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Short Communication

Characterization of soils of a micro-watershed in eastern dry zone of Karnataka

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The system of farming in eastern dry zone of Karnataka has changed considerably during last few years due to peri-urban pressure and absentee landlords. The region faces several constraints related to erratic and scanty rainfall, soil erosion, crusting, gravelliness in some soils and acidity in major soils of the middle sector and salinity and alkalinity in soils of lower sector. Sand mining from surface soils for immediate profits and urbanization are the recent problems being witnessed in the region (Hegde *et al.* 2008). For sustaining the productivity, it is essential to undertake soil and water conservation measures on the basis of sound scientific database. Hence, it was felt imperative to characterize the land resources of the area.

Amani Shirpurakere watershed (531 ha), was selected under National Agricultural Technology Project (Rainfed Agro-ecosystem). It is located between 13°18' N to 13°20' N latitude and 77°16' E to 77°18' E longitude. The elevation ranged from 915 to 942 m above MSL. Climate of area is semi-arid and mean annual rainfall is 889.0 mm (30 years average) and it is received mainly from south-west monsoon. Mean annual temperature of area is 23.8 °C and the area qualifies for 'isohyperthermic' soil temperature and 'ustic' soil moisture regimes, respectively.

The study area forms a part of Bangalore plateau of granites and gneisses. The present land use is a mixed forest with eucalyptus plantations on partly eroded upper middle sectors. The crops grown are ragi, maize, field beans, cool season vegetables, potato, onion, tomato, cucumber, mango, grapes, banana, flowers, coconut, arecanut and mulberry. Paddy and vegetables are mostly cultivated near the tank.

Ten transects were drawn along the direction of slope at different locations in the watershed. Soil profiles were exposed and studied at close intervals along transects. The site and morphological characteristics were studied (Soil Survey Division Staff 2000) and classified (Soil Survey Staff 2003). Ten soil series were identified and mapped as soil series with phases on 1:8,000 scale using cadastral maps as base map (Fig. 1). Horizon-wise samples collected from typifying pedons were analyzed for pH, EC, organic carbon, CEC and exchangeable cations following standard procedure (Black 1965, Jackson 1973; Sarma *et al.* 1989). Composite soil samples were collected and analyzed for available macro and micronutrients.

All the soils are very deep and non-gravelly barring soils of series 9. Except soils of series 7, 8, 9 and 10, all other soils were comparatively redder and associated with argillic horizon.

Bulk density of pedons ranged from 1.20 to 1.75 Mg m^{-3}. Soil texture in upper layer varied from sand (soil series 1, 3), loamy sand (soil series 8), sandy loam (soil series 2, 4, 5 and 6) and sandy clay loam (soil series 7, 9 and 10). Clay content of soils varied from 5.1 to 26.0 per cent in surface layers (Table 1). The clay content in the B horizon of series 1 to 6 ranged from 25.3 to 54.1 per cent. The wide sand to silt ratio indicate that weathering was influenced by varied pedo-environment. Sathisha and Badrinath (1994) also observed similar findings in the soils of Western Ghats in Dakshina Kannada at uplands and midlands of Agumbe.

Table 1. Physical and chemical properties of soils

Horizon	Depth (cm)	Particle- size			Coarse fragment	pH (1:2.5 H_2O)	BD (Mg m^{-3})	EC (dS m^{-1})	OC (g kg^{-1})	C.E.C (cmol (+) kg^{-1})	Exchangeable bases					CEC/ clay ratio	Base saturation (%)
		Sand	Silt	Clay							Ca	Mg	K	Na	Sum		
		----------(%)----------			(% v/v)						(cmol (+) kg^{-1})						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series 1: Fine, mixed, isohyperthermic Kandic Paleustalfs																	
Ap	0-15	87.8	6.8	5.4	-	6.2	1.55	0.20	1.2	2.1	1.4	0.4	0.0	0.0	1.8	0.39	86
Bt1	15-36	58.4	6.7	34.9	-	6.2	1.33	0.15	2.2	6.6	3.7	1.1	0.1	0.1	5.0	0.19	77
Bt2	36-55	52.2	11.4	36.4	-	6.5	1.31	0.18	2.2	7.6	4.3	1.5	0.1	0.2	6.1	0.21	80
Bt3	55-94	50.0	10.6	39.4	-	6.6	1.16	0.19	1.9	6.9	4.1	1.5	0.1	0.1	5.8	0.18	84
Bt4	94-120	47.2	17.3	35.5	-	6.4	1.09	0.14	2.0	6.4	3.0	1.4	0.1	0.1	5.4	0.18	84
Bt5	120-166	43.0	15.5	41.5	-	6.4	1.15	0.10	1.1	6.3	3.9	1.2	0.1	0.1	5.3	0.15	84
Series 2: Fine, mixed, isohyperthermic Typic Kandiustalfs																	
Ap	0-16	82.2	3.4	14.4	-	7.2	1.39	1.23	2.8	5.4	3.7	1.0	0.3	0.2	5.2	0.26	96
Bt1	16-32	47.5	6.3	46.2	-	6.8	1.41	0.58	2.4	6.8	4.2	1.6	0.2	0.6	6.6	0.15	97
Bt2	32-61	43.1	6.8	50.1	-	6.3	1.27	0.43	1.7	7.1	3.9	1.6	0.2	1.0	6.7	0.14	94
Bt3	61-96	41.5	4.5	54.0	-	6.3	1.34	0.28	2.1	7.8	4.1	1.4	0.1	1.0	6.6	0.14	85
Bt4	96-132	42.5	6.0	51.5	-	6.3	1.44	0.29	2.8	7.4	4.0	1.3	0.1	0.8	6.2	0.14	84
Bt5	132-160	40.9	10.4	48.7	-	6.6	1.20	0.19	1.2	7.4	5.5	1.5	0.1	1.2	6.3	0.15	85
Series 3: Fine, mixed, isohyperthermic Typic Kanhaplustalfs																	
Ap	0-14	68.7	6.2	5.1	-	5.6	1.63	0.37	2.5	1.6	0.7	0.2	0.1	0.0	1.0	0.31	63
Bt1	14-45	63.7	7.5	28.8	-	5.8	1.47	0.20	2.5	4.6	3.1	0.8	0.1	0.1	4.1	0.16	89
Bt2	45-80	52.3	8.4	39.3	-	6.2	1.22	0.12	2.2	6.6	4.6	1.4	0.1	0.1	6.2	0.17	94
Bt3	80-102	51.2	9.2	39.6	-	6.2	1.21	0.12	1.9	6.4	4.5	1.6	0.1	0.0	6.2	0.16	97
BC1	102-135	50.4	8.5	41.1	45	6.1	1.35	0.16	1.6	5.8	3.4	1.4	0.1	0.0	4.9	0.14	84
BC2	135-182	52.4	12.3	35.3	50	6.2	1.38	0.10	1.0	4.2	2.6	1.2	0.0	0.0	3.8	0.12	90

contd.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series 4: Fine, mixed, isohyperthermic Rhodic Kandiustalfs																	
Ap	0-14	73.9	9.6	16.5	-	6.7	1.55	1.05	4.0	5.7	4.6	1.3	0.2	0.3	6.4	0.35	96
Bt1	14-32	70.0	7.3	22.7	-	6.6	1.58	0.45	4.2	5.8	4.9	1.4	0.1	0.1	6.5	0.26	96
Bt2	32-60	52.9	4.4	43.7	-	5.7	1.24	0.32	4.2	7.0	4.6	1.3	0.1	0.2	6.2	0.16	89
Bt3	60-89	46.6	4.3	49.1	-	5.8	1.20	0.37	3.4	7.7	5.1	1.4	0.1	0.3	6.9	0.16	90
Bt4	89-122	43.0	8.7	48.3	-	5.8	1.15	0.93	3.2	7.8	5.0	1.7	0.1	0.2	7.0	0.16	94
Bt5	122-153	43.7	10.6	45.7	-	5.8	1.29	1.47	1.7	7.5	5.3	1.4	0.1	0.3	7.1	0.16	95
Bt6	153-178	44.9	12.2	42.9	-	6.0	1.24	0.75	1.4	7.2	5.3	1.4	0.1	0.3	7.1	0.17	95
Series 5: Fine, mixed, isohyperthermic Typic Rhodustalfs																	
Ap	0-12	73.5	9.4	17.1	-	6.0	1.42	0.29	4.5	4.9	2.4	1.1	0.3	0.1	3.9	0.29	80
Bt1	12-36	35.9	45.4	18.7	-	6.1	1.25	0.20	6.1	14.5	9.2	2.8	0.1	0.1	12.2	0.28	84
Bt2	36-59	32.6	15.9	51.5	-	6.2	1.25	0.10	4.2	14.2	9.0	3.0	0.1	0.1	12.2	0.28	86
Bt3	59-87	32.6	13.3	54.1	-	6.2	1.39	0.10	3.5	14.9	9.0	2.9	0.1	0.2	12.2	0.28	82
Bt4	87-127	44.7	12.7	42.6	20	6.8	1.15	0.10	2.0	20.8	12.7	3.9	0.1	0.4	17.1	0.49	82
BC	127-159	25.8	23.8	50.4	5	7.0	1.28	0.14	2.0	22.6	13.6	4.4	0.1	0.4	18.5	0.45	81
Series 6: Fine-loamy, mixed, isohyperthermic Typic Paleustalfs																	
Ap	0-20	75.2	11.4	13.4	-	6.5	1.70	0.33	3.3	10.6	8.6	1.1	0.1	0.0	9.8	0.32	92
Bt1	20-38	66.9	7.8	25.3	-	6.9	1.42	0.18	3.9	10.8	7.4	2.1	0.1	0.1	9.7	0.25	90
Bt2	38-67	59.1	6.8	34.1	-	7.3	1.22	0.18	2.3	10.4	7.6	1.8	0.1	0.2	9.7	0.28	93
Bt3	67-99	56.0	7.3	36.7	-	7.0	1.26	0.18	1.5	10.7	7.3	2.0	0.1	0.4	9.8	0.26	92
2Bt4	99-141	45.3	11.4	43.3	-	7.1	1.38	0.17	2.1	12.8	8.7	2.2	0.1	0.6	11.6	0.30	91
2Bt5	141-173	52.1	6.7	41.2	-	7.1	1.44	0.35	0.6	12.3	8.3	2.2	0.1	0.6	11.2	0.28	91
Series 7: Fine-loamy, mixed, isohyperthermic Aquic Haplustepts																	
Ap	0-14	64.5	14.7	20.8	-	7.3	1.75	0.53	5.1	20.0	13.2	4.8	0.1	0.3	18.4	0.48	92
Bw1	14-43	58.0	20.8	21.2	-	7.8	1.76	0.29	2.3	22.0	14.9	5.4	0.1	0.1	20.5	0.52	93
Bw2	43-62	48.8	17.2	34.0	-	8.1	1.71	0.21	1.9	23.9	16.1	5.8	0.2	0.1	22.2	0.81	93
Bw3	62-94	38.6	20.6	40.8	-	7.7	1.61	0.18	1.4	33.5	23.1	7.2	0.2	0.8	31.3	0.82	93
Bw4	94-128	55.9	9.4	34.7	-	7.8	1.77	0.13	1.3	23.6	15.5	6.9	0.2	0.4	23.0	0.68	97
BC	128-166	62.1	13.5	24.4	-	7.9	1.93	0.21	0.7	16.6	10.6	4.9	0.2	0.3	16.0	0.68	96

contd.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series 8: Fine -loamy, mixed, isohyperthermic Typic Haplustepts																	
Ap	0-12	83.3	9.8	6.9	5	5.0	1.68	0.62	1.5	3.3	2.4	0.3	0.1	0.0	2.8	0.48	85
Bw1	12-24	78.7	11.3	10.0	5	6.1	1.60	0.25	2.4	5.4	3.7	1.1	0.1	0.1	5.0	0.54	93
Bw2	24-48	64.5	11.0	24.5	-	6.7	1.38	0.24	1.5	6.6	4.7	1.1	0.1	0.2	6.1	0.27	92
Bw3	48-70	63.6	10.3	26.1	-	7.0	1.41	0.16	1.1	7.7	4.8	2.0	0.1	0.2	7.1	0.30	92
Bw4	70-103	60.7	10.9	28.4	-	7.3	1.43	0.18	1.2	8.6	5.9	1.6	0.1	0.2	7.8	0.30	91
Bw5	103-146	59.8	10.7	29.5	-	7.3	1.59	0.20	1.0	9.0	6.4	1.5	0.1	0.2	8.2	0.28	91
Bw6	146-171	59.9	8.0	32.1	-	7.0	1.94	0.17	1.4	9.2	6.4	1.7	0.1	0.2	8.4	0.28	91
Series 9: Fine-loamy, mixed, isohyperthermic Calcic Haplustepts																	
Ap	0-15	61.2	12.8	26.0	-	6.8	1.35	0.44	6.0	9.8	5.9	2.5	0.2	0.1	8.7	0.38	89
Bw1	15-35	57.8	14.0	28.2	-	7.7	1.43	0.31	3.5	9.0	5.5	2.2	0.1	0.2	8.0	0.32	89
Bw2	35-56	41.8	16.2	42.0	-	7.9	1.57	0.26	3.9	18.1	11.1	4.7	0.2	0.3	16.3	0.43	90
Bk1	56-90	55.6	17.1	32.8	25	7.9	1.28	0.27	2.4	15.1	9.5	4.1	0.1	0.2	13.9	0.35	92
Bk2	90-116	58.4	17.2	30.2	50	7.9	1.44	0.27	2.3	15.0	9.4	4.1	0.1	0.2	13.8	0.34	92
Series 10: Fine-loamy, mixed, isohyperthermic Fluventic Haplustepts																	
Ap	0-15	50.8	24.8	24.4	-	6.0	1.20	0.29	1.2	6.6	4.1	1.4	0.2	0.2	5.9	0.27	89
Bw1	15-32	62.2	21.8	16.0	-	6.5	1.40	0.28	3.0	5.0	2.8	1.2	0.1	0.1	4.2	0.31	84
Bw2	32-52	42.9	22.6	34.5	-	6.3	1.36	0.09	2.9	8.6	4.8	1.7	0.1	0.2	6.8	0.25	79
Bw3	52-83	68.0	4.8	27.2	-	6.2	1.23	0.08	2.0	7.4	3.9	1.3	0.1	0.2	5.5	0.27	74
2BC1	83-131	50.2	13.8	36.0	-	6.6	1.48	0.11	1.7	8.5	5.2	1.9	0.1	0.2	7.4	0.24	87
2BC2	131-156	62.6	15.6	21.8	-	6.6	1.31	0.13	1.8	6.4	3.9	1.5	0.1	0.2	5.7	0.29	89
2BC3	156-169	73.1	10.1	16.8	-	6.8	1.84	0.17	1.0	3.9	2.5	0.8	0.0	0.1	3.4	0.23	87

Table 2. Available nutrient status of the surface soils of selected pedons

Soil series	Available nutrients (kg ha^{-1})			Available micronutrients (mg kg^{-1})			
	N	P_2O_5	K_2O	Fe	Mn	Zn	Cu
1	367.5	94.1	38.3	13.99	19.07	0.48	0.60
2	319.6	295.2	171.8	21.83	7.92	0.68	1.66
3	191.8	83.7	74.8	18.40	21.60	0.38	0.66
4	335.6	385.0	148.0	35.22	9.68	0.80	2.92
5	207.7	14.0	192.1	50.32	11.32	1.40	0.58
6	191.8	10.3	52.6	29.00	8.20	0.76	0.32
7	271.7	28.7	107.5	10.22	17.70	1.56	0.28
8	383.5	243.0	48.6	15.74	96.45	1.04	0.62
9	287.6	58.8	149.1	34.64	21.83	1.74	0.48
10	287.6	19.6	137.1	26.24	35.86	1.82	0.42
Mean	284.4	123.2	117.3	25.56	24.96	1.07	0.85

N: Low-<280 kg ha^{-1}, Medium-280-560 kg ha^{-1}, High- > 560 kg ha^{-1}, P: Low-<20 kg ha^{-1}, Medium-20-50 kg ha^{-1}, High- >50 kg ha^{-1}, K: Low-<150 kg ha^{-1}, Medium-150-300 kg ha^{-1},

***Micronutrients:** Deficient: **Cu**- <0.2, **Fe**-<2.5, **Mn**- <2.0, **Zn**-Low-<0.5, Marginal 0.5-0.75, Adequate 0.75-1.5, High->1.5 ppm*

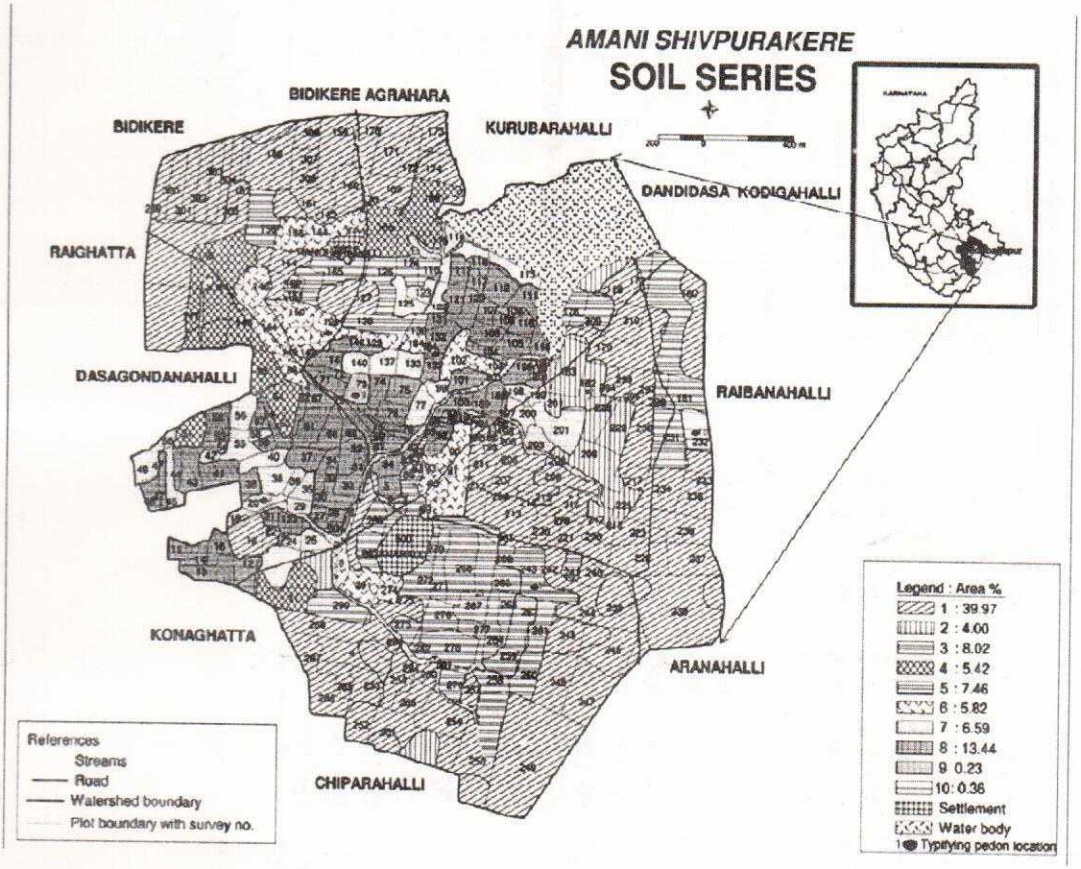

Fig. 1 Soil map of Amani Shivpurakere watershed

The pH of surface soils ranged from 5.0 to 7.3., EC from 0.20 to 1.23 dS m^{-1} and CEC from 1.0 to 11.8 cmol (p+) kg^{-1} (Table 1). The low CEC of soil series 1 to 4 is due to low activity clay. Organic carbon content ranged from 1.2 to 6.0 g kg^{-1} in surface layers. Organic carbon, pH and CEC in soils of different pedons did not follow a regular trend but decreased with depth. Sum of exchangeable bases (Ca, Mg, K and Na) in surface layers ranged from 1.0 to 11 cmol(p+)kg^{-1}.

The soils of series-1 had argillic B horizon and are classified as fine, mixed Kandic Paleustalfs. These soils are poor in organic carbon, slightly acidic, rich in phosphorus, poor in potassium and adequately supplied with micronutrients (Table2). These soils occupy nearly 40 per cent of the watershed area. The soils of series-3 (Fine, mixed Typic Kanhaplustalfs) had 45-50 per cent gravels in last two horizons and have a well developed argillic B horizon with low CEC per kg clay. These soils are rich in potassium and cover 8 per cent of the watershed area. The soils of series-5 (Typic Rhodustalfs) had gravel content of 30-70 per cent (beyond 100 cm) with a well developed argillic B horizon and cover an area of 7.5 per cent. The soils of series-7 were very deep and had dark brown (10YR) surface horizon and sub-surface horizons in 2.5Y to 10 YR hue with value 2 to 6 and chroma 0 to 6. These soils are slightly to moderately alkaline, medium in organic matter content but poor in zinc. These soils cover an area of 6.5 per cent of the watershed. The soils of series (1 to 6) were classified as Alfisols owing to the presence of argillic or kandic horizon. Sub-surface horizon had CEC of 16 cmol (+) or less per kg clay and an apparent ECEC of 12 cmol (+) or less per kg clay in 50 per cent or more of its thickness between the point where the clay increase requirements are met.

Though the Bangalore plateau receives a low amount of rainfall (889 mm), the short period of rainfall and the gently sloping topography contributed to the desilication process in upper part of the soil profiles and active laterization process due to reduced moist environment in lower depths almost through out the year coupled with fluctuation of water table (Natrajan 1995). Here, the lateritic soils occur in vast gently sloping midlands in contrary to the observations of Brunner (1968) that lateritic soils generally formed in East Mysore plateau due to fluctuating water table in the depressions of the landscape.

Agronomic and soil conservation measures are urgently needed to combat soil erosion and arrest the formation of rills and gullies. Some of the important measures are mulching to prevent crust formation, *in-situ* conservation of soil moisture, scientific crop planning, legal stopping of sand mining from land surface.

Very deep non-gravelly soils of the watershed (Soil series 1, 2, 3 & 4) are excellent for crop production if nourished with limiting nutrients and life saving irrigation wherever possible. Very deep soils which are marginally suitable for crop production (soil series 5 and 6) can be restricted to its present land use i.e. forestry or eucalyptus plantations or may be put to horticulture or bio-fuel plantation crops under suitable agronomical interventions. Lower sector soils (soil series 7 and 8) can be continued with their present land use to rice, ragi and vegetables cultivation and coconut on field bunds with application of sulphur. Degraded soils (soil series 9, 10) having limited extent and can be used as grazing lands, poultry farms, bio-fuel or eucalyptus plantations.

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