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Effect of climate change on morphological characteristics of the soils of Vaigai River Basin, Alluvial Tract, Madurai District, Tamil Nadu

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Abstract
The pedological characterization of alluvial tract soils of Vaigai river basin, Madurai District, Tamil Nadu was taken during 2019-20. Initially a Reconnaissance Soil Survey was carried out with Toposheet as a base map. Totally nine representative pedons in Northern and Southern bank of the Vaigai river alluvial basin were selected and studied for their morphological characteristics. Along the course of Vaigai river basin, deposition of alluvial soil was evidenced by the poorly developed AC profiles in both side. The depth of the soil varied from d_4 to d_5 in both banks. The color of the pedons varies with hue ranging from 10YR to 7.5YR, value 2 to 6and chroma 2- 8 and in Northern bank ; from 10YR to 7.5YR,values varies by 2.5 to 6 and chroma by 1 to 6 in the Southern bank. The texture of soil varied from weak to structure less. Some yellowish brown mottles with jarosite were foundin the Northern bank and micaceous coatings found in the Southern banks. The calcium carbonate nodules were found in most of the pedons and the permeability of the soil was very rapid. Coconut, Banana and paddy are the major crops grown in this alluvial tract. Climate change, urbanization, is short of monsoon rain and industrialization had created the major impact on the shrinkage of land under cultivation and smash up the soil health. The present study on characteristics of alluvial tract of Vaigai River basin both in Northern and southern banks understood about the change due to anthropogenic activities and climate change scenario.

Keywords: Pedon, morphology, Vaigai River, alluvial, climate change

Introduction
The alluvial soil always remains a subject of prime concern from age old history owing to its fertility and diversified usage. In India, nearly 46% of total area is occupied by alluvial soil and contributes to nearly 40% of our agricultural production. Formed under transportation and sedimentation of fluvic cycle, specific pedogenic process endowed in the evolution of each pedon always varies from one another. Due to climate change over the years by periodic flooding, drying and change of river course, it undergoes a marked change in the soil characteristics. Alluvial soil lies on the bank of Vaigairiver which originates from the Varushnadu hills of Western Ghats and stretches to a length of 256km debouching at Bay of Bengal. A river basin soil characteristics depends on the underlying lithology, climate, topography and hydrodynamics of the river (Sharma *et al.*, 2020) [11]. Vaigai River enters the city at Cholavandhan on curvilinear path upto Sakkimangalam and then enters into Sivagangai to debouch at Bay of Bengal. On its way out creates typical landform features like alluvial fan, terraces, river basin etc. Henceforth, it is highly essential to gain a sound knowledge on soil fertility, limitation factors for crop husbandry and alternate land use planning in northern and southern bank of Vaigai river basin of alluvial soil due to climate change scenario. This paper clearly depicts the changes in pedon characteristics both in northern and southern bank of Vaigai river basin, Madurai District, Tamil Nadu in recent years.

Materials and Methods
Study area
The Vaigai river basin of Madurai district lies between 10°01'34.0"N 77°57'21.3"E and9°52'18.0"N 78°12'36.1"E.Geology underlying the basin comprises of Hornblende, Biotite Gneiss and Alluvium formed under Semi-arid tropical climate with annual precipitation of 84^0mm. The mean annual summer temperature ranges from 40 °C to 26.3 °C and the mean annual winter temperature ranges from 29.6 °C to 18 °C.Total area of district comprises of 3,741.73 sq. km of which 0.55% is occupied by alluvium.

Vaigai River on its course creates various landforms such as active floodplain, levee, river basin, terraces, and recent flood plain. Our study area focuses on the alluvial basins of Vaigai River. For better interpretation area had been classified under northern of the river comprises of Vadipatti and Madurai North taluk whereas the Southern bank covers Usilampatti and Madurai South region.

Methodology

Reconnaissance Soil Survey (RSS) was carried out by using toposheets, Land Sat Images, and GPS. Based on the variation in soil cover, nine pedons representing different physiographic features (Table 1 &2), landforms were selected on either side of the river basin as outlined by AIS&LUS (1970) [15]

Table 1: Location of the typical soil profile in Northern bank of the river

Pedon no	Location	Geo- coordinates	Elevation (m)
NP_1	Sholavandhan	10°01'16" N ; 77°57'39" E	174
NP_2	Thenur	9°59´6" N ; 78°0´17" E	153
NP_3	Samayanallur	9°58´37"N ; 78°01´57"E	150
NP_4	Sakkimangalam	9°52´41"N ; 78°11´28"E	123

Table 2: Location of the typical soil profile in Southern bank of the river

Pedon no	Location	Geo- coordinates	Elevation (m)
SP_1	Mannadimangalam	10°2´38"N; 77°55´48"E	182
SP_2	Keelamathur	9°58´7" N; 78°1´50" E	157
SP_3	Viraganur	9°54´11"N ; 78°09´42"E	126
SP_4	Puliankulam	9°52´41"N;78°10´48"E	129
SP_5	Silaiman	9°52´22"N;78°11´55"E	122

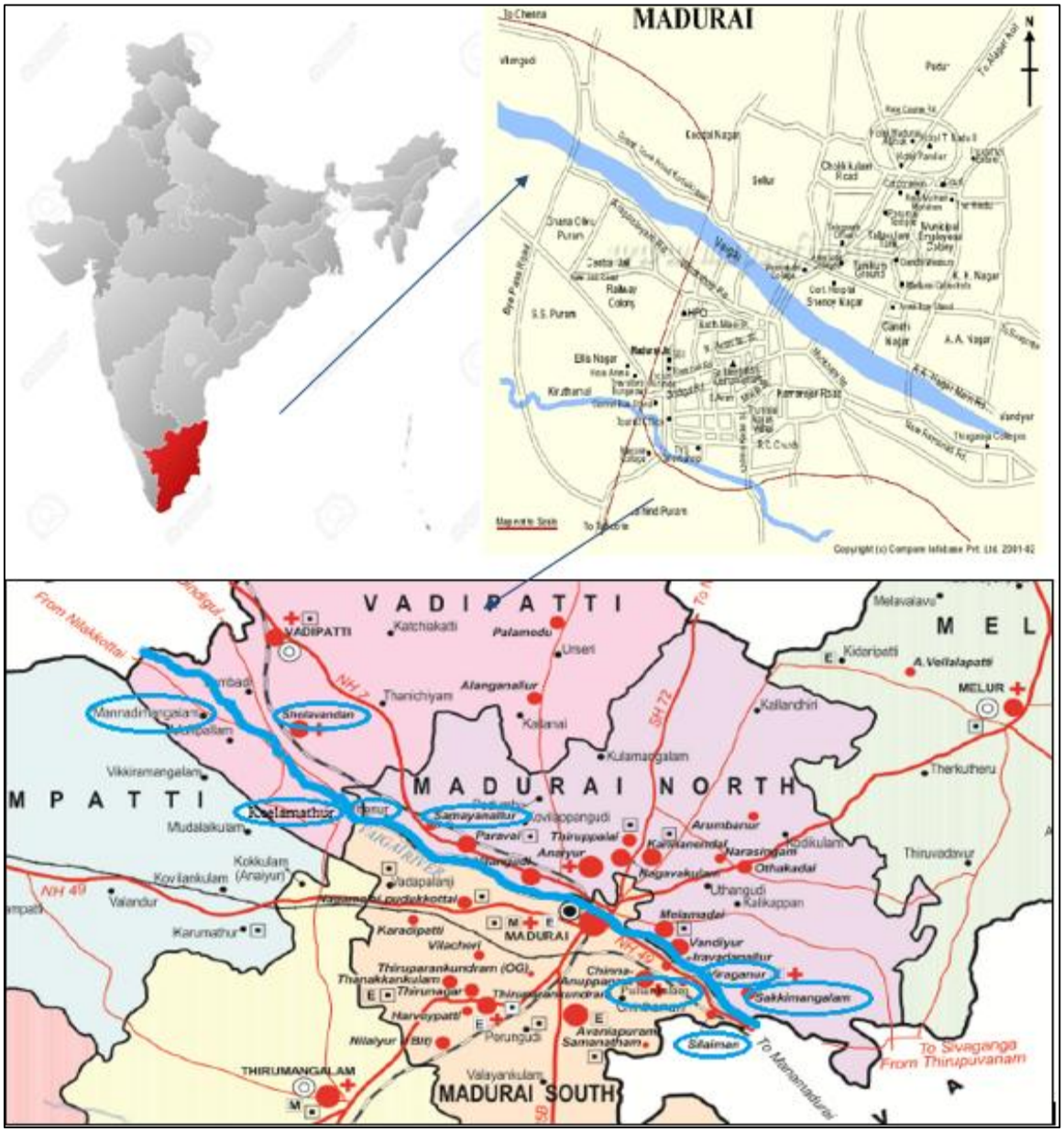

Fig 1: Location of the Study area- Madurai, Tamil Nadu

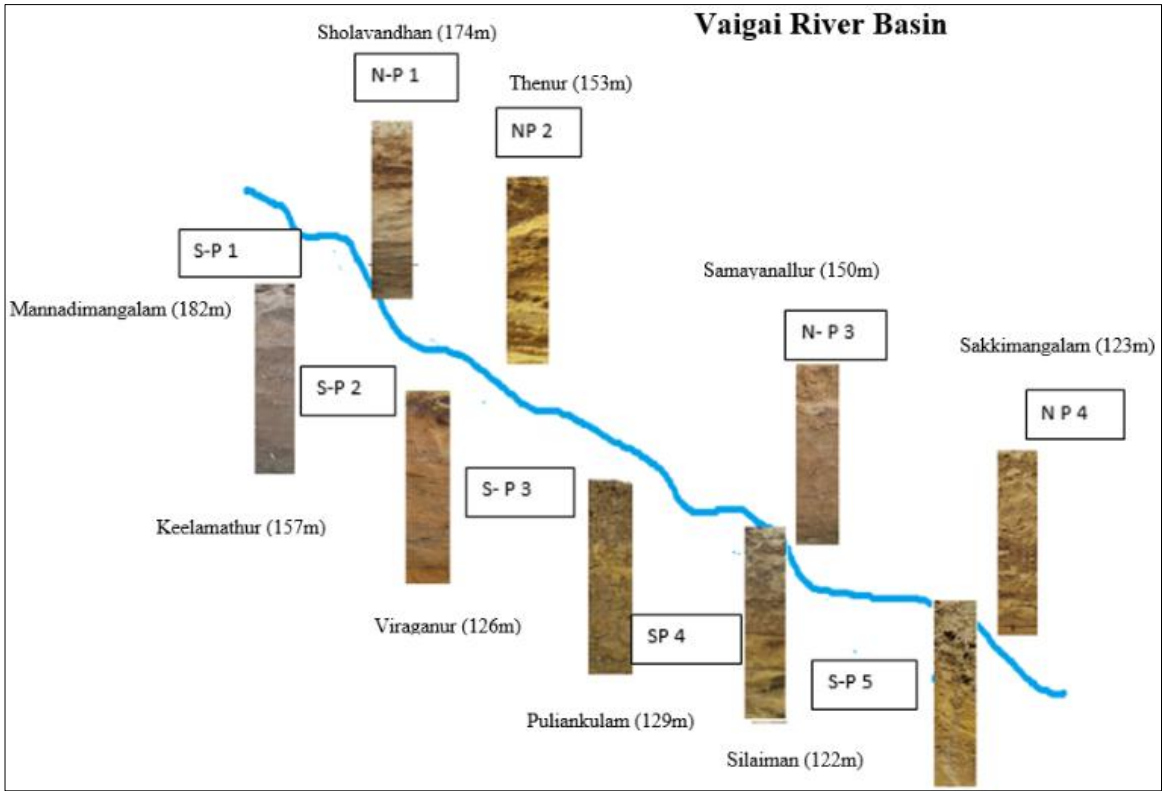

Fig 2: Morphological characteristics of alluvial soil in Northern and Southern bank, Madurai District

The Morphological characteristics were studied as described (Schoeneberger *et al*., 2012) [9] and classification (Soil Survey Staff, 2014) [17]. Horizon wise samples were collected and processed for further studies.

Results and Discussion

The results on the morphological characteristics are presented in the tables 3 to 4.

Horizon Differentiation

The deposition of alluvial soil is evidenced by the poorly developed horizon sequence of A-C along the course of Vaigai river basin. On the northern bank of Vaigai river, four representative pedons viz., NP_1, NP_2, NP_3 and NP_4 and southern bank, SP_1, SP_2, SP_3 and SP_4were excavated and has A-C sequence with altered variation in master horizon. The pedon SP_5 located in the Southern bank river was well developed nature due to subsequent flooding and illuviation of clay.

Horizon Boundary

The horizon of the pedon in the Northern bank had unique topography of smooth throughout, with exception that wavy in NP_2, had abrupt in NP_1, diffused in NP_2, midlandNP_3 was gradual and diffused in NP_4. On contrast to the above, SP_1 had abrupt and smooth boundary, SP_2 with diffused, wavy and SP_3 with clear and smooth boundary. The pedon SP_4 and SP_5 had heterogeneous transition of abrupt, clear, gradual with smooth and wavy topography. Abrupt, Smooth boundary formation might be due to ploughed soil nature and gradual diffuse boundary was due to the absence of anthropogenic activities (Negassa and Gebrekidan, 2003) [4].

Solum Depth

The depth of the soil in river basin was shallow to deep as the slope of the tract narrows down. Depthness of the soil varied from $d_4$to d_5 in the northern bank with 150^+cm, whereas in Southern bank, it decreased from d_5 to d_4. The solum depth decreased gradually in the Southern bank of the river due to subsequent deposition of alluvial soil on each flooding as highly influenced by slope and degree of erosion (Nasre *et al.*, 2013) [3]. The solum development was more prominent in lower and mid plain contrast to upper pediment based on its landscape position (Sharma *et al.*, 2020) [11].

Soil Colour

The colour of the soil both dry and moist conditions, ranged from 10YR to 7.5YR, value 2 to 6, chroma 2- 8, with the exception of NP_2 and subsurface appeared as yellowish red and reddish yellow. Similarly on Southern bank, the colour ranged from 10YR to 7.5YR, but in SP_5 having dark reddish brown with 5YR. Hue varies by 2.5 to 6 and chroma by 1 to 6.The soil colour appeared to be the function of chemical and mineralogical composition, soil texture conditioned by topographic position and moisture regime (Siressha and Naidu, 2013 [13]. According to Sarmah *et al*., (2019) [7], 10YR hue was attributed due to the hydrated oxides of Fe formed under humid condition. Higher value and chroma observed in subsurface of $NP_1$and NP_2 of Northern bank and SP_2 and SP_4 might be due to the illuviation of Fe and Al (Dutta *et al.*, 2017) [1]. Low chroma indicated the aquic condition with poor drainage and immature of parent material (Samrah *et al.*, 2019) [7].

Soil Texture

The pedons, NP_1, NP_3, and NP_4had coarse textured throughout the profile with least degree of weathering on contrast to NP_2, where initial weathering can be observed by intermittent coarse to medium textured as Loamy Sand to Silty Clay Loam. Wide textural variation from coarse to moderately coarse were observed throughout the southern bank of river with fine heavy clay in SP_5 due to clay and silt deposition from different parent material, stratification under each flooding, *in-situ* weathering (Sandhu *et al.*, 2017) [8].

Soil Structure

The crumb to single granular type of soil structure dominated in the pedons of NP1, NP_3, NP_4 and NP_2 had sub angular blocky. On contrast, the Southern bank of river had structure less to strong. Single grain and granular type were seen inSP_1 and SP_2. Single grain structure represented the initial stage of soil development and lithological discontinuity (Sittangang *et al.*, 2006) [14]. Crumb formed due to the addition of organic matter by vegetation cover (Sireesha and Naidu, 2013) [13]. Accumulation of fine clay might be attributed to the angular blocky, sub angular blocky and platy structure in SP3, SP_4 and SP_5 (Supriya *et al*., 2019) [16].

Soil Consistency

The friable to very friable (moist), soft, loose (dry) consistency with non sticky and non plasticity with stickiness had been noticed in the Northern bank of the alluvial plain. Varying degrees of firm to friable (moist), loose to extremely hard (dry), non sticky and non plastic to slightly sticky, slightly plastic was observed in the pedons of southern bank. Friable characteristics of the soil clearly suggested the permeability of soil (Nsor and Ibanga, 2008) [5]. Non stickiness and plasticity suggested the negligible quantity of clay and organic matter in it (Sekar *et al.*, 2019) [10].

Mottles/Coatings

The yellowish brown mottles with jarosite nodules were found in the Northern bank of river. The reddish brown mottles (Singh and Agarwal, 2005) [12] and micaceous coatings were seen in the lower banks of river basin.

Cutans

The clay cutans with slickenside were seen in the pedons of SP_4 and SP_5 might be due to the clay illuviation in Bt horizon (Gebrekidan and Mishra, 2005) [2] and (Patil and Kumar, 2014) [6].

Roots and Pores

The fine, medium and tubular to irregular roots could be seen in the pedons of both banks was due to the cultivation of coconut, banana and paddy.

Presence of Calcium Carbonate

The strong effervescence were observed with dilute HCl inNP_3 and in SP_1, SP3indicated the presence of $CaCO_3$ concentration (Vedadri and Naidu, 2018) [18].

Permeability

The soils in both banks of Vaigai river had moderate rapid to very rapid permeability indicated the presence of AC profile.

Conclusion

Studies on the morphological characteristics of soils of Vaigai river basin are in the initial stage of soil development and classified as Entisol order and Padugai bench mark soil series. Owing to sand mining, dumping of industrial waste, anthropogenic activities and climate change, variations in the characteristics of alluvium were noticed. The alluvial lands subjected to periodical floods will have to be protected by adequate flood control measures to prevent damage crop and soil health. Thus there is substantial and significant addition of information to the existing knowledge on the soils of this tract.

Table 3: Effect of climate change on morphological characteristics of Northern bank of VaigaiRiver, Madurai District, Tamil Nadu.

Horizon	Depth of pedon (cm)	Colour		Texture	Structure			Consistence				Bnd		Mottles/Coatings						CaCO3 (dil. HCl)	Roots			Cutans
		Moist	Dry		G	S	T	Dry	Moist	stk	pls	D	T	amt	dst	cont	kd	loc	col		Qty	sz	shp	-
Pedon 1: Sholavandhan, 10°01'16"N, 77°57'39" E,Altitude – 174m																								
A11	0-50	10YR3/3	10YR2/2	LS	1	f	Cr	s	vfr	so	po	a	s	-	-	-	-	-	-	3	-	-	-	-
A12	50-114	10YR4/6	10YR3/3	S	0	f	sg	l	vfr	so	po	a	s	c	f	p	j	s	-	2	-	-	-	-
A13	114-140	10YR4/3	10YR3/3	S	0	f	sg	l	vfr	so	po	a	s	c	f	p	j	s	-	1	-	-	-	-
C	140+	Alluvium																						
Pedon 2 : Thenur, 9°59´6"N, 78°0´17"E Altitude – 153m																								
A11	0-20	7.5YR5/8	7.5YR 5/5	L	1	vf	Cr	s	fr	ss	sp	d	w	-	-	-	-	-	-	1	f	m	t	-
A12	20-46	5YR 5/8	5YR 6/8	LS	0	m	Cr	l	fr	so	po	d	w	c	f	p	-	-	-	1	-	-	-	-
A13	46-64	7.5YR 5/4	7.5YR 5/6	SiCL	1	f	C	l	fi	ss	vp	d	w	-	-	-	-	-	-	1	-	-	-	-
A14	64-100	7.5YR 6/6	7.5YR 6/4	LS	0	f	Cr	l	fr	so	sp	a	s	-	-	-	-	-	-	1	-	-	-	-
C	100+	Alluvium																						
Pedon 3 : Samayanallur, 9°58´37"N, 78°01´57"E, Altitude – 150m																								
A11	0-24	7.5YR4/3	7.5YR5/3	SL	2	m	sbk	l	fr	ss	sp	g	s	-	-	-	-	-	-	3	f	m	t	-
A12	24-50	7.5YR4/4	7.5YR5/4	LS	1	m	sbk	l	fr	so	po	g	s	-	-	-	-	-	-	3	f	m	t	-
A13	50-80	7.5YR4/4	7.5YR5/6	LS	1	m	sbk	l	fr	so	po	g	s	-	-	-	-	-	-	3	f	f	t	-
A14	80-110	7.5YR5/3	7.5YR6/3	LS	1	m	sbk	l	fr	so	po	g	s	-	-	-	-	-	-	3	F	f	t	-
C	110+	Alluvium																						
Pedon 4 : Sakkimangalam, 9°52´41"N, 78°11´28"E, Altitude – 123m																								
A11	0-15	7.5YR3/4	10YR3/3	LS	1	f	G	l	fr	so	po	d	s	-	-	-	-	-	-	1	f	f	T	-
A12	15-28	10YR5/3	10YR4/3	LS	0	f	sg	l	fr	so	po	d	s	-	-	-	-	-	-	1	f	f	t	-
A13	28-68	10YR4/3	10YR3/3	LS	1	fi	sg	l	fr	so	po	d	s	vm	p	c	m	m	m	1	f	f	t	-
C	68+	Alluvium																						

Table 4: Effect of climate change on morphological characteristics of Southern bank of VaigaiRiver, Madurai District, Tamil Nadu

Horizon	Depth of pedon (cm)	Colour		Texture	Structure			Consistence				Bnd		Mottles/Coatings						CaCO3 (dil. HCl)	Roots			Cutans
		Moist	Dry		G	S	T	Dry	Moist	stk	pls	D	T	amt	dst	cont	kd	loc	col		Qty	sz	shp	-
Pedon 1: Mannadimangalam, 10°2´38"N, 77°55´48"E, Altitude – 182m																								
A11	0-22	7.5YR3/3	7.5YR3/2	SiL	1	m	sbk	s	fi	vs	vp	a	s	-	-	-	-	-	-	3	f	f	p	-
A12	22-34	7.5YR3/4	7.5YR3/4	S	0	f	sg	l	fr	so	po	a	s	f	d	d	p	m	-	3	f	vf	t	-
A13	34-52	7.5YR3/3	7.5YR4/3	LS	1	f	gr	l	fr	so	po	a	s	f	d	f	i	m	-	2	f	vf	t	-
A14	52-60	7.5YR2.5/3	7.5YR3/3	S	0	f	sg	l	fr	so	po	a	s	-	-	-	-	-	-	2	f	vf	t	-
A21t	60-80	7.5YR2.5/3	7.5YR3/3	SiC	1	f	gr	s	fi	vs	vp	a	s	-	-	-	-	-	-	2	-	-	-	-
A22	80-126	7.5YR2.5/3	7.5YR3/3	LS	1	f	gr	s	l	so	po	a	s	-	-	-	-	-	-	1	-	-	-	-
C	126+	Alluvium																						
Pedon 2 : Keelamathur, 9°58´7"N , 78°1´50"E, Altitude – 157m																								
A11	0-20	10YR3/2	7.5YR 4/4	SCL	0	f	Cr	s	vf	so	po	d	w	-	-	-	-	-	-	1	f	m	t	-
A21	20-64	10YR4/3	10YR5/4	S	0	f	sg	l	fr	so	po	d	w	m	d	c	p	m	-	1	-	-	-	-
A22	64-110	7.5YR3/2	10YR 5/3	S	0	f	sg	l	fi	so	po	d	w	vm	p	c	a	f	-	1	-	-	-	-
C	110+	Alluvium																						
Pedon 3 : Viraganur, 9°54´11"N, 78°09´42"E, Altitude – 126m																								
A11	0-55	10YR3/3	10YR4/3	SCL	3	f	sbk	sh	fi	ss	sp	c	s	-	-	-	-	-	-	3	f	f	v	-
A12	55-80	10YR4/1	10YR4/2	SL	2	m	abk	s	fr	so	po	c	s	-	-	-	-	-	-	3	f	f	v	-
A13	80-110	7.5YR3/3	7.5YR3/4	SL	2	m	abk	s	fr	so	po	c	s	-	-	-	-	-	-	2	f	f	v	-
C	110+	Alluvium																						
Pedon 4 : Puliankulam, 9°52´41"N, 78°10´48"E , Altitude – 129m																								
A11	0-52	10YR3/3	7.5YR2.5/2	SC	1	f	pl	s	fi	ss	sp	a	s	m	d	p	s	p	f	3	m	m	ir	f,d,p,s
A21	52-71	10YR3/6	7.5YR4/3	S	0	c	sg	l	fr	so	po	a	w	c	d	d	y	s	f	1	f	vf	ir	-
A22	71-96	10YR4/3	10YR3/3	LS	1	fi	sg	l	fr	so	po	d	s	vm	p	d	r	s	p	1	f	vf	ir	-
C	96+	Mixed calcareous Alluvium																						
Pedon 5 : Silaiman , 9°52´22"N, 78°11´55"E, Altitude – 122m																								
A11t	0-20	10YR3/1	10YR4/1	SiCL	3	vc	abk	vh	ss	pp	c	w		-	-	-	-	-	-	3	m	m	t	f,d,p,s
A21t	20-60	5YR3/3	7.5YR4/3	SiCL	3	vc	pl	vh	ss	pp	g	w		-	-	-	-	-	-	3	m	m	t	-
A22t	60-90	7.5YR3/2	7.5YR4/3	SiCL	3	vc	abk	eh	ss	pp	g	s		-	-	-	-	-	-	3	c	m	t	f,d,p,s
A23t	90-100	10YR3/2	10YR4/2	SiCL	3	vc	abk	eh	ss	pp	g	s		-	-	-	-	-	-	3	-	-	-	-
A24t	100-180	10YR3/3	7.5YR4/3	SiCL	3	vc	pl	vh	ss	pp	a	a		-	-	-	-	-	-	3	-	-	-	-
C	180+	Mixed calcareous Alluvium																						

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