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Soil physical and physico-chemical properties of soils of Jangon district in Telangana state

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Abstract
Seven typical pedons from of Jangon district were studied for physical, physico-chemical and chemical properties of the area. The soils were moderately deep to very deep, reddish brown to dark reddish brown in colour, gravelley sand to clay in texture and had varied structure including granular and sub-angular blocky structure. The clay content in soils varied from 2.9 to 59.3 per cent. The clay content increased with depth in all pedons. Silt fraction in the soils 6.9 to 30.7 per cent. The sand content in the soils under investigation varied from 13.9 to 89.3 per cent. Most of the pedons exhibited more or less an increasing trend in bulk density with depth. These soils were near slightly acidic to strongly alkaline in reaction, non-saline and very low to medium in organic carbon. The CEC varied from 1.7 to 44.5 C mol (p^+) kg^{-1} soil and dominated by Ca^{+2} followed by Mg^{+2}, Na^+ and K^+. The soils were very low to medium in available nitrogen, low to medium in available phosphorus and potassium. Available zinc was deficient to sufficient in all the horizon. The soils were defficient in available iron, copper and manganese. The soils were classified as Typic Haplusterts, Typic Haplustepts, Vertic Haplustepts and Typic Rhodustalfs.

Keywords: soil physical, physico-chemical, nutrient status and classification

Introduction
Soil characterization determines the soil's individual inherent potentials and constraints for crop production besides giving detailed information about the different soil properties. Characterization and systematic classification of dominant soil groups is an essential tool and a pre-requisite for soil fertility evaluation and efficient soil-fertilizer-water management practices and, thus, crop management. The ability of the land to produce is limited and the limits to produce are set by soils, climate, landforms conditions and farming situations. Further, the capacity of soil to produce is also limited and constrains are due to intrinsic characteristics, agro-ecological settings, use and management (FAO Statistics, 2007-08). The newly formed Telangana state has variable types of soils. Any progress and development in agriculture depends largely on soil resources. Maintaining soil in the state of high productivity on sustainable basis is important for meeting basic needs of the people. Systematic study of soils is important for scientific utilization of these soils and land resources.

Materials and Methods
The pedons from the study area in Mahabubabad district lies in Central Telangana Zone in Telangana state which lies between 17º 16' & 18º 00' North latitude and 78º 58' & 79º 35' East longitude. The study area is characterised by semi arid climatic condition, with the average rainfall of 803.2 mm (decennial average of 2004-13) of which 90.11 per cent is received during southwest monsoon, 4.80 per cent during northeast monsoon and 5.08 per cent during summer season. Mean monthly rainfall is highest in the month of July month (214.4 mm) followed by September (177.5 mm), August (164.1 mm) months. Annual mean maximum and minimum temperatures of the district are 32.44 ºC and 23.31ºC respectively. The maximum and minimum mean monthly temperature ranges from 17.0ºC to 40.8ºC. The mean minimum temperature is recorded during December (17.0ºC) and maximum in May (40.8ºC). Mean annual air temperature of the district is 27.78 ºC. Therefore, the temperature regime of the study area was classified as isohyperthermic. Natural vegetation comprises of *Ficus* spp, Tamarind (*Tamarindus indica*), neem (*Azadirachta indica*), *Prosopis* and ber (*Zizyphus jujube*) are predominated trees in the study area.

Table 1: Landscape characteristics of pedons

Pedon	Location	Elevation above mean sea level (m)	Physiography	Slope (%)	Drainage	Parent material
1	Jangon	17^{0}46‘16.97”N 79^{0}35‘03.10”E	Undulating lands	3 – 6	Well drained	Granite gneiss
2	Dharmasagar	17^{0}16’27.37”N 79^{0}26’57.73”E	Very gently sloping upland	1 – 3	Moderately well drained	Weathered lime store
3	Palakurthy	17^{0}39’43.7”N 79^{0}26’00.42”E	Undulating inter fluves	10	Well drained	Granite gneiss
4	Raghunathapally	17^{0}45‘53.87”N 79^{0}13’46.95”E	Undulating uplands	3 – 8	Well drained	Granite gneiss
5	Lingalaghanpur	18^{0}00’28.29”N 80^{0}17’22.92”E	Gently sloping pediment	1– 3	Imperially drained	Weathered lime store
6	Bachannapet	17^{0}47‘15.02”N 79^{0}02’24.41”E	Valley	0 – 1	Imperially drained	Weathered granite gneiss
7	Cheryal	17^{0}55‘16.33”N 78^{0}58’14.75”E	Valley	0 – 1% V.S.E.	Imperially drained	Allurium collurin of linetha

Results and Discussion

Soil Morphology

The soil morphological description of the study area will be presented in the table 2.The depth of different pedons of study area of Jangoan district ranges from 16 cm to 195+cm and found to have deep to very deep soulm. Pedon 4 were moderately deep (25 -50 cm), Pedons 3, 6 and 7 were deep (50-100 cm) whereas the pedons 1, 2 and 5 were very deep (>100 cm) respectively. Nasre *et al.* (2013) [10] noticed that soil depth is related to slope and degree of soil erosion. It was noticed that, soils developed on plateau top, escarpments, isolated hillocks and foot slopes were shallow and soils developed on undulating lands, alluvial plains and valleys were deep. The colour of the soil pedons of the study area of Mahabubabad district of Warangal district were varied from reddish brown to dark reddish brown in colour. Whereas hue in the range of 2.5 YR, 5 YR and 7.5 YR value of 3 to 5 and chroma in the range of 2 to 6 respectively. Occurrence of iron oxides at various hydrated forms might have resulted in dark brown colour to the soils (Ramprakash and Seshagiri Rao, 2002) [14]. The texture of the pedons of study area was varied from gravelly sand to clay. Where as In case of pedons 1, 3 and 4 the finer fractions of the increased significantly with the depth of the soil mainly due to eluviation and illuviation processes operated in the pedons. This resulted in the formation of a distinct argillic horizon in the subsurface horizons. Sand content in the soil decreased with increasing depth in these pedons. In the pedons 2 and 7 the texture was clay throughout depth of the profile. However, significant increase in the clay content with increasing depth of the profile was noticed in the pedons 2 and 7. The variations in texture of soils were mainly associated with the differences in composition of parent material and topography (Sitanggang *et al.* 2006) [26]. The structure of the soil pedons size of aggregate was fine to medium, grade was week to medium, the type of aggregate was granular to sub-angular blocky structure. The blocky structures *i.e.*, sub-angular and angular blocky were attributed to the presence of higher quantities of clay fractions.

Table 2: Soil morphological Description of Jangon District of Warangal District In Telangana State

Horizon	Depth (cm)	Soil colour	Texture	Structure			Consistence			Effervescence	Boundary		Concretions $CaCO_3$	
		Moist		S	G	T	Dry	Moist	Wet		D	T	Q	S
Pedon 1														
Ap	0-14	7.5YR 4/5	gs	f	1	gr	-	fr	nssp	eo	c	s	-	-
Bt1	14-39	2.5YR 3/4	gsl	m	2	sbk	-	fr	sssp	eo	g	s	-	-
Bt2	39-75	2.5YR 3/5	gscl	m	2	sbk	-	fr	sp	eo	g	s	-	-
BC	75-110+	2.5YR 3/6	scl	m	1	sbk	-	fr	sp	eo	-	-	m	f
Pedon 2														
Ap	0-14	10.0YR 3/2	c	m	2	sbk	-	fi	sp	e	c	s	c	f
BA	14-33	10.0YR 3/2	c	m	2	sbk	-	fi	vsvp	e	c	s	c	f
Bss1	33-65	10.0YR 3/2	c	m	3	sbk	-	vfi	vsvp	es	g	s	c	f
Bss2	65-102	10.0YR 3/2	c	c	3	abk	-	vfi	vsvp	es	g	s	c	vf
Bss3	102-135+	10.0YR 3/2	c	c	3	abk	-	vfi	vsvp	es	-	-	c	vf
Pedon 3														
Ap	0-10	2.5YR 3/6	ls	m	1	gr	-	l	sopo	eo	a	s	-	-
Bt1	10-26	2.5YR 3/2	scl	m	2	sbk	-	fr	sssp	eo	c	s	-	-
Bt2	26-62	5.0YR 4/3	sc	m	2	sbk	-	fi	sp	eo	c	s	-	-
Cr	62+	Weathered Parent Material												
Pedon 4														
Ap	0-8	2.5YR 3/4	ls	m	1	gr	-	l	sopo	eo	a	s	-	-
Bt1	8-22	2.5YR 3/3	scl	m	2	sbk	-	fr	sssp	eo	c	s	-	-
Bt2	22-46	5.0YR 5/4	sc	m	2	sbk	-	fi	sp	eo	c	s	-	-
Cr	46+	Weathered Parent Material												
Pedon 5														
Ap	0-19	10.0YR 5/6	gscl	m	1	gr	s	fr	sopo	e	c	w	f	f
Bw	19-44	10.0YR 5/8	gscl	m	2	sbk	sh	fr	sspo	e	c	s	c	f
Bw2	44-82	10.0YR 6/6	gscl	m	2	sbk	sh	fr	sssp	es	c	s	m	c

BCk	82-112	10.0YR 5/8	gscl	m	2	sbk	sh	fr	sssp	ev	c	s		
Cr	112+	Weathered Parent Material												
Pedon 6														
Ap	0-22	10.0YR 6/3	sl	m	2	sbk	sh	fr	sopo	eo	g	w	-	-
Bw1	22-48	10.0YR 6/3	gscl	m	2	sbk	sh	fr	sssp	eo	c	s	-	-
Bw2	48-72	7.5YR 5/8	gscl	m	2	abk	sh	fr	sssp	eo	c	s	-	-
Cr	72+	7.5YR 5/8	Weathered Parent Material											
Pedon 7														
Ap	0-15	10.0YR 3/2	c	m	3	sbk	-	fr	vsp	eo	c	s	-	-
Bw1	15-45	10.0YR 3/3	c	m	2	sbk	-	fi	vsvp	es	a	s	-	-
Bw2	45-75	10.0YR 3/3	c	m	2	sbk	-	vfi	vsvp	ev	g	w	-	-
Bw3	75-100	10.0YR 3/3	c	m	2	sbk	-	vfi	vsvp	ev	-	-	-	-

Similar observations were reported by Meena *et al.* (2012) [9] in Malwa plateau of Banswara district in Rajasthan.

The consistence in the pedons of the study area varied from slightly hard to hard, firm to friable, and non-sticky and non-plastic to very sticky and very plastic in dry, moist and wet conditions, respectively. This qualitative physical behaviour of soils, as influenced by dry, moist and wet conditions was due to the textural make up and type and stability of structure. It is also influenced, to a greater extent, by the type of clay minerals present in these soils. Dry consistency of the soils was slightly hard in the surface horizons. Whereas, moist consistency of the soil was friable to firm; wet consistency was non-sticky, non-plastic to very sticky, very plastic. In the pedons 16 and 18 the wet consistency was non-sticky, non-plastic to slightly sticky and slightly plastic. Whereas in pedons 13 and 15the consistency was very sticky to very plastic in most of the horizons indicating the predominance of higher content of high active clays. Presence of friable and non-sticky and non-plastic or slightly sticky and slightly plastic consistency might be due to negligible or very small amount of expanding clay minerals. Satyavathi and Suryanarayana Reddy (2003) [21] and Satyavathi and Suryanarayana Reddy (2004) [20] reported similar consistency in soils of Telangana at different soil moisture limits.

Soil physical properties

The detailed Physical properties of the study area of Jangon district were presented in table 3. Sand percentage of study area ranged from 13.9 to 89.3 per cent. The highest sand content was noticed in AP horizon of pedon 1 and while the lowest sand percentage was recorded in horizon BSS3 pedon 7. Higher sand content in these surface soils could be attributed loss of finer fractions of soils due to erosion, movement of clay to deeper horizons due illuviation and more active chemical weathering in the lower horizons due to better availability of moisture. Similar findings were also reported by Basavaraju *et al.* (2005) [3].

The silt content varied from ranged from 6.9 to 30.7 per cent. The highest silt content was observed in BW3 horizon of pedon 7 where as low silt content was observed in Bt horizon of pedon of 19. This might be due to variation in weathering of parent material or *in situ* formation. These results were in agreement with the findings of Satish Kumar and Naidu (2012a) [19].

Table 3: Soil physical properties of Jangon district in Telangana State

Pedon No. & Horizon	Depth (cm)	Sand (%) (0.2-0.05 mm)	Silt (%) (0.5 mm)	Clay (%) (< 0.002 mm)	Bulk density (Mg m^{-3})	Particle density (Mg m^{-3})	Hydraulic Conductivity (cm hr^{-1})	Water retention		Available Water Content (%)
								33 Kpa	1500 Kpa	
P 1										
Ap	0-14	89.3	7.8	2.9	1.54	2.65	20.2	2.2	0.9	1.3
Bt1	14-39	76.7	6.9	16.4	1.52	2.58	10.2	11.2	4.7	6.5
Bt2	39-75	61.8	7.9	30.3	1.58	2.64	6.2	18.5	8.9	9.6
BC	75-110+	56.7	8.8	34.5	1.62	2.59	5.8	19.1	11.2	7.9
P 2										
Ap	0-14	24.3	25.7	50	1.77	2.63	2.2	32.2	18.5	13.7
BA	14-33	26.7	19.8	53.5	1.75	2.57	1.4	33.5	19.7	13.8
Bss1	33-65	27.9	17.8	54.3	1.78	2.65	1	34.5	20.2	14.3
Bss2	65-102	25.6	17.7	56.7	1.82	2.59	0.65	36.1	20.9	15.2
Bss3	102-135+	21.8	18.9	59.3	1.84	2.65	0.35	38.8	22.2	16.6
P 3										
Ap	0-10	82.9	7.9	9.2	1.56	2.62	14.4	5.2	3.1	2.1
Bt1	10-26	65.7	7.5	26.8	1.42	2.58	6.8	14.4	8.2	6.2
Bt2	26-62	45.8	15.4	38.8	1.45	2.62	4.2	20.2	11.7	8.5
Cr	62+	Weathered Parent Material								
P 4										
Ap	0-8	65.7	19.3	15	1.45	2.63	12.8	9	4.6	4.4
Bt1	8-22	63.9	12.9	23.2	1.56	2.59	6.5	14.2	7	7.2
Bt2	22-46	46.6	16.5	36.9	1.62	2.61	4.4	22.1	11.2	10.9
Cr	46+	Weathered Parent Material								
P 5										
Ap	0-19	61.5	15.5	23	1.41	2.63	8.9	13.4	7.7	5.7
Bw1	19 -44	59.7	14.9	25.4	1.45	2.59	7.5	15.6	8.7	6.9

Bw2	44 to 82	57.9	15.5	26.6	1.45	2.65	6.5	17.5	9.1	8.4
BCk	82 to 112	54.8	15.3	29.9	1.61	2.62	4.2	20.1	11.2	8.9
Crk	112+	Weathered Parent Material								
P 6										
Ap	0-22	70.7	14.8	14.5	1.52	2.65	9.8	9.1	4.7	4.4
Bw1	22-48	65.8	13.3	20.9	1.56	2.61	6.5	13.2	7.1	6.1
Bw2	48-72	64.7	13.5	21.8	1.61	2.63	5.2	15.1	7.3	7.8
Cr	72	Weathered Parent Material								
P 7										
Ap	0-15	33.5	27.3	39.2	1.52	2.57	8.6	20.8	13.2	7.6
Bw1	15-45	18.9	29.5	51.6	1.56	2.63	5.5	33.5	18.1	15.4
Bw2	45-75	15.7	28.3	56	1.54	2.59	4.2	36.2	19	17.2
Bw3	75-100	13.9	30.7	55.4	1.62	2.65	3.2	38.5	18.8	19.7

The clay content in soils of the study area ranged from the clay content in soils of the study area ranged from 2.9 to 59.3 per cent. The highest amount of clay was observed in BSS3 horizon of pedon 2 and while the lowest caly content was noticed in AP horizon of pedon 1.

Increase in clay content with depth might be due to more intensive chemical weathering at deeper layer and eluviation of finer particles from surface horizon leaving behind coarse particles in surface layers. The enrichment of clay in Bw and Bss horizons of pedons 2, 5, 6 and 7 was primarily due to *in situ* weathering of parent material. Sharma *et al.* (2004) [25] observed an increase in clay content in sub-surface horizons as compared to surface horizons in soils of Neogal watershed in north-west Himalayas. Similar observations were also made by Walia and Rao (1996) and Satish Kumar and Naidu (2012) [19] in soils of Bundelkhand region of Uttar Pradesh and in soils of Vadamalapeta mandal of Chittoor district, respectively.

The increase in clay content in the Bt horizon in the pedons 1, 3, and 4 is mainly due illuviation of the clay form the upper horizons. Similar enrichment Bt horizons with the clay content was reported by Ramprakash and Rao (2002) [14] in Krishna district of Andhra Pradesh.

The bulk density of different pedons varied from 1.41 to 1.84 Mg m^{-3}. The higher bulk density values in some pedons may be due to high clay content resulting in greater compaction in swelling clay soils. Similar results were reported by Ashokkumar and Jagdish Prasad (2010) [2] who reported higher bulk density values in the soils of Ahmadnagar district of Maharashtra.

The particle density of different pedons varied from 2.58 to 2.65 Mg m^{-3}. Not much variation in the particle density was recorded among different pedons. No regular increasing or decreasing trend was recorded in particle density in any of the pedons studies in the Mahabubabad district.

The saturated hydraulic conductivity was ranged from 0.35 to 20.2 cm hr^{-1}. The highest hydraulic conductivity was recorded in AP horizon of pedon 1 and while the lowest hydraulic conductivity was found in BSS2 horizon of pedon 2. In all the pedons hydraulic conductivity decreased with increasing depth of the soil. Similar results were earlier reported by Ramprakash and Seshagiri Rao (2002) [14] in Vertisols and Alfisols of Krishna district. Increasing compaction of soil with the depth resulting increasing bulk density, decreasing pore density might have resulted in reduction of the hydraulic conductivity with depth in all the studies pedons. Available water content in the study area ranged from1.3 per cent to 19.7 per cent the highest AWC was observed in BW3 horizon of pedon 7 and while the lowest AWC was recorded in Ap horizon pedon 1.These differences in water holding capacity were due to variation in the depth, clay, silt and organic carbon content of the pedons. These results match with those of Thangasamy *et al.* (2005) [27] in soils of Sivagiri micro-watershed in Chittoor district of Andhra Pradesh.

Soil physico-chemical properties

The detailed Physico-chemical properties of the study area of Jangon district presented in table 4. The soil reaction of the study area was ranged from 6.3 to 9.2 *i.e.*, slightly acidic to strongly alkaline in reaction. The highest value of pH was observed in pedon 2 of BSS3 horizon and while the lowest pH was found in pedon 1 horizon of Bt2 horizon. The near neutral to very strongly alkaline pH may be attributed to the reaction of applied fertilizer material with soil colloids, which resulted in the retention of basic cations on the exchange complex of the soil. Similar results were also reported by Sharma *et al.* (2011) [23].

The electrical conductivity ranged from from 0.03 to 2.5 dSm^{-1}. The lowest electrical conductivity value of 0.03 dsm^{-1} and while the highest electrical conductivity was observed in the BW3 of pedon 7 indicating non-saline in nature. The results in the present study indicate the non-saline nature of soils. The lower electrical conductivity in soils was due to excess leaching of salts and due to free drainage conditions which favoured the removal of released bases by percolating and drainage water. Similar results were observed by Ramprasad *et al.* (2013) [16].

The organic carbon content in study area was found to be very low to medium and ranged from 0.17 to 0.80 per cent. The highest Organic carbon content was recorded in AP horizon of pedon 7 and where as the lowest Organic carbon content was recorded in BW2 horizon of pedon 6. Organic carbon content in all the pedons showed a decreasing trend with depth. Almost all the pedons showed a decreasing trend in organic carbon with depth, which may be due to the fact that the surface horizons showed more organic matter content than sub-surface horizons due to the addition of plant residues and farm yard manure to surface horizons which resulted in higher organic carbon content in surface horizons than in the lower horizons. This observation was in accordance with results of Basavaraju *et al*., (2005) [3] in soils of Chandragiri mandal in Chittoor district of Andhra Pradesh.

Table 4: Soil physico- chemical properties of Jangon district in Telangana State

Pedon No. & Horizon	Depth (cm)	pH (1:2.5)	EC (dS m^{-1})	Organic carbon g kg^{-1}	$CaCO_3$ (%)	CEC [c mol (p+) kg^{-1}]	Exchangeable bases [c mol (p+)kg^{-1}]				Base Saturation (%)
							Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	
Pedon 1											
Ap	0-14	6.8	0.09	0.41	-	1.7	0.5	0.2	0.1	0.2	56.47
Bt1	14-39	6.3	0.08	0.58	-	7.8	2.9	1.4	0.2	0.1	59.97
Bt2	39-75	6.5	0.07	0.55	-	14.1	6.8	2.3	0.2	0.1	66.67
BC	75-110+	6.6	0.05	0.28	-	15.4	7.1	3.3	0.2	0.1	69.48
Pedon 2											
Ap	0-14	8.3	0.28	0.48	4.2	36.2	26.2	8.9	0.4	0.7	100
BA	14-33	8.5	0.31	0.44	6.2	37.2	27.8	7.9	0.9	0.6	100
Bss1	33-65	8.8	0.39	0.39	7.8	38.6	28.6	8.3	1.2	0.5	100
Bss2	65-102	8.5	0.52	0.41	7.8	41.5	30.1	8.2	2.8	0.4	100
Bss3	102-135+	9.2	0.5	0.29	9	44.5	31.1	8.5	4.5	0.4	100
Pedon 3											
Ap	0-10	6.8	0.14	0.41	-	4.8	2	1.4	0	0.2	75
Bt1	10-26	7.3	0.09	0.55	-	14.5	8.1	2.9	0.1	0.2	77.93
Bt2	26-62	7.5	0.1	0.65	-	24.2	14	5.2	0.1	0.2	80.58
Cr	62+	Weathered Parent Material									
Pedon 4											
Ap	0-8	6.7	0.15	0.43	-	7.2	3.1	1.4	0.2	0.4	70.83
Bt1	8-22	7	0.11	0.58	-	11.5	5.8	2.2	0.3	0.2	73.91
Bt2	22-46	7.5	0.09	0.66	-	18.8	9.8	3.5	0.5	0.2	74.47
Cr	46+	Weathered Parent Material									
Pedon 5											
Ap	0-19	8	0.25	0.5	2.4	17.2	15.3	1.6	0	0.3	100
Bw	19-44	8.2	0.2	0.49	4.1	19.6	17.3	2.1	0	0.2	100
Bw2	44-82	8.6	0.18	0.39	11.6	21.5	18.5	2.8	0	0.2	100
BCk	82-112	9.1	0.2	0.36	16.8	24.5	20.7	3.4	0.2	0.2	100
Crk	112+	Weathered Parent Material									
Pedon 6											
Ap	0-22	7.2	0.29	0.45	-	11.2	7.8	3.1	0	0.3	100
Bw1	22-48	7.4	0.35	0.25	-	16.2	12.1	3.8	0	0.3	100
Bw2	48-72	7.5	0.32	0.17	-	17.5	13.2	3.9	0.2	0.2	100
Cr	72	Weathered Parent Material									
Pedon 7											
Ap	0-15	8.3	0.03	0.8	1.2	28.2	19.2	6.8	0.4	1.8	100
Bw1	15-45	8.6	0.05	0.43	6.9	38.2	27	9.1	0.6	1.5	100
Bw2	45-75	8.5	2	0.37	9.8	40.1	28.4	9.4	0.9	1.4	100
Bw3	75-100	8.4	2.5	0.24	11.6	39.8	27.9	9.2	1.4	1.3	100

The $CaCO_3$ content in soil under study area ranged from 1.2 to 16.8 per cent. The highest value of $CaCO_3$ content was observed in the BSS3 horizon of pedon 2 and where as the lowest value of $CaCO_3$ content was found in the AP horizon of pedon 7. Higher contents of $CaCO_3$ observed in the lower horizons of most of the pedons might be due to high clay content which led to impeded leaching, consequently accumulation of $CaCO_3$ in the lower horizons. Similar results were reported by Ramprakash and Seshagiri Rao (2002) [14] in soils of Krishna district, Andhra Pradesh.

The CEC value of in the study area ranged from 1.7 to 44.5 C mol (p+) Kg^{-1} of soil. The highest CEC was observed in the AP horizon of pedon 2 and while the lowest CEC was found in the horizon of AP horizon of pedon 1. The higher CEC values observed throughout the soil depth in the pedons 2 and 7 were due to illuvial accumulation of clay and also because of dominance of smectite clay mineral. These findings were amply supported by the observations of Satish Kumar and Naidu (2012) [19] and Leelavathi *et al.* (2010) [7]. Relatively low CEC is the reflection of parent material and higher degree of weathering leading to depletion of bases. Further, it may be due to dominance of clay minerals with low CEC especially illite and kaolinite. Similar findings were observed by Patil and Jagdish Prasad (2004) [12] and Gangopadhyay *et al.* (2001) [4].

The exchangeable bases in all the pedons found to be in the order of $Ca2^{+}>Mg^{2+}>Na^{+}>K^{+}$ on the exchangeable complex. The percent base saturation on the exchange complex of soil under investigated area varied from 56.47 per cent to 100 per cent. Comparatively exchangeable bases in the present study were more or less in the order of Vertisols > Inceptisols > Alfisols. The basic cations content was low in Entisols which might be due to less clay and high silica content. Similar observations were earlier made by Sarkar *et al.* (2001) [17] and Arun Kumar *et al.* (2002) [1]. Relatively higher exchangeable Ca was observed in surface horizons of some pedons which might be due to redistribution of Ca^{2+} by the vegetation. These observations were in agreement with the findings of Patil and Jagdish Prasad (2004) [12].

Soil Classification

The detailed classification of the study area of Jangon district presented in table 5. Based on morphological, physical, physico-chemical, mineralogical and meteorological data, the soils in the study area of Mulugu division of Warangal district were classified as Alfisols, Inceptisols and Vertisols.

Table 5: Soil Classification of the study area.

Pedon No.	Order	Sub-order	Great group	Sub-group	Family	Tentative soil series
1	Alfisols	Ustalfs	Rhodustalfs	Typic Rhodustalfs	Loamy-skeletal, mixed, isohyperthermic, Typic Rhodustalfs	Jangon
2	Vertisols	Usterts	Haplusterts	Typic Haplusterts	Fine, smectitic, isohyperthermic, Typic Haplusterts	Dharmasagar
3	Alfisols	Ustalfs	Haplustalfs	TypicHaplustalfs	Fine, mixed, isohyperthermic Typic Haplustalfs	Palakurthy
4	Alfisols	Ustalfs	Haplustalfs	Typic Haplustalfs	Fine-loamy, mixed, isohyperthermic Typic Haplustalfs	Raghunathapally
5	Inceptisols	Ustepts	Haplusterts	Calcic Haplustepts	Fine-loamy, mixed, isohyperthermic, Calcic Haplustepts	Lingalaghanpur
6	Inceptisols	Ustepts	Haplustepts	Typic Haplustepts	Loamy-skeletal, mixed, isohyperthermic Typic Haplustepts	Bachannapet
7	Inceptisols	Ustepts	Haplustepts	Vertic Haplustepts	Fine, smectitic, isohyperthermic, Vertic Haplustepts	Cherial

The pedon 2 had shown the following characteristics, Cracks that are opened and closed periodically, Intersecting slicken-sides and / or wedge shaped aggregates and pressure faces, More than 30 percent clay (weighted mean) in the fine earth fraction of all the horizons, Absence of lithic contact within 100 cm of the mineral soil surface, Absence of calcic, halic, salic and sodic horizons. Hence, pedons were classified as Fine, smectitic, isohyperthermic, Typic Haplusterts at sub-group level. Ramprakash and Seshagiri Rao (2002) [14] and Ramprakash (2005) [15], taxonomically classified some soils of Krishna district in Andhra Pradesh, Soils in Ramannagudem watershed in Nalgonda district.

The Pedons 3, and 4 were classified as Fine, mixed, isohyperthermic Typic Haplustalfs due to the absence of Lithic contact, cracks with in 125 cm, lack of COLE value of more than 6.0, frigid temperatures, mesic or thermic soil temperatures, vertic properties, aquic conditions, saturation of water in any of the horizons for more than 20 days, pumice or pumice like fragments, entire lamille forms, 75 % sand in the 75 cm argillic layer, calcic layer in the 100 cm depth of the pedon. Whereas Pedon 1 were classified as Typic Rhodustlfs due absence udic characteristics, lithic contact within 50 cm from the surface. Satyavathi and Suryanarayana Reddy (2004) [20] and Ramprasad and Goverdhan (2011) classidies the Alfisols of Telngana under Typic Rhodustlafs and Typic haplustalfs.

The Pedon 5 was classified as Fine-loamy, mixed, isohyperthermic, Calcic Haplustepts because of having a calcic horizon within 100 cm of the mineral soil surface (82-112 cm layer). Presence of Calcic Haplustepts in Northern and Central Telangana Region was earlier reported by NBSS & LUP (2005). Whereas Pedon 7 had shown cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slicken-sides or wedge shaped aggegates in a layer 15 cm or more thick that has its upper within 125 cm of the mineral soil surface. Ramprakash (2005) [15] characterized and classified soils having similar characteristics in Nalgonda district of Andhra Pradesh as Vertic Haplustepts.

The pedon 6 did not exhibit intergradation with other taxa or an extragradation from the central concept. Hence, pedon 6 were logically classified as Loamy-skeletal, mixed, isohyperthermic Typic Haplustepts at sub-group level. Niranjana *et al.* (2011) [11] classified banana growing soils in Pulivendla region of Andhra Pradesh as Typic Haplustepts at sub-group level.

Pedon 7 had shown cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slicken-sides or wedge shaped aggegates in a layer 15 cm or more thick that has its upper within 125 cm of the mineral soil surface were classified as Fine, smectitic, isohyperthermic, Vertic Haplustept. The presence of cambic sub-surface diagnostic horizon (Bw) in these pedon was recognized by the above features. Jagdish Prasad *et al.* (2001) [5] reported that presence of cambic sub-surface horizon was the diagnostic criteria for Inceptisols.

Soil nutrient status

Macronutrient status

The nutrient status of the study area of Jangon district presented in table 6. The available nitrogen in the soils under present investigation ranged from 145 to 385 kg/ha. The lowest value of 145 kg ha^{-1} soil was observed in BW2 horizon of pedon 6. The highest value of 385 kg ha^{-}

Table 6: Available major nutrients (kg ha^{-1}) and micronutrient content (mg kg^{-1}) of Jangon district in Telangana State

Pedon No. & Horizon	Depth (cm)	Available macronutrients			Available micronutrients			
		N	P	K	Zn	Cu	Fe	Mn
		kg ha^{-1}			mg kg^{-1}			
Pedon 1								
Ap	0-14	250	25.5	315	1.82	21.11	40.47	8.92
Bt1	14-39	215	15.5	295	1.62	19.34	36.97	8.8
Bt2	39-75	200	10.5	185	1.01	18.15	18.79	8.4
BC	75-110+	164	8.5	175	0.33	0.45	11.8	8.1
Pedon 2								
Ap	0-14	385	35.5	360	3.28	18.56	13.78	23.05
BA	14-33	195	28.5	315	2.96	17.6	14.32	22.8
Bss1	33-65	175	19.5	285	2.48	12.65	10.27	21.3
Bss2	65-102	164	16.5	195	2.35	5.95	9.65	18.6
Bss3	102-135+	155	13.5	175	2.15	5.5	9.87	13.4
Pedon 3								
Ap	0-10	185	21.5	300	5.71	6.26	59.87	28.9
Bt1	10-26	165	17.5	295	3.98	5.36	58.89	37.7

Bt2	26-62	150	14.5	185	2.86	4.54	45.34	26.67
Cr	62+	Weathered Parent Material						
Pedon 4								
Ap	0-8	325	30.5	330	5.19	2.87	25.46	61.59
Bt1	8-22	285	22.5	285	3.52	2.87	23.12	21.61
Bt2	22-46	255	19.5	252	2.31	2.1	12.46	7.32
Cr	46+	Weathered Parent Material						
Pedon 5								
Ap	0-19	295	17.5	199	1.14	2.5	28.1	8.6
Bw	19-44	252	11.5	175	0.98	1.79	9.09	7.26
Bw2	44-82	185	10.5	164	0.56	0.56	8.74	7.94
BCk	82-112	164	8.5	155	1.55	1.93	9.06	8.84
Crk	112+	Weathered Parent Material						
Pedon 6								
Ap	0-22	195	35.5	296	1.27	1.55	8.21	6.72
Bw1	22-48	155	18.5	156	1.04	1.35	7.53	5.21
Bw2	48-72	145	12.5	145	0.9	0.75	11.1	3.34
Cr	72	Weathered Parent Material						
Pedon 7								
Ap	0-15	300	30.5	360	0.49	1.1	9.6	3.3
Bw1	15-45	280	19.5	315	0.44	0.86	9.8	3.8
Bw2	45-75	265	10.5	305	0.32	0.79	7.1	1.9
Bw3	75-100	215	13.5	275	0.31	0.46	6.2	1.8

soil was noticed in AP horizon of pedon 5. The available nitrogen was found to be maximum in the surface horizons and decreased more or less with depth of the pedons, which might be due to decreasing trend of organic carbon with depth. This observation was in agreement with the results of Sarkar *et al.* (2002) [18] and Satish Kumar and Naidu (2012a) [19]. The available phosphorus in soils of the study area varied from 8.5 to 35.5 kg ha^{-1} soil. The lowest value of 8.5 kg ha^{-1} soil was observed in BCk horizon of pedon 23. The highest value of 35.5 kg ha^{-1} soil was noticed in AP horizon of pedon 2 and 6. In general, higher available phosphorus was observed in the surface horizons and decreased regularly with depth. The reason for high available phosphorus in surface horizons might possibly be due to the confinement of crop cultivation to the rhizosphere which improves the organic carbon content in surface and supplementing the depleted phosphorus by external sources *i.e.*, fertilizers and presence of small amounts of free iron oxide and exchangeable Al^{3+} in the surface horizons (Thangasamy *et al.* 2005) [27]. The available potassium in soils of the study area ranged from 145 to 360 kg ha^{-1} soil. The lowest value of 145 kg ha^{-1} soil was observed in BW2 horizon of pedon 6 and the highest value of 360 kg ha^{-1} soil was noticed in AP horizon of pedon 2 and 6. Most of the pedons exhibited more or less a decreasing trend with depth. Slow weathering and fixation of released potassium might have resulted in low exchangeable potassium status (Ramprakash and Seshagiri Rao, 2002) [14]. Amount and type of clay, organic carbon, soil pH and CEC significantly affects the K-availability in the soil. Similar observations were also noticed by Sharma and Anil Kumar (2003) [24] a significant and positive correlation between clay content and available K as K availability was largely controlled by clay minerals.

Micro nutrients

The available zinc was ranged for 0.31to 5.71 mg kg^{-1} soil. The lowest value of 0.31 mg kg^{-1} soil was noticed in BW2 horizon of pedon 7 and the highest value of 5.71 mg kg^{-1} of soil was recorded in AP horizon of pedon 3.

The available copper in soils under study area ranged from 0.45 to21.11 mg kg^{-1} soil. The lowest value of 0.45 mg kg^{-1} soil was observed in BC and BW3 horizon of pedon 1 and 7. Whereas the highest value of 21.11 mg kg^{-1} of soil was noticed in AP horizon pedon 19.

The available iron ranged from 6.20 to 59.87 mg kg^{-1} soil. The lowest value of 6.20 mg kg^{-1} soil was recorded in BW3 horizon of pedon 7 and where as the highest value 59.87 mg kg^{-1} soil was noticed in AP horizon of pedon 3.

The available manganese in soils of the study area of ranged from 1.80 to 61.59 mg kg^{-1} of soil. The lowest value of 1.80 mg kg^{-1} soil was observed in BW 5 horizon of pedon 7 and the highest value of 61.59 mg kg^{-1} soil was noticed in AP horizon of pedon 4.

The availability of these ions (Zn, Cu, Fe and Mn) increased with increase in organic matter because organic matter acts as a chelating agent for complexation of these micronutrients which reduces their adsorption, oxidation and precipitation into unavailable forms. Similar kind of relationship between Zn and organic carbon was also reported by Mahesh Kumar *et al.* (2011) [8].

Conclusion

Based on morphological, physical and physico-chemical properties of Mahabubabad district were slightly neutral to moderately alkaline, non-saline, low to medium in organic carbon and CEC. The exchangeable bases in all the pedons in the order of $Ca^{2+} > Mg^{2+} > Na^{+} > K^{+}$ on the exchange complex. Whereas, the soils were low to medium in available nitrogen, low to high in available phosphorus and potassium. Available zinc was deficient to sufficient in all the horizon. The soils were sufficient in available iron, copper and manganese. The soils were classified as Typic Rhodustalfs, Typic Haplustalfs, Typic Haplustepts, Calcic Haplustepts, Vertic Haplustepts and Typic Haplusterts.

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