon. Genetic blood of the parent materials is very much depicted in the properties of soils overlying them if these soils are derived from the underlying geological parent materials and the formation such soils is the function of variation in the parent materials while rest of the soil forming factors remain constant and thus more often the soil properties namely depth, texture, structure, shrink and swell potential, clay mineralogy, CEC, nutrient status, sodicity, salinity, acidity *etc*., are related to parent materials (Gray and Murphy, 2002) [4].
The influence of parent material on soil properties is very conspicuous at the initial stage of soil development as the parent material provides matter for soil formation and however its influence on soil properties becomes obscure and diminishes gradually with the advancement in the soil development as other soil forming factors interact with parent material in influencing soil formation as the pedogenic processes are dynamic in nature.
Studies on soils derived from diversified parent materials under the same climate and vegetation in addition to almost the same topography is meager in northern parts of the Karnataka and thus present investigation was taken up to know the influence of the parent materials on properties, genesis, as well as taxonomic category of the soils.

2. Materials and methods
Study area is a part of budhihal micro-watershed (4D7A312F) which is situated between $16^{0}23^{'}9.52$” N and $16^{0}21^{'}46.286$” N latitude and $76^{0}23^{'}46.086$” E and $76^{0}24^{'}18.432$” E longitude in Yadgir district of Karnataka.

As per the geological map of scale 1:50000, budhihal micro watershed is characterized by the predominant geological materials limestone, shale and granite and however diversified geological materials namely low siliceous mafic basalt, intermediately siliceous schist, grey shale and pink shale in addition to highly siliceous felsic granite and sandstones were observed in a small patch (Fig. 1) when the said micro water shed area was traversed. The small patch of area characterized by diversified geology in budhihal micro watershed was selected for the present study and is situated in between 16^{0}21'49.898 N and 16^{0}23'07.242 N latitude and 76^{0}24'04.876 E and 76^{0}23'55.015 E longitude and is characterized by semi arid climate. Seven soil profile sampling sites, one from each geology were selected and geomorphological features of the same were recorded (Anonymous, 1951) [1]. Geographical locations of the representative soil profiles one from each geology and elevations above mean sea level were recorded using GPS. Only four representative soil profiles one from each geology greyshale, pink shale, limestone and sandstone are presented here. Based on morphological features, soil horizons were demarcated and examined for morphological features (Table 1) and the terminologies used to describe the pedons were as per Anonymous (1951) [1]. Horizon-wise collected soil samples were processed and analyzed for particle size analysis by International pipette method (Piper, 1966) [9], soil reaction by potentiometric method, organic carbon content by Walkely and Black's Wet Oxidation method (Jackson, 1967) [7], free calcium carbonate content by rapid titration method (Piper, 1966) [9]. Exchangeable cations of soil samples were extracted by 1 N ammonium acetate (Thomas, 1982) [16] and exchangeable sodium and potassium were determined flame photometrically and exchangeable calcium and magnesium were determined by standard EDTA titration (Jackson, 1967) [7]. Cation exchange capacity of soils was determined, using 1 *N* sodium acetate (pH 8.2) as described by Richards (1954) [11]. Total elements of fine earth were extracted by HF-$HClO_4$ decomposition (Jackson, 1967) [7]. Total sodium and potassium contents in the extract was estimated flame photometrically, Ca and Mg contents were estimated by versanate titration method (Jackson, 1967) [7] and total silicon, aluminum, iron concentrations were measured by atomic absorption spectrophotometer using appropriate hallow cathode lamps and these elements were expressed as their respective oxides to predict the dominant primary mineralogical composition of soils for the confirmation of the parent materials of the soils.

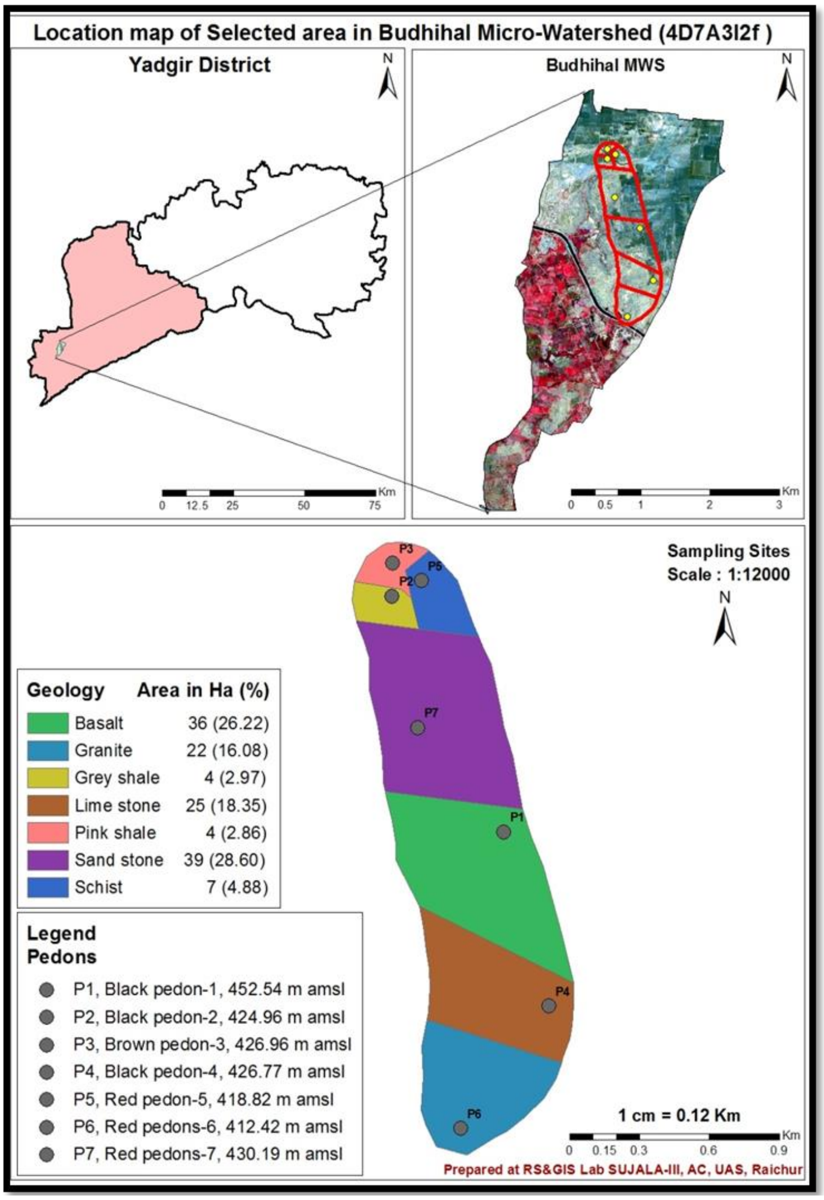

Fig 1: Diversified geology and profile sampling spots in a selected area of Budihal MWS (4D7A312F**)**

3. Results and discussion

3.1 Morphological features

3.1.1 Solum depth

Pedon-2 having more yellower hue (10YR) were deeper as compared to the brown (Pedon-3) and red (Pedon-7) pedons having less yellower hue (5YR) and this could be attributed to the more of chemical weathering than physical weathering in the former than in the later pedons (Krishnamoorthy and Govinda Rajan, 1977) [8] and shale derived pedons-2 and 3 were moderately deep and that of sandstone (Pedon-7) and lime stone (Pedon-4) were shallow. Comparatively, solum thickness was less in pedon-4 and this could be attributed to the soil depth determining factors, rate of weatherability of parent material as well as the rate of soil erodability (Gray and Murphy, 2002) [4]. Comparatively higher sand to silt ratio (Table 1) as well as moderate erosion with higher slope was the evident for the lowest solum thickness of pedon-4 derived from lime stone. The pedon-7 derived from highly siliceous sandstone was shallower than the pedons-2 and 3 derived from moderately siliceous grey shale and pink shale respectively and this could be attributed to higher sand to silt ratio in the former pedon than in the later pedons.

3.1.2 Pedogenic horizons

Surface horizons were thick (15 cm) in all the pedons as these soils were under plough and comparatively degree of profile development was maximum in pedon-7 derived from sand stone, moderate in the pedons-2 and 3 derived from shale and minimum in pedon-4 derived from lime stone and this could be attributed to the more well drained condition which facilitated downward movement of soil constituents in the pedon-7 than in the pedon-3 and 2 and 4. Comparatively very weak soil horizonation in pedon-4 could also be attributed to the more of soil erodability than weatherability of parent material as indicated by higher sand/silt ratio (Table 1). Comparatively moderate drainage and moderate soil erodability in both the pedons-2 and 3 derived from shale could be attributed to moderate development of horizons. These findings are in aggrement with the findings of Bhattacharjee *et al.* (1974) [3]. Pedogenic horizons such as argillic in the pedon-7 could be attributed to the downward movement of clay and the cambic horizons in the pedons-2 and 3 could be attributed to altered soil structure and or soil colour.

3.1.3 Soil color

Black soil color and more of yellower hue (10YR) in the pedons-2 and 4 derived from grey shale and lime stone respectively as compared to red soil color and less of yellower hue (5YR) in the pedon-7 (Table 1) derived from sandstone could be attributed to the more of free calcium carbonate, clay-humus complex with lime and less of iron oxides in the former group of pedons and reverse was true in the later pedon whereas the brown soil color and moderate yellower hue (7.5 YR) in pedon-3 could be attributed to moderate content of free calcium carbonate, clay-humus complex with lime and comparatively higher amount of iron oxides as it was derived from pink shale and the pink color of the parent material was due the iron oxide content (Singh, 1956: Rudramurthy and Dasog, 2001) [12]. It was further supported by the Pearson correlation where SiO_2 was positively and significantly correlated (0.848**) with sesquioxides (Table 3). Moist soil color chroma, the index of drainage was the lowest (Table 1) in the soils derived from greyshale (Pedon-2) and lime stone (Pedon-4) and this could be attributed to the poor internal drainage due to higher amount of clay as well as type of clay as the pedon-2 was derived from clay forming parent material grey shale as well as the presence of appreciable amount of high active clay as indicated by CEC/Clay ratio (Table 2). Poor internal drainage in the pedon-4 could be attributed to high calcium carbonate content as well as moderate CEC/Clay ratio. The highest chroma in the pedon-7 could be attributed to the well-drained condition as these pedons were derived from the high siliceous low clay forming parent materials sand stone. Pedon-3 recorded moderate moist chroma (Table 1) which suggested that moderately well drained condition of the soil in addition to higher iron oxides content (Table 3) that too hydrated iron oxides of pedon-3 imparted brown colour to it and even Pearson correlation indicated that SiO_2 was significantly correlated with sesquioxides (0.848**), CEC (-0.298*) and CEC/Clay (-0.538**). Similar kind of observations was reported by Harrison and Ramaswamy Sivan (1912) [5]; Basu and Sirur (1938) [2] and Raychaudhuri (1941) [10].

3.1.3 Soil structure

Irrespective of the parent materials, stronger soil structure grade in sub surface than in surface horizons of the pedons-2 and 3 could be attributed to the illuviation of clay with or without iron oxides in subsurface horizons and eluviation of the same in surface horizons and these findings are in agreement with Sitanggang *et al*. (2006) [15]. Moderate soil structure grade throughout the solum in lime stone derived pedon-4 could be attributed to the quality of clay. The moderate CEC/clay ratio in lime stone derived pedon-4 suggested the presence appreciable amount of smectite group of clay in it. The soil structure grade was weaker throughout the solum of pedon-7 and this could be attributed to low clay forming felsic sand stone as well as presence of low active clays illite and or kaolinite as indicated by the CEC/Clay ratio (Table 2) and it was supported by the significant negative correlation (-0.538**) between SiO_2 and CEC/Clay ratio the index of clay quality.

3.2 Particle size class of whole soil and fine earth

Dominant finer (clay) texture in the pedons-2 and 3 could be attributed to their parent material the clay rich mud stone shale of both the pedons-2 and 3. However clay texture of pedon-3 was prefixed by extremely gravelly as the gravels content was more because of more of physical weathering than chemical weathering as compared to the pedon-2.

Comparatively coarser soil texture sandy loam (Table 1) in the pedon-7 could be attributed to its parent material high siliceous sand stone as it was low clay forming and rich in quartz, the more resistant mineral for weathering and it was further supported by the highest SiO_2 content in fine earth fraction of the soil (Table 3). Though the pedon-4 derived from basic rock limestone confirmed from the highest CaO content (Table 3) in fine earth fraction registered coarser soil texture sandy clay loam and this could be attributed to more soil erodability and it was confirmed by the higher sand/silt ratio (Table 1) and these findings are in agreement with Gray and Murphy (2002) [4]. The correlation coefficient values of SiO_2 with sand (0.015), silt (0.199) and clay (-0.134) suggested that the pedon-7 derived from sandstone were coarser than the rest pedons -2 and 3derived from intermediately siliceous parent material shale.

3.3 Soil reaction (pH)

Alkaline nature of all the pedons could be attributed to both the mineralogical composition of the parent materials as indicated by elemental composition of fine earth (Table 3) as well as internal drainage of the soils. Both the shale and limestone the parent materials of the pedons-2, 3 and 4 respectively were composed of calcium supplying calcite mineral and highly siliceous felsic sandstone the parent material of the pedon-7 was composed of both quartz and feldspars which were the poor suppliers of bases and thus these basic cations could be attributed for the alkalinity of all the pedons and it was further confirmed by strong significant correlation between pH and oxides of total elements which were the indices of the dominant primary minerals of the parent materials. Correlation coefficient of soil reaction with SiO_2, Na_2O, K_2O, CaO and MgO were -0.350*, -0.279, -0.408**, 0.095 and 0.509** respectively.

Alkalinity of soils due to the nature of the parent materials was also supported by strong significant positive correlation between pH and exchangeable bases namely calcium (0.442**), magnesium (0.535**) and sodium (0.775**). Poor internal drainage in the soils derived from very low and intermediately siliceous parent materials lime stone and shale favored the accumulation of bases in soils and thus soil reaction was more in them and reverses was also true with respect to the soils derived from highly siliceous parent material sand stone as it was well drained. Satyanarayana and Biswas (1970) [13] also attributed higher pH values in black pedon than in brown and red pedons to the poor internal drainage in former pedon and better leaching environment in the later pedons.

3.4 Soil organic carbon (OC)

Irrespective of the parent materials, decreasing trend of OC down the solum (Table 1) in all the pedons could be attributed to the fact that amount of biomass added to the sub soil was very less as the crop residues after the harvest of crop were uprooted and either removed from the field and used as fuel or burnt in the field. Comparatively higher OC content in the pedons-2 and 3 could be attributed to their parent material shale as it was rich in organic matter.

3.5 Cation exchange capacity (CEC) and base saturation

Increasing trend of cation exchange capacity of soils down the solum could be attributed to the increasing trend of clay down the solum. Pedon-7 derived from highly siliceous felsic sandstone recorded the lowest CEC, total exchangeable basic cations as well as percent base saturation as compared to that of rest of the pedons derived from very low (Limestone) and intermediately siliceous (Shale) parent materials of the pedon-4 and the pedon-2 and 3 respectively could be attributed to the mineralogical composition of the parent materials as the very low and intermediately siliceous parent materials were rich in bases supplying minerals while highly siliceous parent materials were poor in bases supplying minerals and it was very much evident from the total elemental analysis of fine earth (Table 3) fraction of the soils as well as significant negative correlation coefficient value (-0.298*) between SiO_2 and CEC which has confirmed the influence of parent materials on CEC of soils.

Irrespective of parent materials, the exchangeable site of soils, was dominated by calcium and was followed by magnesium, sodium and potassium. Among the soils studied very low (Pedon-4) and intermediately siliceous parent materials(Pedons-2 and 3) derived soils witnessed higher saturation of Ca and Mg (Table 2) while highly siliceous parent material(Pedon-7) derived soil registered higher sodium and potassium saturation and it was very much evident from the total elemental analysis of fine earth (Table 3) fraction of the soils as well as significant negative correlation coefficient value (-0.298*) between SiO_2 and CEC which has confirmed the influence of parent materials on CEC of soils. Similar kind of observation were reported by Hallsworth and warring (1964) [6].

3.6 Soil genesis

Both pedogenic factors and pedogenic process influenced the genesis of diversified soils under study. Pedons-2, 3, 4 and 7 were overlying the diversified geological materials greyshale, pinkshale, limestone and sandstone respectively. Higher amount of sharp edged coarse fragments in whole soil and higher amount of sand in fine earth of all the pedons confirmed that these soils have been developed insitu and were sedentary in nature.

Higher content of both clay and silt and lower content of sand in addition to higher organic matter content throughout the solum in both the pedons-2 and 3 unlike other pedons and appreciable amount of both CaO and Fe_2O_3 (Table 3) in both the pedons-2 and 3 confirmed that the underlying geological material shale was the parent material of both the pedons-2 and 3. Comparatively higher amount of iron oxides as well as lower yellower hue in pedon-3 than in pedon-2 as the pedon-2 was situated in lower elevation as compared to the pedon-3 suggested that the poor internal drainage in pedon-2 favored the accumulation of more of bases and comparatively well drained condition in pedon-3 favored leaching of bases and thus pedon-3 was less yellower than the pedon-2. Higher amount of CaO and lower amount of SiO_2 in fine earth (Table 3) of pedon-4 as compared to that of other pedons suggested that the very low siliceous and abundant calcium supplying calcite mineral rich underlying geological material lime stone was the parent material of pedon-4.

Higher amount of silicon, iron, sodium and potassium oxides and lower amount of Ca and Mg oxides in fine earth of the pedon-7 indicated that the dominant mineralogical composition of underlying geological materials were both quartz and feldspars. More of both coarse fragments and sand fraction, sodium and potassium saturation and Na_2O/CaO ratio and less of both Ca and Mg saturation in addition to low clay content in the pedon-7 as compared to that of rest of the pedons also confirmed that highly siliceous sandstone the geological materials underlying the pedon-7 was the parent material.

Low base saturation (Table 2), low molar ratio (Table 3), lower yellower hue (Table 1) and low CEC/Clay ratio (Table 2) in the pedon-7 derived from highly siliceous felsic sandstone as compared to that of rest of the pedons suggested leaching, decalcification, desilicification and kaolinization were the dominant pedogenic processes in the pedon-7.

Calcification was the dominant pedogenic process in very low siliceous limestone derived pedon-4 as this pedon witnessed calcic horizon, high base saturation, moderate CEC/clay ratio and more yellower hue.

Calcification and silicification were at moderate rate in the pedons-2 and 3 derived from intermediately siliceous shale as they witnessed moderate base saturation, molar ratio and CEC/Clay ratio. More yellower hue in pedon-2 as compared to the pedon-3 suggested that rate of both calcification and silicification was more in former pedon than in the later pedon and comparatively less yellower hue and higher chroma in the pedon-3 than in the pedon-2 suggested that the former pedon was tending towards brownification and or rubification as the pedon-3 were well drained as compared to pedon-2. Thus the genetic blood of the parent materials was observed in the soils derived insitu.

Table 1: Morphological, physical and chemical properties of soils

Depth (cm)	Horizon	Moist soil color	Soil structure	Soil consistency	Effervescence	Coarse fragments %	Sand %	Silt %	Clay %	Sand/ silt Ratio	Textural class	pH 1:2.5	OC (g kg^{-1})	Free $CaCO_3$ %
Pedon-2 (Grey shale)														
0-15	Ap	10YR3/2.5	2msbk	sh,fr,ss,sp	Strong	15.19	28.31	24.36	47.33	1.16	g1 c	8.30	12.00	13.45
15-28	B1	10YR3/2.5	2msbk	sh,fr,ss,sp	Strong	12.26	34.90	23.57	41.53	1.48	c	8.39	11.00	14.25
28-45	B2w	10YR3/2	3mabk	h,fi,ms,mp	Strong	11.08	34.28	23.55	42.17	1.46	c	8.45	9.50	13.70
45-65	B3w	10YR3/2	3mabk	h,fi,ms,mp	Strong	10.34	33.60	22.29	44.11	1.51	c	8.41	9.00	13.75
65-78	B4w	10YR4/2	2msbk	sh,fr,ms,mp	Strong	10.37	34.28	21.90	43.82	1.57	c	8.79	8.70	13.80
78-88	B5	10YR4/2	3msbk	sh,fr,ss,sp	Strong	7.29	33.87	22.25	43.88	1.52	c	8.89	8.50	13.85
88-110	BC	10YR4/2	3msbk	sh,fr,ss,sp	Strong	15.84	31.54	25.37	43.09	1.24	g1c	8.94	8.20	13.80
110+	C	10YR5/3	3msbk	sh,fr,ss,sp	Strong	54.11	39.00	20.04	40.96	1.95	g2 c	8.89	8.00	13.90
SWA						11.25	33.15	23.01	43.83	1.44	c	8.51	9.80	13.79
Pedon-3 (Pink shale)														
0-15	Ap	7.5YR3/3.5	1msbk	s,vfr,ss,sp	Strong	72.82	24.59	28.86	46.55	0.85	g3 c	8.21	9.50	10.10
15-25	B1	7.5YR4/3	1msbk	sh,vfr,ss,sp	Strong	71.43	22.01	28.16	49.83	0.78	g3 c	8.31	8.00	10.85
25-35	B2w	7.5YR4/3	2msbk	h,fr,ss,sp	Strong	70.53	19.21	28.43	52.36	0.68	g3 c	8.36	7.00	10.15
35-48	B3w	7.5YR6/3	2msbk	h,fr,ss,sp	Strong	69.72	18.23	27.76	54.01	0.66	g3 c	8.45	6.50	10.15
48-68	B4w	7.5YR7/3	2msbk	h,fr,ss,sp	Strong	68.14	18.95	26.48	54.57	0.72	g3 c	8.56	6.00	10.15
68-80	B5w	7.5YR4/5	2msbk	sh,fr,ss,sp	Strong	71.43	25.83	28.43	45.74	0.91	g3 c	8.58	5.50	10.15
80-98	B6	7.5YR7/3	2msbk	sh,fr,ss,sp	Strong	70.53	26.52	28.00	45.48	0.95	g3 c	8.71	5.50	10.15
98-110	C	7.5YR7/5	1msbk	sh,fr,ss,sp	Strong	74.75	31.00	26.72	42.28	1.16	g3 c	8.77	4.50	10.20
SWA						70.49	22.29	27.90	49.81	0.79	g3 c	8.48	6.75	10.21
Pedon-4 (Limestone)														
0-15	Ap	10YR4/2	2msbk	sh,fr,ss,sp	Strong	3.45	71.39	6.17	22.44	11.57	scl	8.38	2.00	19.50
15-25	A2	10YR4/2	2msbk	h,fi,ms,mp	Violent	1.74	69.75	6.15	24.10	11.34	scl	8.26	1.80	20.25
25-40	ACk	10YR4/3	2msbk	sh,fr,ss,sp	Violent	7.86	73.26	6.17	20.57	11.87	scl	8.42	4.60	25.53
40+	C	10YR5/3	2msbk	sh,fr,ss,sp	Violent	83.83	73.31	6.15	20.54	11.93	g3 scl	8.44	9.30	24.20
SWA						2.77	70.74	6.16	23.10	11.48	scl	8.33	1.92	19.80
Pedon-7 (Sandstone)														
0-15	Ap	5YR5/5	1msbk	s,vfr,ss,sp	No	7.99	71.95	14.02	14.03	5.13	sl	7.68	3.20	0.18
15-28	B1t	5YR4/5.5	1msbk	sh,fr,ss,sp	No	7.07	70.11	13.03	16.86	5.38	sl	7.75	3.10	0.14
28-35	B2	5YR4/5	1msbk	sh,fr,ss,sp	No	6.32	73.06	10.04	16.90	7.28	sl	7.78	2.80	0.13
35-48	BC	5YR4/5	1msbk	sh,fr,ss,sp	No	9.12	70.90	8.59	20.51	8.25	scl	7.78	2.40	0.25
48+	C	5YR4/5	1msbk	sh,fr,ss,sp	No	27.32	72.82	10.13	17.05	7.19	g2 sl	7.90	2.00	0.30
SWA						7.31	71.49	12.85	15.65	5.65	sl	7.72	3.08	0.16

Table 2: Cation exchange properties of soils

Depth (cm)	Horizon	Ca	Mg	K	Na	CEC	Base	Ca	Mg	K	Na	CEC/Clay ratio
			$cmol(p^+)kg^{-1}$				Saturation %					
Pedon-2 (Grey shale)												
0-15	Ap	19.35	2.00	0.44	1.68	29.34	80.00	65.96	6.82	1.50	5.73	0.62
15-28	B1	19.46	3.60	0.39	1.50	29.87	83.54	65.16	12.05	1.31	5.02	0.72
28-45	B2w	20.25	4.00	0.35	2.44	32.98	82.00	61.41	12.13	1.06	7.40	0.78
45-65	B3w	21.20	4.38	0.31	3.18	34.61	84.00	61.26	12.66	0.90	9.19	0.78
65-78	B4w	21.35	4.42	0.33	4.26	36.70	82.72	58.17	12.04	0.90	11.61	0.84
78-88	B5	21.94	4.46	0.35	4.40	37.69	82.65	58.22	11.83	0.93	11.67	0.86
88-110	BC	20.16	3.12	0.36	4.16	34.32	81.00	58.74	9.09	1.05	12.12	0.80
110+	C	20.5	3.15	0.28	3.86	34.74	80.00	59.01	9.07	0.81	11.11	0.85
SWA		20.55	3.8	0.36	2.83	33.35	82.52	61.86	11.29	1.1	8.27	0.76
Pedon-3 (Pink shale)												
0-15	Ap	14.18	1.6	0.54	1.23	23.40	75.00	60.60	6.84	2.31	5.26	0.50
15-25	B1	16.14	1.82	0.36	1.11	26.26	74.00	61.47	6.93	1.37	4.23	0.53
25-35	B2w	17.66	2.01	0.24	3.19	27.76	83.20	63.61	7.24	0.86	11.49	0.53
35-48	B3w	17.43	3.52	0.18	3.34	29.56	82.77	58.95	11.91	0.61	11.30	0.55
48-68	B4w	17.86	3.6	0.18	2.76	31.20	78.21	57.24	11.54	0.58	8.85	0.57
68-80	B5w	13.86	3.87	0.15	2.96	27.56	75.63	50.30	14.04	0.54	10.74	0.60
80-98	B6	13.06	3.98	0.16	2.50	26.39	74.64	49.48	15.08	0.61	9.47	0.58
98-110	C	12.98	4.12	0.17	2.52	26.84	73.73	48.36	15.35	0.63	9.39	0.63
SWA		15.67	3.04	0.25	2.45	27.61	77.43	56.78	10.91	0.95	8.76	0.55
Pedon-4 (Limestone)												
0-15	Ap	10.80	1.40	0.31	1.10	14.54	93.62	74.29	9.63	2.13	7.57	0.65
15-25	A2	11.65	1.60	0.26	1.20	15.74	93.46	74.02	10.17	1.65	7.62	0.65
25-40	ACk	10.96	1.80	0.23	1.32	15.44	92.70	71.00	11.66	1.49	8.55	0.75
40+	C	11.35	1.70	0.21	1.34	15.70	93.00	72.30	10.83	1.34	8.54	0.76
SWA		11.14	1.48	0.29	1.14	15.01	93.56	74.18	9.84	1.94	7.59	0.65
Pedon-7 (Sandstone)												

0-15	Ap	1.37	1.12	0.20	0.53	4.66	69.15	29.42	24.05	4.29	11.38	0.33
15-28	B1t	1.93	1.19	0.13	0.58	5.83	65.72	33.12	20.42	2.23	9.95	0.35
28-35	B2	2.24	1.25	0.16	0.63	6.48	66.00	34.54	19.28	2.47	9.71	0.38
35-48	BC	2.26	1.26	0.17	0.82	6.89	65.45	32.80	18.29	2.47	11.90	0.34
48+	C	2.98	1.30	0.19	0.73	7.54	68.98	39.53	17.24	2.52	9.68	0.44
SWA		1.75	1.17	0.16	0.56	5.45	67.26	31.81	21.74	3.16	10.51	0.34

Table 3: Total elemental composition of fine earth

Depth cm	Horizon	SiO_2 %	Al_2O_3 %	CaO %	MgO%	Na_2O %	K_2O %	Fe_2O_3 %	SiO_2/R_2O_3 ratio	Na_2O/CaO ratio
Pedon-2 (Grey shale)										
0-15	Ap	58.8	10.6	5.6	2.99	0.08	1.00	1.66	4.80	0.014
15-28	B1	55.6	10.8	5.6	3.98	0.47	0.54	1.99	4.35	0.084
28-45	B2w	55.1	10.7	7.0	3.99	0.48	0.58	1.48	4.52	0.069
45-65	B3w	54.7	10.5	7.65	2.99	0.52	0.60	1.27	4.65	0.068
65-78	B4w	54.6	10.6	6.6	3.99	0.53	0.59	1.29	4.59	0.080
78-88	B5	52.7	9.8	6.6	3.98	0.57	0.75	1.66	4.60	0.086
88-110	BC	52.0	9.5	9.8	3.5	0.52	0.82	1.80	4.60	0.053
110+	C	53.0	10.0	10.2	3.99	0.6	0.87	1.17	4.74	0.059
SWA		55.37	10.54	6.59	3.58	0.43	0.67	1.53	4.59	0.065
Pedon-3 (Pink shale)										
0-15	Ap	57.2	12.8	5.6	1.99	0.18	0.18	1.21	4.08	0.032
15-25	B1	56.8	13.2	5.6	1.98	0.35	0.35	2.30	3.66	0.063
25-35	B2w	56.5	13.5	4.8	2.95	0.46	0.50	2.4	3.55	0.095
35-48	B3w	55.2	12.9	5.8	3.26	0.5	0.70	2.6	3.56	0.086
48-68	B4w	55.4	12.6	6.4	3.50	0.55	0.75	1.8	3.85	0.086
68-80	B5w	55.0	11.5	6.0	1.99	0.58	0.81	1.26	4.31	0.097
80-98	B6	54.9	12.0	7.5	2.50	0.6	0.65	1.35	4.11	0.080
98-110	C	54.0	11.5	9.5	3.20	0.58	0.70	1.2	4.25	0.061
SWA		55.76	12.58	6.1	2.66	0.47	0.57	1.78	3.9	0.077
Pedon-4 (Limestone)										
0-15	Ap	15.6	4.8	36.5	2.99	0.07	0.27	1.07	2.66	0.002
15-25	A2	18.4	4.6	36.1	3.10	0.05	0.15	0.59	3.55	0.001
25-40	ACk	18.4	4.2	35.4	3.86	0.06	0.23	1.26	3.37	0.002
40+	C	19.5	4.0	36.0	4.99	0.15	0.46	0.53	4.3	0.004
SWA		16.72	4.72	36.34	3.03	0.06	0.22	0.87	3.01	0.001
Pedon-7 (Sandstone)										
0-15	Ap	75.4	23.5	3.6	1.56	0.87	1.50	1.59	3.01	0.242
15-28	B1t	73.2	23.8	3.4	1.85	1.02	1.83	2.68	2.76	0.299
28-35	B2	73.4	26.8	3.4	1.42	1.23	1.42	1.65	2.58	0.362
35-48	BC	72.6	26.2	2.6	1.40	0.91	1.45	1.23	2.65	0.350
48+	C	71.5	25.5	3.2	1.90	1.06	1.84	1.41	2.66	0.331
SWA		74.18	24.27	3.49	1.63	0.99	1.6	2	2.83	0.28

3.7 Soil taxonomy

In spite of high clay content and clay illuviation, illuvial horizon did not fulfill the requirements of argillic horizon and thus pedon-2 derived from grey shale and pedon-3 derived from pink shale were qualified for Inceptisols at order level and at sub order level they were qualified for Ustepts as they possessed Ustic moisture regime. At great group level these soils were classified as Haplustepts as they possessed more than 60 percent base saturation as well as appreciable amount of free calcium carbonate but did not posses either calcic, umbric or mollic horizons. At subgroup level pedon-2 was qualified for Vertic Haplustepts as it possessed pressure faces as well as the cracks of size more than 5 mm width to a depth of 30 cm which exist for some time in most of the years while the pedon-3 was classified as Typic Haplustept as both these pedons possessed central concept of Haplustept.

As the pedon-4 derived from limestone did not posses any diagnostic horizon was qualified for Entisol at order level. As it was better drained than aquent and non fluvialtile in nature it was qualified for Orthent at sub order level. At great group level it was classified as Ustorthent as it possessed ustic moisture regime and at sub group level it was classified as Lithic Ustorthent as there was a lithic contact within 50cm depth.

Red pedon-7 derived from sandstone was qualified for Alfisols at order level as they possessed argillic horizon where clay content was 1.2 times higher than that of overlying horizon. At sub order level they were classified as Ustalfs as they possessed ustic moisture regime and at great group level they were classified as Haplustalf as they did not have duripan, plinthite, natric, oxic, kandic and cambic horizons. Sand stone was keyed out as Lithic Haplustalf at sub group level as it exhibited lithic contact within 50 cm depth.

4. Conclusion

In general the genetic blood of the parent materials was observed in the soils overlying them as the remarkable differences in both particle size classes, morphological and chemical properties of soils of selected area in Budihal micro watershed was observed and it was attributed to the underlying diversified geological materials which were the parent materials of the soils as it was confirmed by the total elemental analysis of soils, molar ratio and CEC/Clay ratio. Intermediately siliceous shale derived pedons-2 and 3 registered deeper solum depths, finer texture and well developed soil structure as compared to the highly siliceous sandstone derived pedon-7. Soil reaction, CEC, total exchangeable basic cations as well as percent base saturation were comparatively low in highly siliceous sand stone derived pedon-7 as compared to the shale derived pedons-2 and 3. Calcareous lime stone derived pedon-4 recorded lowest solum thickness while soil texture soil structures as well as CEC were moderate and they were in between the shale and sand stone derived pedons. Soils under study were keyed out at subgroup level as Vertic Haplustepts (Pedon-2), Typic Haplustepts (Pedon-3), Lithic Usthorthent (Pedon-4) and Lithic Haplustalf (Pedon-7).

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