The Andhra Agric. J 59(4): 568-573, 2012

Study of Soil Characteristics Modified by Physiography in Hanumankoppa Micro-watershed Under Northern Transitional Zone of Karnataka

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ABSTRACT

Eight typical pedons representing uplands and lowlands selected in Hanumankoppa micro-watershed under northern transitional zone of Karnataka were studied for their morphological, physical, chemical and physico-chemical properties in relation to variation in physiography during 2007-08. The upland soils were moderate, fine and sub-angular blocky in structure, moderately deep (90-110 cm), reddish brown to red in colour (5 YR- 7.5 YR), sandy loam in texture, slightly acidic to neutral in reaction, low in CEC (6.9 to 18.9 cmol (p^+) kg^{-1}) and medium base saturated. The low land soils were strong, fine and granular to sub- angular blocky in structure, deep to very deep (>145 cm) with yellowish brown to brownish grey in colour, clay loam to sandy clay in texture, neutral to slightly alkaline in reaction, medium in CEC (6.2 to 34.2 cmol (p^+) kg^{-1}) and highly base saturated.

Key words : Base saturation, Cation Exchange Capacity, Micro-watershed, Physiography

Soil forming factors and anthropogenic activities govern the properties of soils. The physiography has left a distinct imprint on the soil characteristics which form the basis of putting the soils under different taxa (Sharma *et al.,* 1996). The information is meager especially on the physiographic relationship on morphological, physical and chemical characteristics of soils under micro-watershed level. However, for proper agricultural planning under micro-watershed level, adequate assessment of soil resources has long been considered as an essential pre requisite and different measures are adopted and executed carefully in each of toposequences according to their capability. Besides, this is an approach to explore the suitability of various crops under micro-watershed on each of the physiographic unit. Hence, a systematic study of physiography relationship on morphological, physical, chemical and physico-chemical characteristics of soils under micro-watershed has been attempted.

MATERIAL AND METHODS

The Hanumankoppa micro-watershed is situated between $14^0$43'20" to $14^0$41'58.4" N latitude and $75^0$03'55.9" to $75^0$04'09.3" E longitude and at average elevation of 775 m above MSL and falls under northern transitional zone (zone 9) of Karnataka. The micro-watershed falls in Hanagal taluk and district Haveri and lies along Hanagal-Sirsi road comprising of five villages *viz.*, Hanumankoppa, Balahalli, Savikeri, Sringeri and Hiruru.The area has sedimentary rocks comprising Dharwad schist. In general, the physiography is marked by upland, midland and lowlands. The area falls in semi-arid zone of Karnataka and receives annual rainfall of 933.4 mm, most of which is concentrated during the months of June to September. The mean average annual air temperature is 24^0C. The area belongs to ustic and isohyperthermic.

Based on cadastral map and scanned toposheet of the study area, eight pedons, representing uplands (P1,P2,P3, P4 and P5) and lowlands (P6, P7 and P8) were selected and studied in the field during 2007-08. The horizon-wise soil samples were collected and analyzed for physico-chemical and chemical characteristics by adopting standard procedures (Jackson, 1979).

RESULTS AND DISCUSSION

Morphological properties

The depth in upland pedons (P1, P2 and P4) was comparatively less than that of lowland pedons (P6 and P7) and were presented in Table 1.The variation in depth is related to physiography, because of non-availability of adequate amount of water for prolonged period on upland pedons associated with removal of finer particles and their deposition at lower pediplain.The results obtained are in agreement with the findings of Ramprakash and Seshagiri Rao (2002).The colour of upland pedons (pedon 1, 2 and 4) was dominantly redder hue(7.5 YR and 5 YR) except pedon 1, which was dark olive brown (2.5 Y), whereas in lowland pedons (P6, P7 and P8) was dark greyish brown (10 YR), brown (7.5 YR). This variation in colour is a function of chemical and mineralogical composition,textural makeup and moisture regimes modified by physiography.The colour of the upland forest pedons (P3andP4) was 10 YR 2/1 m and 5 YR 3/2 m, respectively. The dark matrix colour in the above pedons might be due to presence of high organic matter content in the surface horizons (Tripathi *et al.*, 2006). Further, the sub-surface horizons had comparatively brighter colour throughout the profile.The texture of Ap horizon in upland pedons (P1, P2 and P5) was sandy loam whereas in lowland pedons (P6, P7 and P8) the texture was clay loam to sandy clay in texture, because of deposition of finer fractions from uplands. Similar findings reported by Arun kumar *et al.,* (2002). The upland pedons (P3 and P4) were sandy clay loam in texture, because of lesser mobilization and translocation of finer fractions owing to forest land use, which might also be due to improvement in soil structure by addition of organic matter through leaf foliage. The structure of upland pedons (P1 andP2) was moderate, fine, sub-angular blocky whereas in lowland pedons (P6, P7 and P8) the structure was strong, fine granular to sub-angular blocky, which was reflection of their sandy loam and sandy clay to clay loam in texture, respectively. Similar observations were also made by Singh and Agarwal (2003).The upland forest pedons (P3andP4) and lowland forest pedon (P8) exhibited strong, fine, granular and strong, medium, granular structure which might be due to addition of organic matter and prevailing moist conditions in these soils.The consistence of upland pedons (P1, P2 and P5) varied from slightly hard to very hard, friable to extremely firm, non-sticky and non-plastic to sticky and plastic in dry, moist and wet conditions, respectively. This physical behaviour influenced by the type of clay minerals present in soils. The lowland pedons (P6,P7 andP8) sticky and plastic to very sticky and very plastic, firm to very firm and slightly hard to very hard in wet, most and dry conditions, respectively. This might be due to higher clay content. Similar observations made by Sarkar *et al.,* (2001) in soils of lower outlier of Chhotanagpur plateau.

Physical properties

In upland pedons (P1, P3 and P4) the clay content increased with depth but stabilizes at second and or third horizon (Table 2.).In upland pedons (P2 and P5), sub-surface horizons exhibited higher clay content due to the illuviation from surface horizons during the process of soil development. Similarly, the illuviation process also affected the vertical distribution of silt and sand content. Similar observations were also made by Sharma *et al.,* (2004).Silt content in all the pedons (except P3) exhibited an irregular trend with depth due to variation in weathering of parent material as influenced by physiography. These results are in agreement with the findings of Naidu (2002).The surface horizons of upland pedons exhibited higher sand content than lowland pedons, which could be attributed to removal of finer fractions and consequent enrichment of sand fractions on the upper slopes. The upland pedons (P1, P2 and P5) exhibited low water holding capacity than low land pedons (P6, P7 and P8) due to higher sand and lesser clay content. The Ap horizon of upland pedons (P3 and P4) and lowland pedon (P8) showed lower bulk density which could be attributed to high organic matter content contributed by leaf foliage under forest land use.In all pedons (except P2 and P5) bulk density increase with depth probably related to increase in coarse fragments and or filling of pores by illuvial materials leading to compaction.

Chemical properties

The Ap horizon of upland pedons relatively lower in reaction than that of horizon in lowland pedons (Table 3). This increase in soil reaction down the slope could be due to leaching of bases from higher topography and getting deposited at lower elevations (Sitanggang *et al.,* 2006). The forest pedons (P 3, P4 and P8) relatively lower in reaction, which might be due to release of organic acids during decomposition of leaf foliage and these acids might have brought down the pH of the surface horizons.The Ap horizon of upland pedons relatively less in salinity, which might be due to free drainage conditions favoured the removal of released bases by percolating water. In lowlands, slightly higher EC values recorded than midlands and uplands. This can be attributed to accumulation of salts in lowlands. Similar findings were recorded by Sitanggang *et al.,* (2006) in soils of Shikohpur watershed in Gurgaon district of Haryana. The cation exchange capacity of upland pedons (P1, P2 and P5) was low (6.9 to18.9 cmol (p+) kg^{-1}) whereas, higher CEC (6.2 to 34.2 cmol (p+) kg^{-1}) was observed in lowland pedons (P6, P7 andP8). This might be due to significant and positive correlation(r=+0.40) of clay with CEC (Sharma and Anil Kumar, 2003).The CEC in all the pedons (except P2) decreased with depth, which could be attributed to decreased

Table 1. Morphological features of the pedons modified by physiography under micro-watershed.

Pedon No.	Horizon	Depth (cm)	Colour		Structure	Texture	Consistency			Other silent features
			Dry	Moist			Dry	Moist	Wet	
			Uplands							
Pedon 1	Ap	0-25	2.5 Y 6/4	2.5 Y 3/3	2 f sbk	sl	sh	fr	sssp	
	Bw_1	25-50	2.5 Y 6/6	2.5 Y 5/4	2 m sbk	cl	sh	sfi	sssp	
	Bw_2	50-75	2.5 Y 6/6	2.5 Y 6/4	3 c sbk	scl	h	fr	sssp	
	BC	75-100	2.5 Y 6/6	2.5 Y 4/4	3 c sbk	sl	vh	efi	sssp	
	C	100-110+	2.5 Y 7/4	2.5 Y 5/3	massive	ls	eh	efi	so po	
Pedon 2	Ap	0-22	10 YR 6/6	10 YR 3/6	2 c sbk	sl	h	fi	sssp	Clay films around sand are observed at 22-72 cm
	Bt_1	22-46	7.5 YR 5/6	7.5 YR 4/6	3 f sbk	scl	h	vfi	s p	
	Bt_2	46-72	7.5 YR 5/6	7.5 YR 5/3	2 m sbk	sc	h	vfi	s p	
	BC	72-100+	7.5 YR 5/6	7.5 YR 6/3	massive	sl	vh	sfi	ss p	
Pedon 3	A_1	0-14	10 YR 3/1	10 YR 2/1	3 f gr	scl	sh	fr	sssp	
	Bw_1	14-32	10 YR 4/2	10 YR 3/3	3 m gr	scl	sh	fr	s p	
	Bw_2	32-55	10 YR 5/3	10 YR 4/3	3 f sbk	scl	h	fr	sssp	
	BC	55-85	10 YR 6/3	10 YR 4/4	2 f sbk	sl	vh	fi	so s_0	
	C	85-100+	10 YR 6/2	10 YR 5/3	massive	ls	vh	fi	sspo	
Pedon 4	A_1	0-15	5 YR 3/2	5 YR 3/2	3 f gr	scl	sh	fi	sssp	
	AB	15-45	5 YR 4/2	5 YR 3/3	3 f sbk	scl	sh	sfi	s sp	
	BC	45-80	5 YR 5/6	5 YR 4/3	3 c sbk	sl	sh	efi	sspo	
	C	80-110	5 YR 6/6	5 YR 6/6	massive	sl	h	fi	so po	
Pedon 5	Ap	0-20	7.5 YR 6/8	7.5 YR 4/4	3 m sbk	sl	h	sfi	so po	Clay films around sand are observed at 20-70 cm
	Bt_1	20-40	7.5 YR 5/6	7.5 YR 4/6	2 m sbk	Scl	h	fi	ss p	
	Bt_2	40-70	7.5 YR 5/6	7.5 YR 4/4	2 m sbk	Scl	h	fi	sssp	
	C	70-100+	7.5 YR 5/8	7.5 YR 4/6	massive	Sl	h	fi	sspo	
			Lowlands							
Pedon 6	Ap	0-15	10 YR 5/3	10 YR 4/2	3 f gr	sc	l	vfr	s p	Pressure faces are observed between 35-100 cm depth
	Bw_1	15-35	10 YR 5/2	10 YR 3/2	3 c sbk	sc	vh	vfi	vs p	
	Bw_2	35-75	10 YR 5/2	10 YR 3/2	3 c sbk	sc	vh	vfi	vsvp	
	BC	75-100	10 YR 5/2	10 YR 3/3	3 c sbk	scl	vh	vfi	sssp	
	C	100-135+	10 Y 5/2	10 YR 4/2	massive	sl	eh	efi	sspo	
Pedon 7	Ap	0-25	10 YR 6/4	10 YR 3/6	2 f sbk	cl	vh	vfi	s p	Pressure faces are observed between 25-85 cm depth
	Bw_1	25-50	10 YR 5/3	10 YR 4/5	2 f sbk	scl	vh	vfi	s p	
	BC	50-85	10 YR 7/3	10 YR 5/3	3 c sbk	sl	h	fi	ss p	
	C	85-125+	10 YR 7/2	10 YR 6/3	massive	ls	h	fi	sspo	
Pedon 8	A_1	0-12	7.5 YR 3/2	7.5 YR 2.5/1	3 m gr	cl	sh	fi	vs p	
	Bw_1	12-25	7.5 YR 4/3	7.5 YR 3/3	3 m sbk	scl	h	vfi	s sp	Pressure faces are observed between 25-85 cm depth
	Bw_2	25-55	7.5 YR 5/2	7.5 YR 4/4	2 m sbk	scl	h	fi	s po	
	BC	55-85	7.5 YR 6/3	7.5 YR 4/6	2 m sbk	sl	h	fi	sspo	
	C	85-120+	7.5 YR 6/2	7.5 YR 5/2	massive	ls	h	fi	sspo	

Table 2. Physical properties of the pedons modified by physiography under micro-watershed

Pedon No.	Horizon	Depth (cm)	Gravel % of whole soil	Coarse sand	Fine sand	Total sand	Silt	Clay	Tex-tural class	Bulk density (Mg/m^3)	MWHC (%)
				% of fine earth							
				Uplands							
Pedon 1	Ap	0-25	25	39.2	23.1	62.3	19.1	18.6	sl	1.23	15.1
	Bw_1	25-50	27	36.1	22.0	58.1	20.5	22.3	cl	1.34	15.8
	Bw_2	50-75	30	42.7	16.3	59.0	18.4	22.6	scl	1.44	16.8
	BC	75-100	34	56.9	13.6	70.5	10.7	18.8	sl	1.49	17.0
	C	100-110+	58	76.2	6.9	83.1	4.3	12.6	ls	1.50	13.8
Pedon 2	Ap	0-22	27	36.3	20.2	56.5	21.1	12.9	sl	1.20	14.4
	Bt_1	22-46	28	23.8	24.0	48.5	20.2	31.3	scl	1.32	28.2
	Bt_2	46-72	35	29.5	17.2	47.3	16.3	36.4	sc	1.30	26.2
	BC	72-100+	39	57.4	14.0	71.7	12.0	16.3	sl	1.60	15.1
Pedon 3	A_1	1-14	21	39.0	19.0	58.0	13.5	28.5	scl	1.20	34.2
	Bw_1	14-32	28	38.3	19.2	58.2	15.0	26.8	scl	1.25	26.3
	Bw_2	32-55	32	46.8	14.3	61.1	15.1	23.8	scl	1.40	22.0
	BC	55-85	36	55.6	12.3	67.9	13.1	19.0	sl	1.47	20.0
	C	85-100+	42	68.2	14.3	82.5	9.3	8.2	ls	1.52	16.3
Pedon 4	A_1	0-15	19	34.9	14.3	49.2	23.8	27.0	scl	1.22	29.4
	AB	15-45	25	33.2	16.8	50.0	22.4	27.6	scl	1.28	29.2
	BC	45-80	28	41.8	15.2	57.0	18.0	25.0	sl	1.57	18.0
	C	80-110	32	57.7	10.8	68.5	16.8	15.6	sl	1.60	10.5
Pedon 5	Ap	0-20	23	52.1	17.1	69.2	17.4	13.4	sl	1.27	16.2
	Bt_1	20-240	29	44.7	13.1	57.2	11.6	30.6	scl	1.30	32.8
	Bt_2	40-70	31	48.6	9.4	58.0	9.2	32.8	scl	1.35	29.8
	C	70-100	42	62.3	10.0	72.3	16.2	11.5	sl	1.50	15.8
				Lowlands							
Pedon 6	Ap	0-15	7	32.6	18.1	50.7	13.1	36.1	sc	1.26	32.7
	Bw_1	15-35	10	32.3	16.8	49.1	13.9	37.0	sc	1.24	29.8
	Bw_2	35-75	18	35.2	13.2	48.4	12.5	39.1	sc	1.40	25.1
	BC	75-100	23	52.1	14.2	66.2	7.1	26.6	scl	1.58	17.3
	C	100-135+	33	62.9	10.2	73.1	8.7	18.2	sl	1.60	13.4
Pedon 7	Ap	0-25	8	26.6	14.4	41.0	22.0	37.0	cl	1.22	21.9
	Bw_1	25-50	14	25.3	20.8	46.1	18.9	35.0	scl	1.26	30.8
	Bw_2	50-85	18	30.6	12.2	42.8	19.5	37.7	sc	1.28	18.2
	BC	85-125+	28	50.2	14.9	65.1	16.2	18.8	sl	1.54	12.8
	C	125+	34	56.3	19.3	75.6	7.6	16.7	ls	1.58	10.0
Pedon 8	A_1	0-12	5	24.2	17.4	41.6	19.6	38.8	cl	1.20	22.9
	Bw_1	12-25	8	27.7	16.2	43.9	20.0	36.1	scl	1.22	31.3
	Bw_2	25-55	18	36.9	20.9	57.8	10.2	32.4	scl	1.35	22.8
	BC	55-85	22	43.6	12.2	65.8	17.8	26.3	sl	1.46	14.2
	C	85-120+	42	55.3	11.3	66.9	12.7	20.4	ls	1.58	10.3

Table 3: Chemical properties of the pedons modified by physiography under micro-watershed

Pedon	Horizon	Depth (cm)	Exchangeable bases Ca	Mg	Na	K	CEC	BS (%)	pH	Organic Carbon ($g\ kg^{-1}$)
				cmol (p+)/kg						
				Uplands						
Pedon 1	Ap	0-25	4.6	3.2	0.5	0.7	18.9	53.3	6.20	4.6
	Bw_1	25-50	5.2	3.4	0.9	1.6	17.3	64.6	5.64	3.9
	Bw_2	50-75	5.8	3.9	0.9	1.5	16.2	75.2	6.55	1.5
	BC	75-100	3.6	2.8	1.0	1.4	11.8	75.9	6.25	1.4
	C	100-110+	3.4	1.4	1.1	1.3	7.0	95.5	6.44	0.9
Pedon 2	Ap	0-22	2.8	1.4	0.2	0.7	9.6	54.2	5.56	3.6
	Bt_1	22-46	8.7	5.1	0.5	1.7	22.2	71.8	5.42	3.2
	Bt_2	46-72	7.6	4.9	0.8	1.7	20.1	74.9	6.08	2.5
	BC	72-100+	2.9	1.2	0.9	0.5	6.9	80.9	6.56	0.5
Pedon 3	A_1	0-14	18.0	8.2	0.5	0.9	38.4	74.9	5.02	13.2
	Bw_1	14-32	17.4	6.8	0.5	1.1	36.4	76.7	6.03	6.8
	Bw_2	32-55	14.8	6.5	0.7	1.1	29.8	77.9	6.32	5.9
	BC	55-85	7.9	3.1	1.0	1.1	18.2	72.8	6.60	1.9
	C	85-100+	3.7	2.1	1.1	1.0	12.4	64.6	6.89	0.5
Pedon 4	A_1	0-15	17.5	5.6	0.2	0.6	28.4	84.5	5.25	12.4
	AB	15-45	16.0	6.2	0.4	0.7	32.8	72.4	5.35	7.2
	BC	45-80	10.0	4.9	0.7	1.5	22.4	80.1	6.25	6.1
	C	80-110	3.2	1.4	1.3	1.6	12.0	62.1	6.32	1.8
Pedon 5	Ap	0-20	3.6	1.9	0.1	0.4	10.5	57.6	5.53	4.5
	Bt_1	20-40	10.6	5.6	0.5	0.8	25.3	68.0	5.98	4.1
	Bt_2	40-70	6.3	3.9	1.2	1.5	16.4	79.2	6.38	3.0
	C	70-100+	2.0	0.8	1.2	1.4	5.9	94.9	6.51	1.0
				Lowlands						
Pedon 8	Ap	0-15	16.5	7.3	0.2	0.5	34.2	71.3	6.54	6.2
	Bw_1	15-35	18.1	7.2	0.3	0.6	30.1	88.2	7.31	4.5
	Bw_2	35-75	17.9	7.2	0.3	0.7	28.8	88.7	7.59	3.7
	BC	75-100	10.1	6.2	0.4	0.9	18.3	97.8	7.92	1.5
	C	100-135+	8.2	4.1	0.5	0.9	14.5	95.9	7.98	0.3
Pedon 9	Ap	0-25	17.5	7.3	0.0	0.3	32.1	78.7	6.40	6.8
	Bw_1	25-50	16.1	7.0	0.1	0.3	30.0	79.1	6.48	4.8
	Bw_2	50-85	14.9	6.5	0.3	0.4	27.6	80.2	6.89	3.3
	BC	85-125+	7.8	2.9	0.4	0.6	14.3	82.3	7.95	2.9
	C	125+	2.9	1.6	0.7	0.9	6.2	96.3	8.11	0.8
Pedon 10	A_1	0-12	19.1	8.2	0.1	0.2	32.5	86.5	5.25	13.7
	Bw_1	12-25	18.6	10.1	0.0	0.3	40.8	84.8	5.72	8.1
	Bw_2	25-55	12.4	8.2	0.2	0.5	25.8	84.3	6.34	5.3
	BC	55-85	7.6	3.8	0.7	0.2	19.8	61.5	6.72	1.2
	C	85-120+	4.0	2.2	0.9	0.2	13.2	56.3	6.82	1.1

organic carbon and clay content below the solum depth. The results are in agreement with the findings of Swarnam *et al.,* (2004). The Ap horizon in upland pedons is less base saturated than Ap horizon of lowland pedons, indicating high degree of leaching in upper slopes. These findings are in conformity with those reported by Sitanggang *et al.* (2006). The exchangeable bases in all the pedons were in the order of Ca^{+2} > Mg^{+2}> Na^{+}> K^{+} on the exchange complex.From the distribution of Ca^{+2} and Mg^{+2}, it is evident that Ca^{+2} shows the strongest relationship with all the species, comparing these ions (Ca^{+2}, Mg^{+2}, K^{+} and Na^{+}) it was clear that Mg^{+2} was present in low amount than Ca^{+2} because of its higher mobility. These results are in conformity with findings of Sharma *et al.,* (1996).In pedons (P3, P4and P8) high content of exchangeable bases and decreased with depth. This might be attributed to decomposition of leaves and litter of the deciduous forest species which contributes higher Ca^{2+} content due to biocycling.

The study reveals that there was a close relationship between physiography and soils. The formation of the diverse group of soils can be attributed to the variation in topography, causing erosion, leaching, sedimentation and other pedogenic process modified by water table.

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(Received on 09.09.2011 and revised on 26.09.2011)