Agric. Res, J. Kerala 1985, 23 (1) 9—16

MORPHOLOGY AND PARTICLE SIZE DISTRIBUTION IN THE SOIL PROFILES FROM A CATENA IN KERALA*

V. K, Venugopal and M. M. Koshy'

College of Horticulture, Vellanikkara 680654
Trichur, Kerala

Attempts have been made by pedologists to study association between soil orders, either as a catena or as an association in relation to topography. Special mention may be made of the work carried out by Nye (1 955), Biswas and Gawande (1962) and Martini and Mosquero (1972).

Kerala state is an area of great geomorphological contrasts with predominantly undulating topography. Considerable variations are observed in the soils and cropping pattern which are primarily influenced by topography a factor which has not been given due consideration in analysing the problems and perspective of agricultural development in the state. The earliest attempts to study formation of Kerala soils in relation to factors of soil formation was by Koshy (1962). The present study was undertaken with a view to bring out the differences in profile morphology and mechanical composition of a transect extending from crest of the hill to valley,

Materials and Methods

The investigations were carried out in a catena located in Poruvazhy village of Kunnathur taluk in Quilon district. The site lies lattitude and 76°39' and 76°42'E longitude. The transect feeWfVietres Extending from crest to valley. One soil profile each was excavated on the four diverse group of soils identified in the crest, upper mid-slope, nearly level lower slope and valley portions of the transect. The morphological features wereobserved and recorded as per Soil Survey Manual (1951). Soil samples representing the different horizons from the profile were collected for laboratory characterisation. The mechanical analysis was carried out by the International Pipette method (Wright, 1934).

Results and Discussion

A cross section of the topossquence is depicted in Fig. 1. Brief comparative morphological features of the profile are given in Table 1.

The colour of the surface horizons of the profile located in the transect from crest to valley bottom (4 profiles) varied from yellowish red (5 YR 4/6) to very dark greyish brown (10 YR 3/2). A decrease in the chroma was observed from crest to valley. A striking gradation in colour from reddish in the crest to different shade of grey for the lower slope members was observed. The greyish colour was found to intensify with depth in the profiles of the lower physiographic positions. This has been attributed to progressive decrease in drainage conditions within the

* Part of Ph. D. thesis submitted by first author to the Kerala Agricultural University, 1980.

1 College of Agriculture, Vellayani 695 522, Trivandrum, Kerala

Table 1

Abbreviated morphological description of soil profiles

Horizon	Depth (cm)	Munsell notation Dry	Moist	Texture	Structure	Consistence	Boundary
Profile I (Crest)							
AP	0-25	5 YR 5/6	5 YR 4/6	sc	$m_2$sbk	dsh, mfr ws, wp	cs
A_1	25-40		5 YR 4/6	gcl	$m_2$sbk	mfr, ws, sp	gw
B_{21}	40-60		5 YR 4/6	gsc	$m_2$sbk	mfi, ws, wp	gw
B_{22}	60-130		2.5 YR 3/6	gc	$m_3$sbk	mfi, ws, wp	
C	130-158+		Hard quarriable laterite				
Profile II (upper mid slope)							
AP	0-18	2.5 YR 4/6	2.5 YR 5/6	sl	$m_2$gr	mfr, wss, wps	cs
B_2	18-76		2.5 YR 4/8	sc	$m_2$sbk	mfi, ws, wp	dw
B_3	76-148+		2.5 YR 3/6	l	$m_2$sbk	mfi, ws, wp	
Profile III (Nearly level lower slope)							
AP	0-20	10 YR 6/4	7.5 YR 4/4	sl	$m_1$sbk	mfr, wss, wpo	cs
B_2	20-56		10 YR 4/4	scl	m.sbk	mfi, ws, wps	dw
II C_1	56-81		10 YR 4/6	ls	ma	mfr, wss, wpo	dw
II C_2	81-102		10 YR 5/2	sl	ma	mfr, wss, wps	
Profile IV (valley)							
AP	0-15	—	10 YR 3/2	sl	ma	mfr, wso, wpo	cs
B_1	15-23		10 YR 4/1	sl	$m_2$sbk	mfi, wss, wpo	gw
B_2	23-56		10 YR 3/1	scl	ma	mfr, ws, wps	dw
C_1	56-79		2.5 YR 6/0	sl	ma	mfi, wss, wpo	dw
II C	79-96+	—	2.5 Y 5/0	c	ma	mvfi, wvs, wvp	

FIG DIAGRAMATIC REPRESENTATI OF PROF LES IN A TOPOSEQUENCE
LOCATION – P UVAZHY

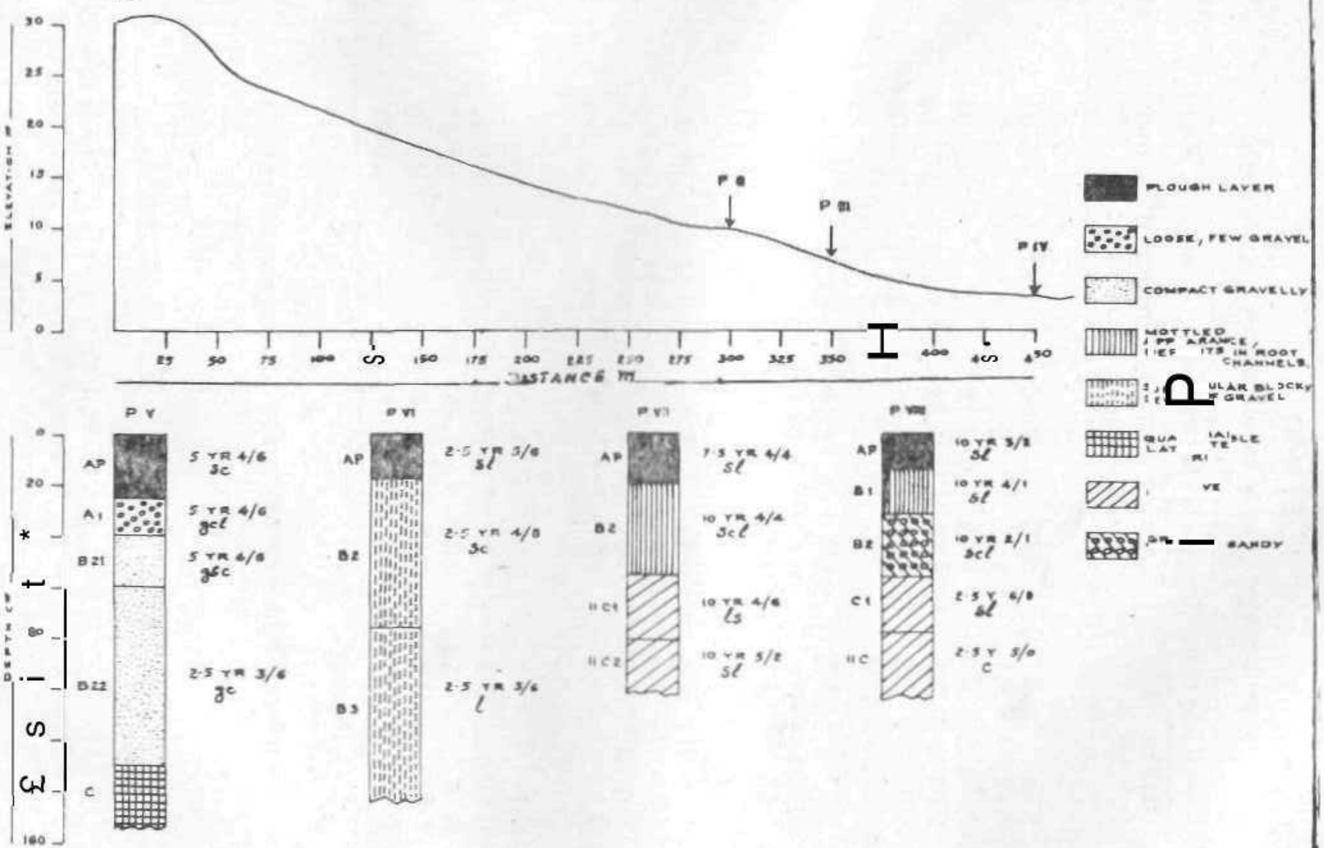

Table 2

Mechanical composition of soils of foposequence

Sample	Depth (cm)	Coarse fragment > 2 mm %	Mechanical analysis <2 mm soil basis Coarse sand %	Fine sand %	Silt %	Clay %	Fine sand Coarse sand %
Profile I							
1	0-25	13.2	36.4	24.6	1.5	37.9	0.68
2	25-40	22.4	36.9	23.9	7,3	29,1	0.49
3	40-60	77.9	31.3	20.8	0.5	41.1	0.67
4	60-130	85.0	25.6	17.6	4.6	48.2	0.69
5	' 130-158	45.8	53.1	15.2	8.2	13.8	0.29
Profile II							
6	0-18	6.3	44.9	19.9	8.4	19.7	0.44
7	18-76	—	43.2	15.8	3.1	34.3	0.36
8	76-148 +	—	38.4	17.8	25.5	16.4	0.46
Profile III							
9	0-20	13.4	49.4	25.5	9.1	12.7	0.52
10	20-56	12.9	42.6	28.1	6.6	18.3	0.66
11	56-81	10.8	49.7	25.2	13.9	6.3	0.51
12	81-102+	3.4	48.4	24.7	7.1	14.8	0.51
Profile IV							
13	0-15	—	54.4	15.8	6.2	11.9	0.46
14	15-33	—	55.6	26.7	4.0	12.6	0.48
15	33-56	—	46.7	23.6	2.5	22.9	0.50
16	56-79	—	61.2	21.1	0.5	15.1	0.34
17	79-96+	—	19.3	7.6	6.3	61,1	0.39

Table 3

Mechanical composition of soil (Mean values for profiles)

Sl. No.	Constituent		Profiles I	II	III	IV
1	Coarse fragments	(%)	48.9	2.1	10.1	Nil
2	Coarse sand	(%)	36.7	42.2	47.5	47,4
3	Fine sand	(%)	20,4	17.8	25.9	18.9
4	Silt	(%)	4.4	12.4	92	3.9
5	Clay	(%)	34.0	23.4	12.0	24.7
6	Fine sand/ coarsesand		0.59	0.42	0.55	0.43

Table 4

Mechanical composition of soils (Range values for toposequence)

Sf. No.	Constituent		Maximum value	Sample No.	Minimum value	Sample No.
1	Coarse fragments	(%)	85	4	Nil	13
2	Coarse sand	(%)	61.2	16	19.3	17
3	Fine sand	(%)	26.7	14	7.6	17
4	Silt	(%)	25.5	8	0.5	16
5	Clay	(%)	61.1	17	6.3	11
6	Fine sand/ coarsesand		0.69	4	0.29	5

profile due to changing physiography and consequent changes in water table. Thus the soils of the upper slope members were well drained, while imperfectly drained soils were observed in the valley. The soils of the valley exhibited, aquic characters like grey colour, mottles and characteristic grey colours in the lower most layers. Similar observations on graditional changes in soil colour in consonance with differential drainage have been made by Biswas and Gawande (1962) in the toposequence in Madhya Pradesh and Webster (1965) in a Rhodesian catena. The redder hues of the upper slope members are evidently due to the presence of oxidised forms of iron under well drained conditions (Sombroek, 1966).

The structure of the surface soils of the crest were subangular blocky while those of the valley was massive. A down slope decrease in structural development with complete absence of structure in the valley was observed. The diminution in soil structure and profile differentiation of the lower slope members is indicative of aggradational and degradational changes of soil material in the nearly level slope member. The complete submergence of the valley profile during monsoon hinder proper structure development On the other hand the profile at the crest and upper mid-slope have all the necessary conditions for development of structure as revealed by their profile morphology. Lack of poor structure development in the lower slope members as observed in the present study has been reported by Martini and Mosquero (1972) in a toposequence in Costa Rica which was attributed to rejuvenation of landscape by various phenomena. Similar observations were also made by Webster (1965) in a Zambian toposequence.

The coarse fragments in the sequential profiles of the catena showed a tendency to decrease down slope and it varied from 0 to 85 per cent The mean values for the gravel in profiles showed maximum (48.9%) in the crest profile, while the valley sons were totally devoid of gravel. Between the upper mid slope and the nearly level lower slope, the latter recorded higher values. Accumulation of ferrugenous gravel in the crest profile was maximum in the B_{22} horizon, which on field examination revealed very compact nature. This layer gradually merged with the hard laterite layer below. Mohr *et al.* (1 954) observed that the ferrugenous laterite gravel may be considered as a disintegration, product of fossilised laterite. Close observation of the gravel leads to the conclusion that they may be formed by dehydration of fragmented laterite debris. The sequential profiles of the toposequence have thus gravel free deep soils in the upper mid-slope and lower slope positions and gravel rich soils in the crest in close proximity. Carson and Kirkby (1978) observed that falling and flowing water exerted large forces on slope debris which are resisted by frictional and cohesive forces. The heavy rainfall of the study area and the combined effects of the static and dynamic causes of differentiation brought about by site differences and slope are responsible for the down slope transport of materials by soil creep and surface wash. The formation of deep soils with low gravel content can reasonably be attributed to the above processes. Such observations on toposequences have been reported by Sivarajasingham *et af.* (1962) and Rengaswamy *et al.* (1978).

The mechanical composition of the soils are presented in Table 2, and the mean values for profiles and the range values for toposequence are given in Tables 3 and 4,

The coarse sand fraction varied from 19.3 to 61.2%. Mean values of the crest and valley profiles showed an increase in the coarse sand fraction, the values recorded being 36.7 and 47.5 per cent respectively. In the case of the fine sand fraction, the variation was from 7.6 to 26.7 per cent. The mean values for the crest and valley profiles were 20.4 and 18,9 per cent. Accumulation of sand fraction in the nearly level tower slope position have been reported by Penck (1927) who concluded that surface wash was responsible for the distribution. The **silt** fraction did not show any fixed pattern of distribution in the toposequence and varied from 0,5 to 25,5 per cent.

The clay fraction varied from 6.3 to 61.1 per cent, the maximum being recorded in the last layer of the valley profile. The mean values for the crest and valley profiles were 34.0 and 24,7 respectively. Another significant observation is the accumulation of clay noted in the lower most layer of the valley profile. The intense rainfall in the area and the consequent erosion processes from the slope have resulted in horizontal movement of clay from the slopes and deposition in the valley. Subsequent intense leaching and illuviation through the upper sandy layers of the profile has resulted in deposition in the lower layers near the water table to form a clay pan. Nye (1955) working on an African catena observed increase in clay content at the level of the water table.

The ratio of fine sand/coarse sand varied from 0.29 to 0.69. The mean values of the crest and valley profiles were 0.59 and 0.43 respectively, indicating a decrease down slope. Similar observations have been reported by Ruhe and Walker (1968).

Thus the four diverse groups of soils identified in the toposequence have been the result of variations in topography, causing, erosion, colluviation sedimentation and other pedogenic processes modified by water table. The association of sequential profiles identified in the area are the result of catenary evolution by the processes described above and fall within the ambit of the definition of catena put Forward by Milne (1935).

Summary

Investigations on the morphology and mechanical composition were carried out in a toposequence located in the mid-upland laterite region of Kerala. The sequential profiles in the toposequence showed a striking gradation in colour from reddish in the crest to different shades of grey in the valley. The structural development showed a decrease down slope. Another significant observation was the striking decrease in the content of coarse fragments down the slope. Among the size fractions, sand tended to accumulate in the nearly level lower slope position, while clay fraction decreased down slope. The formation of the diverse group of soils have been attributed to the variations in topography, causing erosion colluviation, sedimentation and other pedogenic processes modified by water table.

സംഗ്രഹം

ലാറ്ററൈറ്റ് ഇനത്തിൽപ്പെടുന്ന കേരളത്തിലെ കരഭൂമിയിലുള്ള ഒരു 'ടോപ്പോസീക്വൻസ്' കേന്ദ്രമാക്കി, അതിന്റെ രൂപവും ചേരുവയും പഠനവിധേയമാക്കുകയുണ്ടായി. ഒരു 'ടോപ്പോസീക്വൻസി'ൽ അനുക്രമമായി കാണപ്പെട്ട ഭൂമിയുടെ ഓരോ പരിച്ഛേദികയും (പ്രൊഫൈൽ) നിറത്തിന്റെ കാര്യത്തിൽ പ്രത്യേകം ശ്രദ്ധേയമായി. അതായത്, നല്ല ചുവപ്പുനിറമായി കുന്നിൻ ചരിവുകളിലും മങ്ങിയ roloso-Bglrarl സമതലങ്ങളിലും അവ കാണപ്പെട്ടു. മറ്റൊരു പ്രധാനനിരീക്ഷണം ചരിവിനു താഴെ പരുപരുത്ത മണൽ ചരലുകളം കുറവാണെന്നതാണ്. എന്നാൽ ഏതാണ്ട് നിരപ്പായ സ്ഥലങ്ങളിൽ മണലിന്റെ അംശം മാത്രം കൂടിയിരിക്കുന്നതുകണ്ടു. ചരിവ് കൂടുംതോറും ചെളിയുള്ള മണ്ണ് കുറഞ്ഞുവരുന്നത് പ്രത്യേകം കാണപ്പെട്ടു. ഇതിൽ നിന്നും വിവിധ ഗ്രൂപ്പുകളിൽപ്പെടുന്ന മണ്ണ് രൂപം കൊള്ളുന്നതിൽ, സ്ഥലത്തിന്റെ ചരിവ്, മണ്ണൊലിപ്പ്, കൊളുവിയേഷൻ, സെഡിമെന്റേഷൻ എന്നീ പ്രവർത്തനങ്ങളുടെ സ്വാധീനം അതാത് സ്ഥലങ്ങളിലെ ജലവിതാനം നിയന്ത്രിക്കുന്നതായി മനസ്സിലായി.

Acknowledgement

The authors are grateful to the Kerala Agricultural University for financial assistance and other facilities provided for the study.

References

Biswas, T. D and Gawande, S. P. 1962. Studies in genesis of catenary soils of sedimentary formation in Chhatisgarh Basin of Madhya Pradesh. I. Morphology and mechanical composition. *J. Indian Soc. Soil Sci.* 13: 183-195

Carson, M. A, and Kirkby, H. J. 1978. *Hill Slope Form and Process.* Cambridge University Press

Koshy, M. M. 1962. Studies on formation, morphology, and chemistry of Kerala soils. Ph. D. thesis, University of Kerala

Martini, J. A. and Mosquera, L. 1972. Properties of five tropepts in a toposequence of humid tropics in Costa Rica. *Proc. Soil Sci. Soc. Am.* **36:** 473-477

Milne, G. 1935. Composite units for mapping of complex associations. *Trans 3rd int. Congr. Soil Sci.* 1: 345-47.

Mohr, E. C. J., Baren Van, F. A. and Schuylenborg Van, J. 1954. *Tropical Soils.* The Hague: Mouton, pp. 481

Nye, P. H. 1955. Some soil forming processes in humid tropics. III Laboratory studies on development of a typical catena over granite gneiss. *J. Soil Sci.* 6: 63-72

Penck, W. 1927. *Die Morphologische Analigte Stuteagart. Trans. 1953.* Macmillan, London

Rengaswamy, P., Sarma, U. A. K., Murthy, R. S. and Krishnamoorthy, G. S. R. 1978. Mineralogy, genesis and classification of ferrugenous soils of the eastern Mysore plateau, India. *J. Soil Sci.* 29 (3): 431-445

Ruhe, R. V. and Walker, P. H. 1968. Hill slope models and soil formation 1. open systems. *Trans. int. Congr. Soil Sci. 9th* 4: 557-60

Sivarajasingham, S., Alexander, L. T., Cady, J. G. and Cline, M. G. 1962. Laterite. *Adv. Agron.* 14: 1-60

Sombroek, W G. 1966, *Amazon Soils,* A reconnaissance of the Brazillian Amazon region Centre for Agricultural Publications and Documentation, Wageningen

Soil Survey Staff; 1951. *Soil Survey Mannual,* USDA *Hanb. No. 18.* Washington U, S. Government Printing Office

Webster, R. 1965. A catena of soils in northern Rhodesian plateau. *J. Soil Sci.* 16: 31-43

Wright, C. H. 1934. *Soil Analysis.* Thomas Murray and Co. London