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Smectite Distribution in Three Representative Vertisol Pedons ot Different Agroclimatic Regions of India

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Abstract: *Three benchmark Vertisol pedons pertaining semi-arid (moist), semi-arid (dry) and arid regions of India were studied for the depthwise distribution of smectite in different soil size fractions. Smectite content is more in semi-arid (moist & dry) soils comparing with arid soils and its content increased with depth and in BC horizon it decreased. Smectite dominates the clay fraction of Bss horizons and the depth distribution of smectite indicates illuviation of fine clay smectite in the studied soils.*

More than 2350000 km^2 of clayey soils high in smectites are distributed over the world (Buol *et al.*, 1997). The occurrence of smectite in soils has been reviewed extensively by Jackson and Sherman (1953), Pal and Deshpande (1987), Wilding and Tessier (1988), Bhattacharyya *et al.*(1993). Appreciable amounts of smectite exist in soils in any of the four B's: 1) basins, 2) B horizons, 3) Super B horizons, and 4) in basic rock-derived soils (Jackson, 1965). In each of these environments high Si and basic cations occur; conditions necessary for smectite formation and/or preservation. Leaching is often at a minimum (Jackson and Sherman, 1953). Reduced leaching simply protects smectite from weathering (Borchardt, 1989). The mineralogy of almost all soils classified as Vertisols by the USDA is dominated by smectite (Soil Survey Staff, 1975; Blokhuis, 1982; Dixon, 1982) and it plays a major role in establishing the physical and chemical properties of these soils. A knowledge of depthwise distribution of smectite is essential to understand about the properties of Vertisols. Hence, the present study was undertaken.

Materials and Methods

Three benchmark Vertisols were selected for the study. These soil series are Bhatumbra in Bidar, Karnataka representing semi-arid (moist), Semla Gondal, in Rajkot, Gujarat representing semi-arid (dry), and Sokhda, in Rajkot, Gujarat representing arid region. These soils were developed in the alluvium of weathered Deccan basalt.

Particle-size distribution was determined by the International pipette method after removal of organic matter, $CaCO_3$ and iron oxides. Sand (2000-50 µm), coarse silt (CS 50-20 µm), medium silt (MS, 20-6 µm), fine silt (FS, 6-2 µm), coarse clay (CC, 2-0.6 µm), medium clay (MC, 0.6-0.2 µm) and fine clay (FC, <0.2 µm) fractions were separated according to size segregation procedure of Jackson (1979).

Mineralogy of the silt and clay fractions was carried out by X-ray diffraction analysis of oriented aggregates saturated with either Ca or K, using a Philips diffractometer with Ni-filtered CuKα at a scanning speed of $2^{\circ}2\theta$/min. The minerals were identified using the diagnostic methods of Jackson (1979) and Brown (1984). Semi-quantitative estimates of clay minerals in the clay and silt size fractions were carried out following the method of Gjems (1967).

Depthwise distribution of smectite was calculated on soil basis in all the three pedons.

Results and Discussion

The morphological, physical and chemical properties of studied soils were reported earlier (Satyavathi *et al.*, 2005).

CS and MS in Bhatumbra pedon, CS, MS, FS, CC and MC in the remaining two pedons viz. Semla Gondal and Sokhda does not show any trend with depth. In Bhatumbra pedon FS, CC and MC decreased with depth, whereas in all the studied profiles FC increased considerably (Tables 1, 2 and 3).

Smectite was the dominant clay mineral in CC, MC and FC fractions at all depths in the studied soils. Soils of semi-arid (moist & dry) had more smectite in 100g soil (47 to 68) as compared to arid region soils (34 to 47). The relative mean annual rainfall (MAR) explains the variations observed in smectite content of the studied soils. Thus the soils of MAR (977-924 mm) (Bhatumbra) and 842-583 mm (Semla Gondal) contain more smectite than the other with MAR<533 mm (Sokhda).

The distribution of smectite follow, in general, a definite trend (increases) from the coarse to fine size fractions of the soil. This trend is similar for all horizons of three Vertisols studied. Borchardt *et al.* (1966) also reported that quantitative analyses of nine soils in the north-central USA showed that there was an average of 30 g kg^{-1} of montmorillonite in the 2 to 0.2 µm fraction, 170 g kg^{-1} in the 0.2 to 0.08 µm fraction and 250 g kg^{-1} in the <0.08 µm fraction.

The smectite content increases dramatically from the Ap to the B horizons particularly in the slickensided horizons, as expected for an illuvial process though it decreased in BC horizon (Tables 1, 2 and 3). The clay particles move in a suspended state. When the water is absorbed by the dry

Table 1. *Smectite variations in different soil size fractions of Bhatumbra (Bidar, Karnataka) pedon*

Horizon	Depth (cm)	CS (50-20 μm)			MS (20-6 μm)			FS (6-2 μm)			Sm in total silt (soil basis)	CC (2-0.6 μm)			MC (0.6-0.2 μm)			FC (<0.2 mm)			Sm in total clay (soil basis)	Sm in 100g soil
		CS (%)	Sm %	Sm	MS (%)	SM %	Sm	Fs (%)	Sm %	Sm		CC (%)	Sm %	Sm	MC (%)	Sm %	Sm	FC (%)	Sm %	Sm		
Ap	0-12	5.8	10	0.58	12.5	15	1.87	19.2	23	4.42	7	11.6	35	4.06	23.2	84	19.49	23.9	99	24	47	54
Bw	12-37	7.5	8	0.60	13.2	11	1.45	12.9	15	1.93	4	9.2	35	3.22	22.0	80	17.60	29.8	99	29	50	54
Bss1	37-79	8.9	7	0.62	10.8	12	1.30	11.7	15	1.75	4	6.5	29	1.88	17.1	76	13.00	38.1	99	38	53	57
Bss2	79-110	4.7	7	0.33	11.9	10	1.19	10.5	17	1.78	3	4.7	31	1.46	13.8	74	10.21	49.1	99	49	61	64

Table 2. *Smectite variations in different soil size fractions of Semla Gondal (Rajkot, Gujarat) pedon.*

Horizon	Depth (cm)	CS (50-20 μm)			MS (20-6 μm)			FS (6-2 μm)			Sm in total silt (soil basis)	CC (2-0.6 μm)			MC (0.6-0.2 μm)			FC (<0.2 mm)			Sm in total clay (soil basis)	Sm in 100g soil
		CS (%)	Sm %	Sm	MS (%)	SM %	Sm	Fs (%)	Sm %	Sm		CC (%)	Sm %	Sm	MC (%)	Sm %	Sm	FC (%)	Sm %	Sm		
Ap	0-17	9.3	11	1.02	11.2	15	1.68	12.6	40	5.04	8	2.6	62	1.61	13.1	81	10.61	27.5	99	27	39	47
Bw1	17-42	5.2	7	0.36	13.8	19	2.62	9.1	30	2.73	6	5.4	46	2.48	7.2	75	5.4	47.5	99	47	55	61
Bw2	42-57	7.8	3	0.23	9.2	14	1.29	9.8	37	3.63	5	9.8	42	4.12	2.4	80	1.92	51.5	99	51	57	62
Bss1	57-86	6.4	8	0.51	15.8	13	2.05	9.8	37	3.63	6	6.2	43	2.67	7.8	73	5.69	46.5	99	46	54	60
Bss2	86-115	2.6	7	0.18	13.2	16	2.11	9.8	34	3.33	6	5.2	54	2.81	6.7	75	5.02	54.7	99	54	62	68
Bss3	115-144	5.6	6	0.34	14.9	18	2.68	10.4	28	2.91	6	6.4	50	3.2	6.9	75	5.17	48.5	99	48	56	62
BC	144-155	10.9	4	0.44	12.1	15	1.81	18.5	38	7.03	9	9.2	60	5.52	14.6	85	12.41	13.2	99	13	31	40

Table 3. *Smectite variations in different soil size fractions of Sokhda (Rajkot, Gujarat) pedon.*

Horizon	Depth (cm)	CS (50-20 µm)			MS (20-6 µm)			FS (6-2 µm)			Sm in total silt (soil basis)	CC (2-0.6 µm)			MC (0.6-0.2 µm)			FC (<0.2 mm)			Sm in total clay (soil basis)	Sm in 100g soil
		CS (%)	Sm %	Sm	MS (%)	SM %	Sm	Fs (%)	Sm %	Sm		CC (%)	Sm %	Sm	MC (%)	Sm %	Sm	FC (%)	Sm %	Sm		
Ap	0-11	4.7	Tr	–	10.0	6	0.6	7.1	20	1.42	2	5.5	25	1.37	9.4	59	5.55	26.0	97	25	32	34
Bw1	11-37	1.9	3	0.06	11.3	12	1.36	6.8	24	1.63	3	5.4	35	1.89	5.9	52	3.07	34.1	97	33	38	41
Bw2	37-63	3.1	Tr	–	10.5	7	0.73	7.4	11	0.81	2	4.5	37	1.66	5.4	63	3.40	39.7	95	38	43	45
Bss1	63-98	3.9	3	0.12	9.6	5	0.48	8.5	13	1.10	2	4.5	23	1.03	6.9	55	3.79	39.3	95	37	42	44
Bss2	98-145	4.2	–	–	9.6	Tr	–	7.5	11	0.82	1	8.0	33	2.64	4.3	57	2.45	42.5	96	41	46	47
BC	145-160	9.0	–	–	16.7	–	–	16.9	Tr	–	–	7.4	23	1.70	7.1	54	3.83	34.4	95	33	38	38

peds, the ped faces or void walls act as a filter retaining the clay platelets that are deposited in the subsurface horizons (Soil Survey Staff, 1975). As the finest particles in soil, clays are most susceptible to eluviations and illuviation. Fine clays, in particular, are small enough to be mobile in soil profiles (Pal *et al.* 2006).

Similar depth trends of smectite have been observed by Diruven *et al.* (1976). Rice *et al.* (1985) reported that the amounts of smectite decreased upward in the profile, perhaps due to destruction of the smectite or its alteration to hydroxy-interlayered vermiculite (HIV).

Results of the study indicate that the clay mainly fine clay of the studied soils is dominated by smectite that increases with depth in the profile. Thus, translocation of clay is an important phenomenon in the pedogenesis of these Vertisols (Satyavathi *et al.* 2005).

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