Characterisation and classification of soils of Lower Palar - Manimuthar Watershed of Tamil Nadu

V. Arunkumar, S. Natarajan and R. Sivasamy

Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore 641 003, India

Abstract

The IRS-IB-LISS-II FCC corresponding to the Survey of India toposheets 58 J/12, 58 J/16 and 58 K/9 were interpreted for soil resource studies in Lower Palar-Manimuthar watershed, Tamil Nadu, and soil map was prepared after field and laboratory studies. Based on the morphological, physical and chemical properties, ten soil series were identified and classified according to US Soil Taxonomy. The clay content ranged from 4.9 to 42.8 per cent. Soil reaction ranged from strongly acidic to strongly alkaline. The soils were low in organic carbon content. Surface horizons had CEC values ranging from 14.8 to 20.5 cmol(+) kg^{-1}.

Additional keywords : Soil resources, landforms, soil characteristics and classification

Introduction

Timely and reliable information on soils with respect to their nature, extent, spatial distribution, potential and limitation is very crucial for optimal utilization of natural resources on a sustained basis. Soil surveys provide such information. Remote sensing enables faster and accurate land-use mapping and has proved to be the most efficient, economical and reliable technique to prepare a comprehensive inventory of soil resources and land-use pattern of an area (Ahuja *et al*. 1992; Suresh Kumar *et al*. 1998). The present study was carried out to characterise and classify the soils of Lower Palar-Manimuthar watershed, Tamil Nadu using remote sensing techniques.

Materials and methods

The study area lies between 9° 7' 36" and 10° 3' 07" N latitudes and 78° 32' 43" and 78° 48' 23" E longitudes and covers an area of 38,824 ha in Sivaganga and Pudukkottai districts of Tamil Nadu (Fig. 1). The mean annual rainfall is 710 mm. The mean annual air temperature is 28.7°C. The mean maximum and minimum temperatures are 33.9°C and 23.4°C, respectively. The soil temperature regime is *'isohyperthermic'* and moisture regime is *'ustic'*.

The IRS-IB LISS II-FCC geocoded imageries on 1:50,000 scale of April 1994 corresponding to the Survey of India toposheets 58 J/12, 58 J/16 and 58 K/9 were visually interpreted and physiography map with 17 units was prepared. Sample strips were selected for ground truth. Pedons were examined and morphological

TAMILNADU

Andhra

Karnataka

Bay of
Bengal

Kerala

Palk strait

Gulf of mannar

STUDY AREA

Indian ocean

Trichy

Thanjavur

BAY OF
BENGAL

Dindigul

PUDUKKOTTAI

Madurai

SIVAGANGAI

PALK STRAIT

Virudhunagar
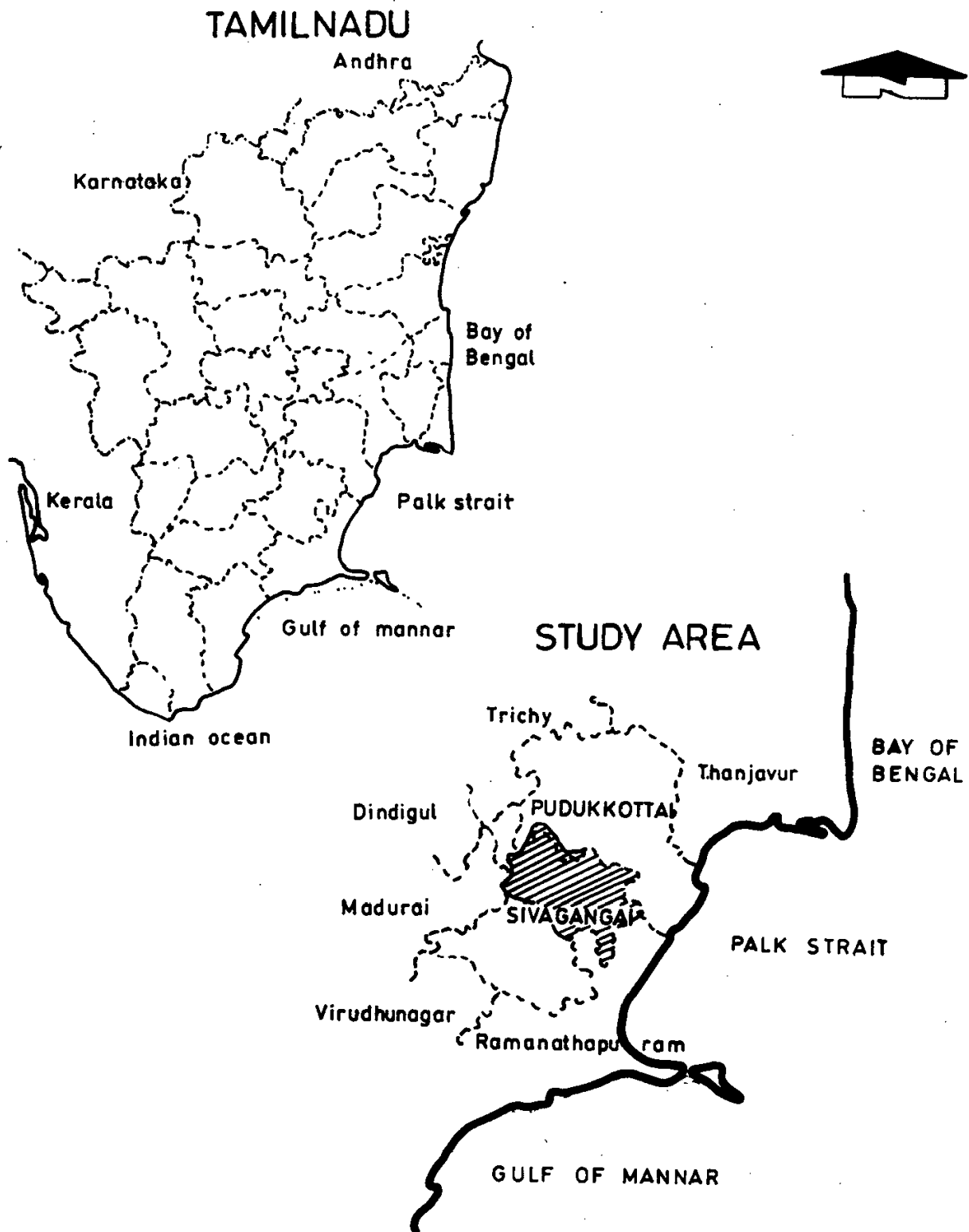
Ramanathapuram

GULF OF MANNAR

Fig. 1. Location map of study area

characteristics were described. Horizon-wise soil samples were collected, processed and analysed for various physical and chemical properties (Jackson 1973; Piper 1966). The soils were classified as per US Soil Taxonomy (Soil Survey Staff 1996).

Results and discussion

Physiography and soils

Based on profile study in sample areas, ten soil series were identified in the study area. They were Neman series (P1), Pillamangalam series (P2), Sirukudalpatti series (P3), Nedumaram series (P4), Vengalur series (P5), Kunnakudi series (P6), Puthirapatti series (P7), Kandavirayanpatti series (P8), Naduvakottai series (P9) and Melkudi series (P10).

The study showed a close relationship between physiography and soils of the area. Among the ten soil series, Nemam, Pillamangalam, Sirukudalpatti and Nedumaram series occured in the undulating plains; Vengalur, Kunnakudi, Puthirapatti and Kandavirayanpatti series in the uplands and Naduvakottai and Melkudi series in the level lands.

Morphological properties

The solum depth (Table 1) varied from shallow to deep. The soils on the level land were deeper compared to the soils of undulating plains and uplands. The surface colour of all the pedons varied from 2.5 YR to 10 YR. The subsurface colour of the pedons P1 and P3 had a hue of 2.5 YR because of the presence of free iron oxides (Singh *et al.* 1995). The subsurface colour of uplands of P5, P6 and P7 registered 2.5 YR and 7.5 YR due to hydrated and unhydrated iron oxides.

Soil structure varies from weak to strong, granular to subangular blocky. Pedon P1 had weak structure in the surface and subsurface whereas the pedons P3, P4 and P5 recorded weak structure in the surface layers only. All the pedons except P1 showed well developed structure in the subsurface indicating moderate to high degree of soil development (Sharma *et al.* 1997). Occurrence of clay films in sub-surface layers of the pedons P3, P5, P6, P7 and P9 was observed. Surface cracks, pressure faces and mottles were noticed in subsoils of P10.

Physical properties

Generally gravel and sand contents were higher in the soils of the uplands and plains whereas silt and clay contents were higher in level lands. Soils of the undulating plain possessed sand to sandy clay loam texture and that of uplands varied from sand to clay. The soils occurring on plain had loam to sandy loam texture and recorded higher clay content than upland soils because of deposition of finer fractions from the uplands (Table 1).

Table 1. Morphological, physical and chemical properties

Horizon	Depth (cm)	Colour	Text	Structure	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	pH (1:2)	EC dSm^{-1}	OC (%)	CaCO$_3$ (%)	CEC c mol (+) kg^{-1}	Exchangeable cations Ca	Mg	Na	K	BSP	ESP
Pedon 1 : Nemam Series																			
A$_p$	0-24	2.5 YR 4/6	sl	flgr	40.0	82.3	0.9	16.7	4.5	0.1	0.2	0.06	16.2	3.6	2.9	0.2	0.1	42.3	0.7
Al$_2$	24-46	2.5 YR 4/6	sl	flgr	44.8	84.4	0.9	14.7	4.4	0.1	0.3	0.07	15.6	3.6	2.9	0.3	0.2	44.5	1.1
Al$_3$	46-110	25 YR 4/6	sl	flgr	43.9	86.5	1.2	12.3	4.1	0.1	0.1	0.08	13.5	3.1	2.7	0.2	0.1	46.0	1.1
Pedon 2 : Pillamangalam Series																			
A$_p$	0-15	10 YR 4/3	scl	m2sbk	20.2	71.5	2.7	25.8	8.5	0.1	0.3	3.01	20.5	9.3	5.5	0.2	0.4	75.2	1.8
Bk$_1$	15-46	10 YR 5/6	scl	c3sbk	20.5	76.9	0.8	22.2	8.0	0.1	0.4	3.46	19.8	10.3	4.7	0.2	0.3	78.5	1.5
Bk$_2$	46-75	10 YR 5/8	scl	m3sbk	23.5	73.1	1.7	25.2	7.8	0.1	0.3	2.33	20.3	10.3	4.6	0.3	0.3	76.4	1.6
Bk$_3$	75-110	10 YR 5/6	sl	m3sbk	22.1	79.3	2.4	18.3	9.0	0.1	0.2	2.46	17.2	10.1	4.0	0.4	0.7	87.9	3.9
Pedon 3 : Sirukudal patti Series																			
A$_p$	0-14	10 YR 4/6	sl	flgr	10.7	81.8	1.9	16.2	5.9	0.02	0.3	0.20	16.3	4.8	3.4	0.2	0.3	53.5	1.6
B$_w$	14-47	2.5 YR 3/6	scl	m1sbk	20.6	79.1	2.0	18.4	5.2	0.02	0.2	0.21	18.3	6.0	4.1	0.2	0.2	57.6	1.4
B$_t$	47-102	2.5 YR 3/6	sc	m2sbk	11.8	67.2	1.2	31.5	5.9	0.05	0.2	0.26	21.3	8.9	5.5	0.1	0.3	69.7	1.4
Pedon 4 : Nedumaram series																			
A$_1$	0-13	10 YR 5/3	s	flsgr	7.2	94.2	0.9	4.9	8.9	0.1	0.2	2.79	17.3	8.5	5.0	0.5	0.2	82.1	1.0
C$_1$	13-25	10 YR 5/3	s	flsgr	12.7	94.0	1.1	4.8	9.2	0.1	0.3	2.91	16.9	8.9	5.0	0.4	0.3	87.1	2.1
C$_2$	25-34	10 YR 5/1	s	flsgr	26.4	94.8	0.8	4.4	9.8	0.1	0.3	2.99	16.3	7.8	4.6	0.4	0.4	81.1	2.8
2B$_w$	34-51	10 YR 5/2	scl	m3sbk	49.5	74.8	6.2	18.9	9.6	0.3	0.2	0.91	19.7	10.7	6.0	0.4	0.7	90.0	3.3
3Bw$_1$	51-72	10 YR 6/2	sl	m3sbk	18.4	82.1	4.9	12.9	10.1	0.3	0.2	0.91	18.3	9.3	2.5	0.3	0.3	83.9	17.8
3Bw$_2$	72-101	10 YR 6/2	scl	m3sbk	24.3	60.1	14.6	25.3	9.7	0.3	0.1	3.33	23.2	14.1	6.4	0.2	0.9	93.5	4.2

-- contd. --

Pedon 5 : Vengalur series

Horizon	Depth	Color	Tex	Struct															
Bt$_1$	0-11	2.5 YR 3/6	c	massive	15.4	54.4	2.7	42.8	5.6	0.1	0.3	0.31	14.8	4.8	3.5	0.2	0.2	59.6	1.5
Bt$_2$	11-35	2.5 YR 3/6	c	m2sbk	27.3	57.3	3.8	38.9	5.9	0.1	0.4	0.38	16.3	6.0	4.0	0.2	0.3	64.4	1.6
Bt$_3$	35-96	2.5 YR 3/6	c	m2sbk	46.4	59.5	3.7	36.7	6.0	0.1	0.3	0.42	19.6	8.0	5.0	0.2	0.3	68.9	1.5

Pedon 6 : Kunnakudi series

Horizon	Depth	Color	Tex	Struct															
A1	0-11	2.5 YR 3/6	sl	mlsbk	20.5	83.8	6.0	10.1	5.0	0.1	0.1	0.03	15.4	4.1	3.0	0.4	0.2	50.1	1.3
Bw$_1$	11-31	5 YR 4/6	sl	mlsbk	24.8	74.6	6.8	18.6	4.60	0.1	0.3	0.06	16.3	4.6	3.1	0.4	0.2	51.4	1.5
Bw$_2$	31-42	2.5 YR 4/8	sl	mlsbk	48.6	74.4	5.8	19.8	4.6	0.1	0.31	0.10	17.20	5.00	2.93	0.31	0.38	49.53	1.62
Bt	42-97	2.5 YR 4/8	scl	mlsbk	62.8	73.3	3.3	23.4	4.1	0.1	0.25	0.12	1//9.8	4.5	3.8	0.2	0.2	44.1	1.1

Pedon 7 : Puthirapatti series

Horizon	Depth	Color	Tex	Struct															
A$_1$	0-13	10 YR 3/8	sl	m2sbk	17.8	81.7	6.1	12.2	5.4	0.3	0.4	0.10	15.4	4.6	3.4	0.2	0.3	55.2	1.7
Bt$_1$	13-26	7.5 YR 4/6	scl	flsbk	13.0	78.6	2.2	19.2	5.2	0.1	0.4	0.12	17.3	7.8	2.0	0.2	0.2	59.1	1.0
Bt$_2$	26-43	7.5 YR 4/4	scl	m3sbk	39.0	73.9	1.8	24.2	5.3	0.1	0.3	0.14	19.3	8.0	5.0	0.3	0.2	70.3	0.9
Bt$_3$	43-66	10 YR 4/4	scl	m2sbk	26.2	66.5	9.4	24.0	5.9	0.1	0.3	0.12	19.6	9.5	4.4	0.3	0.1	72.9	0.7

Pedon 8 : Kandavirayanpatti series

Horizon	Depth	Color	Tex	Struct															
A$_p$	0-12	10 YR 4/6	s	flgr	28.0	88.5	2.6	8.9	7.5	0.4	0.4	0.32	17.4	7.7	4.6	0.5	0.2	74.9	1.1
B$_w$	12-56	7.5 YR 4/4	sl	flgr	40.7	85.0	2.8	11.6	8.6	4.2	0.3	0.41	18.2	5.8	2.0	0.3	4.1	67.4	22.5

Pedon 9 : Naduvakottai series

Horizon	Depth	Color	Tex	Struct															
A$_p$	0-14	10 YR 3/4	scl	c3sbk	21.9	66.28	9.2	24.5	8.5	0.2	0.3	0.92	15.8	4.5	1.6	0.4	2.8	59.3	18.0
B$_w$	14-38	10 YR 3/4	scl	c3sbk	31.5	65.35	8.0	26.6	9.0	0.7	0.3	1.16	20.2	7.0	2.5	0.3	6.8	82.1	33.5
B$_t$	38-76	10 YR 3/4	sc	m2sbk	22.4	60.38	7.2	32.4	8.8	1.5	0.2	1.60	22.7	8.5	4.0	0.3	5.5	80.6	24.3

Pedon 10 : Melkudi series

Horizon	Depth	Color	Tex	Struct															
A$_p$	0-10	10 YR 3/3	l	flsbk	17.5	67.3	14.1	18.6	7.8	0.1	0.3	2.14	18.2	6.0	2.0	0.5	4.6	72.4	25.5
Bwk$_1$	10-29	10 YR 4/3	scl	m2sbk	28.0	67.3	7.0	25.6	9.0	0.3	0.3	2.48	23.9	9.5	3.1	0.4	6.5	81.8	27.2
Bwk$_2$	9-61	7.5 YR 4/4	scl	mlsbk	35.0	73.4	2.2	24.4	7.2	0.1	0.3	2.14	21.2	10.5	6.0	0.4	6.5	81.8	2.2
Bwk$_3$	61-109	10 YR 3/3	c	c3sbk	32.5	50.2	11.2	38.6	9.8	1.1	0.2	1.91	23.0	9.2	4.1	0.4	6.7	88.9	29.3

Texture : s-sand; sl - sandy loam; scl - sandy clay loam; sc - sandy clay; c - clay.
Structure : m-medium; f - fine; 1-weak; 2-moderate; 3-strong; gr-granular; sbk - subangular blocky

Chemical properties

The soils are strongly acidic (pH 4) to strongly alkaline (pH 10) in reaction and this wide variation is attributed to the nature of parent material, leaching, presence of calcium carbonate and exchangeable sodium. Electrical conductivity was less than 1.0 dS m^{-1} except in pedons P8, P9 and P10 which showed the accumulation of soluble salts in the subsoils.

The free calcium carbonate content varied from 0.03 to 3.5 per cent. The pedons P2, P4, P9 and P10 contained free calcium carbonate in the form of concretions and nodules. The precipitation of calcium carbonate from the solution rich in carbonate was facilitated by the high pH values (Sahu and Mishra 1997). The organic carbon content was low (less than 0.5%) in all the pedons.

Cation exchange capacity and extractable bases vary considerably among the soils. The cation exchange capacity varied from 13.5 to 23.9 cmol(+) kg^{-1}. A significant correlation coefficient (r=0.450) between clay and CEC suggests that clay contributes to CEC in these soils. In all the soils, calcium was the predominant cation followed by magnesium, sodium and potassium.

Classification of the soils

Based on the properties, the soils were grouped under the orders *viz.* Entisol, Inceptisol and Alfisol. The pedons P1 and P4 were placed under Entisols as they did not exhibit any diagnostic subsurface horizon and characterised as Orthents and Fluvents respectively. They were placed under Ustorthents and Ustifluvents subgroup due to 'ustic' soil moisture regime.

The pedons P2, P8 and P10 were grouped under Inceptisols. The pedons P2 and P8 qualified for Typic Ustropepts as they possess a cambic subsurface horizon. The pedon P10 was classified as Vertic Ustropepts as it showed vertic properties. The pedons P3 and P5 were placed under Typic Rhodustalfs as it contained argillic horizon with a matrix colour of 2.5 YR. The pedons P6 and P7 had well developed argillic horizon with less than 75 per cent base saturation and therefore classified as Ultic Haplustalfs. The pedon P9 qualified for Typic Natrustalfs subgroups as they possessed argillic horizon and ESP of more than 15.

References

Ahuja, R. I., Manchanda, M. L., Sangwan, B.S., Gopal, V. P., and Agrawal, R. P. (1992). Utilisation of remotely sensed data for soil resource mapping and its interpretation for land use planning of Bhiwani district, Haryana. *Journal of Indian Society of Remote Sensing* **20**, 105-120.

Jackson, M. L. (1973). 'Soil Chemical Analysis'. (Prentice Hall of India pvt. Ltd : New Delhi)

Piper, C. S. (1966). 'Soil and Plant analysis'. (Interscience publication : New York).

Sahu, G. C., and Mishra, K. N. (1997). Morphology and characteristics of soils of an irrigated river flood plain soils of eastern coastal region. *Journal of the Indian Society of Soil Science* **45,** 152-156.

Sharma, B. D., Sidhu, P. S., Rajkumar, and Sawhney, J. S. (1997). Characterization, classification and landscape relationship of Inceptisols in north west India. *Journal of the Indian Society of Soil Science* **45,** 167-174

Singh, S.K., Das, K., Shyampura, R. L., Giri, J.D., Singh, R. S., and Sehgal, J. L. (1995). Genesis and taxonomy of black soils from basalt and basaltic alluvium in Rajasthan. *Journal of the Indian Society of Soil Science* **43,** 430-436.

Soil Survey Staff. (1996). 'Keys to Soil Taxonomy', Seventh Edition (USDA : Washington, D.C.)

Suresh Kumar, Arya V. S., Subrahmanyam, C., Prasad, Jitendra, and Pande, L. M. (1998). A remote sensing approach in appraisal of soils for sustainable land use plan - A case study in semi-arid region. *Agropedology* **8,** 101-106.