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Study of profile distribution of available nutrients in alluvial soils of delta area of Krishna District in Andhra Pradesh

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ABSTRACT

The physico-chemical and chemical characteristics of soils in delta area of Krishna district in Andhra Pradesh have been studied. The study revealed that the soils are deep to very deep, moderately to poorly drained, slightly acidic to moderately alkaline. It indicates slightly alkaline in surface layers and moderately alkaline in sub-surface layers in reaction, non saline in nature, low in organic carbon and low to medium in cation exchange capacity. The soil texture varied from clayey to clay loam and sandy clay loam. Soils are low in available nitrogen, low to medium in phosphorus and potassium and sufficient in sulphur. *Exchangeable calcium is dominant than magnesium and which are in above the critical limit.* The soils exhibit the development of argillic horizon (Bss) while the soils on nearly level lands have cambic horizons (Bw). The soils have been classified as *Udic Haplusterts, Chromic Udic Haplusterts, Aquertic Eutrudepts and Vertic Eutrudepts*

Key words: *Available nutrients, Calcium, Cambic horizon, Magnesium and Organic carbon*

Alluvial soils are some of the world's most useful and productive soil resources. Alluvium, the parent material of alluvial soils, is the sediment deposited by fluvial systems such as rivers and streams. Alluvium includes a wide variety of compositions and textures, depending on the source of geologic materials and the depositional environment. Alluvium occurs in all climate regimes and underlies geomorphic surfaces ranging in age from zero to millions of years.

The alluvial soils always are a part of the ecotones of riverine floodplains between aquatic and terrestrial environments of sedimentary basins with active channels of river (Thoms, 2003) and describing it as fluvial hydro system. Under this complex fluvial hydro system, the alluvial soils are recognized as functional units with sediment transport and deposition, as well as by soil formation (Gerrard, 1987). The dual combination of both pedological and geomorphic processes are vital for providing evidences of past environmental changes (Daniels, 2003) due to variations in morphology of alluvial soils in accordance of landscape position and overbank lithofacies (Autin and Aslan, 2001). The geomorphic processes as a result of river shift, produces soils of different ages and degrees of profile development (McAuliffe, 1994). These alluvial soils in floodplains serves as good profile models to determine the periods of stability in terms of development of pedogenic features and pedoturbation under varied deposition environment (Paton *et al.,* 1995).

The Krishna River's significant influence on the fertility of its surrounding soils underscores the importance of understanding the diverse soil types and their properties. This knowledge can help in tailoring agricultural practices to local conditions, optimizing productivity while ensuring environmental sustainability.

Additionally, as challenges like climate change and urbanization threaten the ecological balance, understanding alluvial soils becomes vital. Effective management strategies informed by this research can enhance soil health, support biodiversity, and ensure that agricultural practices are resilient to changing environmental conditions. Keeping these factors in mind the study has been undertaken for available nutrient status in soils.

MATERIAL AND METHODS

The Krishna River is a key river basin in Peninsular India, commonly known as the "rice bowl" of Andhra Pradesh. It lies in between longitudes of 80° 35' and 81° 05' East, and latitudes of 15° 40' and 16° 30' North, covering a drainage area of about 259,000 square kilometers. The river has an average yearly water flow of 78 billion cubic meters. The average annual soil temperature was determined by adding 3.5°C to the average annual air temperature. The average summer soil temperature (MSST) was found by adding 2.5°C to the average summer air temperature (MSAT) and subtracting a correction factor based on the difference between average summer and winter air temperatures. The profile data set is useful for transfer of research outcomes to other rice growing regions in terms of the combined effects of soil and climate attributes on potential crop establishment, growth and yield of dry season crops.

Six profiles were selected for characterisation of soil properties using standard description terminology and analytical methods for classification, according to Soil Taxonomy (Soil Survey Staff, 2022; Schoeneberger *et al.,* 2012). The six soil profiles from five mandals in Krishna district: Movva, Ghatasala, Challapalli, Nagayalanka, and Penamaluru. The sample locations were situated 27 to 50 km from the Machilipatnam sea coast and at elevations of 6 to 27 meters.

The soil samples representing each horizon of the profile were collected and characterized for important physical, physico-chemical properties and available nutrient status using standard procedures. This selection considered geological, climatic, geomorphic, and other relevant pedological factors. The profile soil samples were collected in May 2022 as the paddy fields are moist, the structural features are expressed and recorded tentatively. The sampling of soils from each horizon was done from bottom to top. The horizon wise soil samples were collected and air dried to pass through <2mm sieve for fine earth fraction. These soil profile samples were analysed for their physico-chemical properties and available nutrient status using standard procedures and classified according to Soil Taxonomy (Soil Survey Staff, 2010). The soil samples were classified into low, medium and high categories as per limits suggested by Muhr *et al.* (1965) for available N, P and K and organic carbon. Available sulphur was rated based on the limits proposed by Tandon (1991).

RESULTS AND DISCUSSION

Physico-chemical characteristics

The pH values weighted average mean ranges from 7.99 to 8.34 it indicates slightly alkaline in surface layers and moderately alkaline in sub-surface layers reaction. This wide variation in pH was due to nature of parent material, leaching, presence of calcium carbonate and exchangeable sodium. These results are in strong agreement with Nandy *et al.* (2012), Reddy and Naidu (2016) and Supriya *et al.* (2019).

However, the EC values in all the horizons show less than one value and these soils did not show any relationship with depth (Table 1). This might be due to different parent material / transportation of material by eluviations / due to undulating nature of the terrain coupled with free drainage conditions. The results are inconformity with Chinchmalatpure *et al.* (1998) , Pillai and Natarajan (2004) and Sashikala *et al.* (2020).

The weighted mean average of organic carbon content ranges from 0.03 to 0.83 percent. The organic carbon content values are low in all the horizons. The organic carbon content of the rice growing alluvial soils was low to medium (0.03 to 0.74 per cent). An irregular trend is observed in organic carbon content across horizons of all profiles with soil depth. The level and profile distribution of the OC content of alluvial soils were depending on soil forming process and land management. Irregular decrease of the OC content with depth reflects stratification of the sediments which is the nature of alluvial soils. The findings are in conformity with the results obtained in study conducted by ISSS/ISRIC/ FAO, (1998); Ramprakash and Sheshagiri Rao (2000) and Mahendru Kumar *et al.,* (2023)

The Vertisols of deltaic plains were found to have CEC values varying from 27.13 to 47.16 cmol (p+) kg^{-1} soil and the higher CEC indicated that these soils may be dominated by smectitic clay minerals (Table 1). The mean CEC value of window I is 33.84

Table 1. Physico–chemical properties of soils of delta area of Krishna district

Profile	Depth(m)	Texture	pH	EC (dSm^{-1})	CEC (C mol kg-1)	OC (%)
P1 Vemulamanda	***Udic Haplusterts***					
Ap	0.00 - 0.18	c	6.85	1.12	34.71	0.83
Bss1	0.18 - 0.40	c	8.01	0.81	35.78	0.28
Bss2	0.40 - 0.70	cl	7.99	1.1	36.87	0.31
1Bss1	0.70 - 1.00	cl	7.97	0.99	46.6	0.12
1Bss2	1.00 - 1.30	sc	7.96	0.8	46.07	0.05
Bss3	1.30 - 1.50	cl	8.37	0.4	46.6	0.06
Bss4	1.50 - 2.00	c	8.4	0.29	28.26	0.03
	W		**8.02**	**0.74**	**38.21**	**0.19**
P2 Kothapalli	***Udic Haplusterts***					
Ap	0.00 - 0.25	sc	7.81	0.72	27.09	0.67
Bss1	0.25 - 0.50	scl	8.33	0.31	30.37	0.26
Bss2	0.50 - 0.90	c	8.4	0.3	26.05	0.38
Bss3	0.90 - 1.30	c	8.22	0.6	37.94	0.34
Bss4	1.30 - 1.70	scl	8.19	1.15	36.87	0.37
Bss5	1.70 - 2.10	cl	8.24	0.73	16.05	0.05
	W		**8.22**	**0.65**	**29.11**	**0.33**
P3 Velivelu	***Chromic Udic Haplusterts***					
Ap	0.00 - 0.20	scl	7.81	0.78	34.71	0.6
Bss1	0.20 - 0.50	scl	8.04	0.76	27.12	0.43
Bss2	0.50 - 0.80	cl	7.95	0.89	32.53	0.4
1Bss1	0.80 - 1.20	cl	8.12	1.01	25.51	0.37
1Bss2	1.20 – 1.50	scl	8.2	1.08	27.67	0.24
Bss3	1.50 - 2.00+	c	7.82	0.72	28.75	0.26
	W		**7.99**	**0.87**	**28.86**	**0.36**
P4 Nangagadda	***Chromic Udic Haplusterts***					
Ap	0.00 - 0.25	c	8.34	0.9	39.57	0.77
Bss1	0.25 - 0.50	c	8.11	0.38	34.57	0.23
Bss2	0.50 - 0.80	c	8.21	0.37	31.46	0.2
1Bss1	0.80 - 1.05	sc	8.22	0.31	28.28	0.08
1Bss2	1.05 -1.20	cl	8.25	0.25	25.42	0.09
2 Bss1	1.20 - 1.40	c	8.35	0.24	18.57	0.17
2Bss2	1.40 - 1.80	cl	8.69	0.22	15.65	0.34
	W		**8.34**	**0.38**	**27.13**	**0.28**
P5 Penamaluru	***Aquertic Eutrudepts***					
Ap	0.00 - 0.20	c	8.82	0.57	37.41	0.32
Bw1	0.20 - 0.60	c	8.67	0.69	54.25	0.47
Bw2	0.60 - 0.90	c	8.33	0.62	52.92	0.05
Bw3	0.90 - 1.22	cl	8.12	0.56	43.9	0.31
Bw4	1.22 - 1.55	cl	8.52	0.51	38.49	0.2
Bw5	1.55 - 1.90+	c	7.45	1.03	36.87	0.12
	W		**8.29**	**0.68**	**44.58**	**0.25**
P6 Ganguru	***Oxyaquic Eutrudepts***					
Ap	0.00 - 0.20	c	7.62	0.45	56.97	0.81
Bw1	0.20 - 0.50	scl	8.05	0.24	51.56	0.31
Bw2	0.50 - 0.82	c	8.21	0.24	49.92	0.29
Bw3	0.82 - 1.10	scl	8.17	0.22	47.56	0.32
Bw4	1.10 - 1.40	cl	8.04	0.25	46.25	0.38
Bw5	1.40 - 1.80	cl	8.07	0.24	39.39	0.37
	W		**8.05**	**0.26**	**47.66**	**0.39**

± 9.49 and with CV value 28.04 percent. The results are in conformity with Orphan *et al*. (2012). The mean value of Ca^{+2} is 24.94 ± 6.87 cmol kg^{-1} and C.V value recorded in 27.54 per cent. Rajeshwar and Mani, (2015) reported the similar finding in smectite type of clay dominant soils.

Availability of nutrients

The weighted mean average of available N, P and K are range from 110.02 to 144.39, 16.92 to 44.02 and 137.09 to 236.38 kg ha^{-1} respectively in different soil series of Krishna basin in Krishna district (Table 2). The surface horizons were low in organic carbon and available nitrogen and low to medium in available phosphrus and potassium. The results are inconformity with Kannan *et al*. (2011), Nandy *et al*.(2012) and Sujatha *et al*. (2021). Available N (kg ha^{-1}) =72.06 + 186.78 (Organic carbon %) with an R^2 of 0.57 and F value of 47.63 for degrees of freedom 1 and 36 and available K (kg ha^{-1}) = -203.21 + 241.85 OC (%) + 40.63 pH with R2 of 0.41 and F value 12.01 for degrees of freedom 1 and 35 at p < .001. The predictor OC and pH explains 40.07 per cent of the variance of available K in these soils. The coefficient of multiple correlation (R) equals **0.637982.**

The individual predictors were examined further and indicated that X1 (t = 4.861, $p < .001$) was significant predictor in the model, and X2 (t = 1.37, $p = .180$) was non-significant predictor in the mode, The exchangeable calcium, magnesium, and sulfur also show irregular trends with depth. The exchangeable Ca in rice growing soils was ranged from 3.25 to 36cmol (p+) kg^{-1} soil with a weighted mean range from 14.56 to 32.59 cmol (p+) kg^{-1} soil. Similarly, the exchangeable Mg in rice growing areas was found to vary from 2.50 to 18.00 cmol (p+) kg^{-1} of soil with a weighted mean range from 5.94 to 14.38 cmol(p+) kg^{-1} of soil (Table 2). The mean value of Ca^{+2} is 18.61 ± 5.10 and C.V value recorded in 27.42 per cent. The similar finding are infirmity with the result of Ramprakash, T and Seshagirirao, M. (2002) and Rajeshwar and Mani, (2015). Taking 1.5 cmol (p+) kg^{-1} of soil for Ca and Mg as critical limit, the exchangeable Ca and Mg were well above their critical limits and found sufficient for crop growth. The exchangeable Ca was found to be the dominant cation followed by Mg because of its higher mobility, earlier removal than the Mg and also Ca dominates in the prevailing semi-arid weathering environment and consequently occupied the major portion on the exchange complex in the groundnut growing soils (Reddy and Naidu, 2016).

The available S in rice growing soils varied from 0.32 to 2.62 mg kg^{-1} with a weighted mean rage from 1.06 to 2.62 mg kg^{-1} (Table 2). Taking 10 mg S kg^{-1} soil as critical value, the available S was sufficient in surface and subsurface horizons of all the pedons of groundnut growing areas. The higher available sulphur may be due to higher amount of organic matter in surface layers than in sub-surface layers. Similar findings were reported by Devi *et al*. (2015).

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Table 2. Macronutrient status of rice growing soils of delta area of Krishna district

Profile	Depth(m)	Available Nutrients					
		N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (mg kg-1)	Ca (cmol (p+) kg-1)	Mg (cmol (p+) kg-1)
P1 Vemulamanda							
Ap	0.00 - 0.18	259.79	40.32	246.4	2.62	25.5	10
Bss1	0.18 - 0.40	190.93	33.33	179.2	1.71	26.5	8.5
Bss2	0.40 - 0.70	181.54	31.72	156.8	0.3	31.5	7.75
1Bss1	0.70 - 1.00	143.98	23.65	123.2	2.17	30.5	5.5
1Bss2	1.00 - 1.30	128.33	20.97	156.8	1.53	30.5	6.75
Bss3	1.30 - 1.50	100.16	18.82	100.8	0.34	17.25	4.75
Bss4	1.50 - 2.00	87.64	15.59	78.4	0.77	6.5	2.5
	W	**144.39**	**24.53**	**137.09**	**1.25**	**22.44**	**5.94**
P2 Kothapalli							
Ap	0.00 - 0.25	209.71	55.37	347.2	0.09	28.5	9.25
Bss1	0.25 - 0.50	169.02	49.46	201.6	1.48	28	10.75
Bss2	0.50 - 0.90	134.59	46.77	179.2	2.24	28.75	11.25
Bss3	0.90 - 1.30	118.94	39.24	156.8	0.69	24.5	14.75
Bss4	1.30 - 1.70	81.38	37.09	134.4	0.55	25.25	9
Bss5	1.70 - 2.10	56.34	24.19	100.8	1.1	7.5	4.75
	W	**119.61**	**40.54**	**174.13**	**1.06**	**23.11**	**9.95**
P3 Velivelu							
Ap	0.00 - 0.20	175.28	48.92	302.4	0.78	25	14
Bss1	0.20 - 0.50	162.76	47.85	246.4	0.64	28	16.25
Bss2	0.50 - 0.80	137.72	46.77	235.2	1.41	28.25	18.25
1Bss1	0.80 - 1.20	100.16	41.93	212.8	1.34	26.5	14
1Bss2	1.20 – 1.50	78.25	36.02	190.4	0.94	22.75	12.75
Bss3	1.50 - 2.00+	62.6	33.33	179.2	1.07	21.75	9.75
	W	**110.02**	**41.21**	**218.4**	**1.06**	**25.09**	**13.73**
P4 Nangagadda							
Ap	0.00 - 0.25	190.93	32.79	302.4	1.12	30.75	9
Bss1	0.25 - 0.50	109.55	29.03	280	1.01	27.5	16.75
Bss2	0.50 - 0.80	90.77	27.42	235.2	1.85	23	7.75
1Bss1	0.80 - 1.05	53.21	22.58	212.8	1.67	7.25	4.75
1Bss2	1.05 -1.20	50.08	19.89	145.6	0.89	6.25	2.5
2 Bss1	1.20 - 1.40	46.95	16.67	123.2	1.01	3.5	5.25
2Bss2	1.40 - 1.80	178.41	15.05	112	1.85	3.25	5
	W	**113.29**	**23.15**	**200.36**	**1.44**	**14.56**	**7.43**
P5 Penamaluru							
Ap	0.00 - 0.20	159.63	63.97	358.4	1.76	24.75	12.25
Bw1	0.20 - 0.60	159.63	53.22	324.8	2.33	30.25	14.75
Bw2	0.60 - 0.90	128.33	43.55	268.8	1.69	27.25	14.25
Bw3	0.90 - 1.22	100.16	38.71	212.8	1.96	28	12
Bw4	1.22 - 1.55	115.81	36.56	156.8	1.96	23	15.25
Bw5	1.55 - 1.90+	93.61	34.41	134.4	3.54	28.75	14.75
	W	**124.9**	**44.02**	**236.38**	**2.27**	**27.28**	**14.03**
P6 Ganguru							
Ap	0.00 - 0.20	237.88	26.34	302.4	2.14	32.5	15.25
Bw1	0.20 - 0.50	165.89	20.43	268.8	1.96	25.75	18
Bw2	0.50 - 0.82	131.46	17.2	224	2.58	34.5	13.5
Bw3	0.82 - 1.10	118.94	15.59	201.6	0.64	36	13.25
Bw4	1.10 - 1.40	125.2	13.44	168	0.39	32.75	13
Bw5	1.40 - 1.80	122.07	12.9	145.6	0.32	33.75	13.75
	W	**143.95**	**16.92**	**209.94**	**1.26**	**32.59**	**14.38**

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