Original Research Article

VERTICAL DISTRIBUTION OF NUTRIENTS IN PADDY GROWING SOILS IN SEMIARID REGION OF VEPURIKOTA MICROWATERSHED IN CHITTOOR DISTRICT OF ANDHRA PRADESH

ABSTRACT

The soil survey was undertaken to study the vertical distribution of plant nutrients in the pedons ofpaddy growing areas of Vepurikota micro-watershed in Chittoor district of Andhra Pradesh to understand nutrient supplying capacity of soils. The results revealed that soils were low in available nitrogen and medium to high in available P_2O_5, low to high in available K_2O and deficient to sufficient in available S. The DTPA extractable Cu was found to be sufficient in surface and sub-surface horizons of all the pedons. The available Zn was deficient to sufficient in all the pedons in both surface and sub-surface horizons and the available Fe and Mn were found to be sufficient and above the critical limits except pedon 4.

Keywords: Macro and micronutrients, Organic carbon, pH, Surface horizon and sub-surface horizon.

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~~INTRODUCTION~~1. INTRODUCTION

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Soil degradation is occurring ~~at an accelerated pace due to inadequate management and faulty land-use practices~~at an accelerated pace due to inadequate management and faulty land-use practice, surpassing the natural rate of deterioration. It is crucial to protect soils from further degradation[15, 16]. Many crops are of long duration and use of hybrids takes a considerable amount of plant nutrients from the soil. Consequently, the soil's capacity to supply plant nutrients is decreasing, resulting in reduced crop productivity. Additionally, intensive cropping and imbalanced application of essential plant nutrients have caused nutrient deficiencies and deterioration in the physical properties of the soils [14]. This, in turn, hinders the growth and development of crops. The fertility of soils and crop yields are significantly influenced by both macro and micronutrientsmicronutrients in soils. To maintain soil fertility and crop productivity, it is important to study the vertical distribution of available nutrients in the soil, which helps to assess the current fertility status. Surprisingly, no such study has been reported yet in the paddy-growing soils of the Vepurikota micro-watershed. Considering all these factors, the present study was planned and executed.

MATERIAL 2. MATERIAL AND METHODS

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Location and Agro-climate: Vepurikotamicrowatershed of Chittoor district, Andhra Pradesh is spread over an area of 1006 ha. The climate of the study area is semi-arid monsooonicmonsoonal with mean annual rainfall of 668.31 mm, of which 83.54per cent is received during June-December.The mean annual temperature is 26.59°C with mean summer temperature of 30.66°C and the mean winter temperature of 23.38°C. The maximum temperature was recorded in April that rises to 35.49°C and the minimum temperature is 20.20°C in December. The soil moisture regime is ustic and soil -temperature regime iso-hyperthermic.

Field survey and Taxonomic classification: Reconnaissance soil survey was conducted and four pedons were arranged in the paddy growing areas of Vepurikotamicrowatershed in Chittoor district, Andhra Pradesh during 2021-22. The taxonomy of these five pedons*viz.*, pedon1 : Fine loamy, mixed, isohyperthermic, TypicNatrustalfs, pedon 2 : Fine, mixed, isohyperthermic, TypicHaplustalfs, pedon 3 : Fine loamy, mixed, isohyperthermic, TypicHaplustalfs and pedon 4 : Fine, mixed, isohyperthermic, VerticHaplustepts. The horizon wise soil samples were collected for detailed analysis. The soil samples were processed and analyzed for available macronutrients and micronutrients using standard methods as described by Jackson (1973). The critical limits proposed by Muhr*et al.* (1965) for available N, P_2O_5 and K_2O, Tandon (1991) and available S (10 mg kg^{-1}), In respect of available micronutrients, the ratings given by Lindsay and Norvell (1978) for Zn (0.6 mg kg^{-1}), for Fe (4.5 mg kg^{-1}), Cu (0.2 mg kg^{-1}) and Mn (2 mg kg^{-1}) were followed for classifying profile soil samples into sufficient or deficient for paddy cultivation.

RESULTS3. RESULTS AND DISCUSSION

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Physico-chemical properties

The Paddy growing soils were slightly acidic to very strongly alkaline in their reactivity (6.03-9.27) (Table 1) and wide variation in pH was attributed to the nature of the parent material, leaching, presence of calcium carbonate, exchangeable sodium and the release of organic acids during decomposition of organic matter. Similar findings were recorded by Leelavathy and Naidu (2020)[17]. The texture of the paddy growing soils varied from sandy clay loam to clay loam and this wider textural variation was caused by topographic position, nature of parent material, *in situ* weathering and translocation of clay (Selvaraj*et al.*,2012). The EC in paddy growing soils was ranged from 0.03 to 1.20 dSm^{-1} indicating their non-saline nature (Table 1). The low EC of paddy growing soils was due to free drainage which favoured the removal of released bases by percolation and drainage(Mohan *et al.*, 2020). The organic carbon content of the paddy growing soils was low to medium (0.01 to 0.60 per cent), which can be attributed to the prevalence of tropical condition, where the degradation of organic matter occurs at a faster rate coupled with low vegetative cover, thereby leaving less organic carbon in the soils (Supriya*et al.*, 2019)[17].

Macronutrients:

The available N varied from 62.72-225.79 kg ha^{-1} in all the pedons of paddy growing areas with a mean of 137.98 kg ha^{-1} (Table 2). Considering 280 kg ha^{-1} as critical level, the available N status was low in the surface and sub-surface horizons and a decreasing trend with depth was observed in all the pedons except pedon 1. The low available nitrogen (N) in the soils could be attributed to the prevailing semiarid conditions in the area, which could promote rapid oxidation and limit the accumulation of organic matter, leading to increased release of NO_3-N which is prone to leaching and subsequent loss from the soil. Similar results were reported bySharma *et al.* (2013)and Borse*et al.* (2018).

The available P_2O_5 content varied from 46.19-217.41 kg ha^{-1}in all the pedons of paddy growing areas with a mean of 75.69 kg ha^{-1}(Table 2). Considering 22.8 kg ha^{-1}as critical limit, the available P_2O_5 status was medium tohigh in the surface and sub-surface horizons and in the pedons 2 and 3, the available P_2O_5 content decreased with depth, which might possibly be due to the confinement of crop cultivation to the rhizosphere and supplementing the depleted Phosphorus by external sources *i.e.*, fertilizers to the surface soil (Nazir*et al.*, 2021)[18]. Variations in available P contents in remaining pedons, might be

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related to the intensity of soil disturbance and the degree of phosphorus fixation with Fe and other cations in the soil (Osujieke*et al.*, 2018).

The available K_2O of paddy growing soils varied from 73.25-381.70 kg $ha^{-1}$with a mean value 157.36 kg ha^{-1}(Table 2). Taking129.6 kg ha^{-1}as a critical limit, the highest available K_2O content was observed in the surface horizons and showed a decreasing trend with depth in all the pedons. This could be ascribed for greater weathering of the potassium bearing minerals, application of potassic fertilizers and upward translocation of K from lower depths along with capillary movement of ground water (Vedadri and Naidu, 2018)[10].

The available S in paddy growing soils varied from 5.29 - 45.25 mg kg^{-1} with a mean of 19.27 mg kg^{-1} (Table 2). Taking 10 mg S kg^{-1} soil as critical value, the available S was sufficient in all surface horizons and a decreasing trend was observed with the depth in all the pedons.Surface horizons in the pedons of paddy growing areas contained more available S than sub-surface horizons which could be due to higher amount of organic matter in surface layers than in deeper layers. Similar type of results were also reported by Thangasamy*et al.* (2005) and Raghu *et al.* (2022).

Table 1. Physico–chemical properties of soils

Pedon No. & Horizon	Depth (m)	Organic carbon (%)	$CaCO_3$ (%)	pH 1:2.5		EC (dSm^{-1})
				H_2O	*1N*KCl	
Pedon 1						
Ap	0.00-0.26	0.60	11.5	7.89	7.02	0.25
A/B	0.26-0.56	0.24	7.5	8.08	6.69	0.19
Btn1	0.56-0.79	0.04	11.5	8.12	6.63	0.18
Btn2	0.79-1.15	0.01	11.5	8.13	6.63	0.21
Cr	1.15	Weathered gneiss				
Pedon 2						
Ap	0.00-0.28	0.18	12.5	8.54	7.10	0.31
B/A	0.28-0.50	0.13	12.5	8.13	6.61	0.24
Bt1	0.50-0.80	0.10	12.0	8.02	6.66	0.19
Bt2	0.80-1.16	0.07	12.5	7.92	6.27	0.20
Bt3	1.16-1.60	0.04	13.5	8.01	6.56	0.20
Cr	1.60	Weathered gneiss				
Pedon 3						
Ap	0.00-0.25	0.39	15.5	6.56	4.72	0.14
Bt1	0.25-0.45	0.27	14.0	6.03	4.31	0.03
Bt2	0.45-0.70	0.06	14.0	7.00	5.24	0.09
Pedon 4						
Ap	0.00-0.30	0.16	18.0	8.96	7.14	1.20
Bw	0.30-0.60	0.07	24.5	9.15	7.29	1.06
BC	0.60-0.90	0.06	15.5	9.27	7.33	0.69
Cr	0.90	Weathered gneiss				
Mean		0.16	13.76	7.98	6.41	0.34
Range		0.01-0.60	7.5-24.5	6.03-9.27	4.31-7.33	0.03-1.20

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Table 2. Macronutrient status of paddy growing soils of Vepurikotamicrowatershed of Chittoor district

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Pedon No. & Horizon	Depth (m)	Available macronutrients			
		N	P_2O_5	K_2O	S
		(Kg ha^{-1})			(mg kg^{-1})
Pedon 1					
Ap	0.00-0.26	175.62	217.41	381.70	38.31
A/B	0.26-0.56	125.44	60.82	195.55	15.20
Btn1	0.56-0.79	150.53	62.47	147.17	9.15
Btn2	0.79-1.15	125.44	62.68	106.18	7.28
Cr	1.15	Weathered gneiss			
Pedon 2					
Ap	0.00-0.28	200.70	80.51	189.50	25.20
B/A	0.28-0.50	150.53	74.46	188.16	16.58
Bt1	0.50-0.80	125.44	52.04	181.44	6.20
Bt2	0.80-1.16	125.44	48.63	158.59	6.01
Bt3	1.16-1.60	112.90	46.39	149.18	5.29
Cr	1.60	Weathered gneiss			
Pedon 3					
Ap	0.00-0.25	225.79	86.44	114.64	35.24
Bt1	0.25-0.45	150.53	86.06	74.19	21.45
Bt2	0.45-0.70	150.53	75.15	73.25	11.25
Cr	0.70	Weathered gneiss			
Pedon 4					
Ap	0.00-0.30	112.90	58.87	135.21	45.25
Bw	0.30-0.60	75.26	77.28	133.32	24.56
BC	0.60-0.90	62.72	46.19	132.38	22.15
Cr	0.90	Weathered gneiss			
Mean		137.98	75.69	157.36	19.27
Range		62.72-225.79	46.19-217.41	73.25-381.70	5.29-45.25

Table 3. Micronutrient status of paddy growing soils of Vepurikota micro-watershed of Chittoor district

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Pedon No. & Horizon	Depth (m)	Available macronutrients			
		Zn	Cu	Fe	Mn
		(mg kg^{-1})			
Pedon 1					
Ap	0.00-0.26	0.95	1.83	46.57	13.39
A/B	0.26-0.56	0.29	0.53	10.68	20.19
Btn1	0.56-0.79	0.32	0.30	12.47	33.45
Btn2	0.79-1.15	0.35	0.25	7.77	15.20
Cr	1.15	Weathered gneiss			
Pedon 2					
Ap	0.00-0.28	0.37	1.74	19.78	6.55
B/A	0.28-0.50	0.26	1.37	9.95	11.75
Bt1	0.50-0.80	0.22	1.52	9.54	23.10
Bt2	0.80-1.16	0.21	1.11	8.99	21.64
Bt3	1.16-1.60	0.16	1.35	8.04	22.49
Cr	1.60	Weathered gneiss			
Pedon 3					
Ap	0.00-0.25	0.74	1.58	30.24	14.77
Bt1	0.25-0.45	0.31	0.74	42.29	30.14
Bt2	0.45-0.70	0.28	0.41	11.38	22.25
Cr	0.70	Weathered gneiss			
Pedon 4					
Ap	0.00-0.30	0.33	0.48	3.09	4.21
Bw	0.30-0.60	0.12	0.35	2.15	2.02
BC	0.60-0.90	0.06	0.32	1.61	1.27
Cr	0.90	Weathered gneiss			
Mean		0.33	0.93	14.97	16.16

Range		0.12-0.95	0.25-1.83	2.15-46.57	1.27-33.45

Micronutrients:

The available Zn content in the soil profiles of paddy growing areas was varied from 0.12 mg kg^{-1} to 0.95 mg kg^{-1} with a mean of 0.33 mg kg^{-1} (Table 3). Further, by taking 0.6 mg Zn kg^{-1} soil as critical limit, the surface horizons of pedons 1 and 3 were above the critical limit and surface and sub-surface horizons in pedons of 2 and 4 were below the critical limit exhibited lower values than critical limit. The low available zinc was possibly due to high soil pH values which might have resulted in the formation of insoluble compounds of zinc or insoluble calcium zincate (Jagdish Prasad *et al.*, 2009)which was confirmed by significant and positively correlation (r =+0.880*) of Zn with organic carbon. Similar findings were reported by Sadanshiv*et al.* (2017) and Satish *et al.* (2018)in Nagalwadi micro-watershed and Brahmanakotkur watershed, respectively.

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The available Fe status in all the pedons was found to be varied from 2.15 and 46.57 mg kg^{-1} soil with a mean of 14.97 mg kg^{-1} soil (Table 3). According to critical limit of 4.5 mg kg^{-1} soil, the paddy growing soils were sufficient in available Fe content except pedon 4. The distribution of available iron in all the pedons showed a decreasing trend with depth.The high iron content might be due to accumulation of organic carbon in the surface horizons and affinity to influence the availability by chelation effect. Similar findings were reported by Prasad and Sakal, (1991) and Satish *et al.* (2018).

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Available Cu in the pedons ranged from 0.25 to 1.83 mg kg^{-1} with an average of 0.93 mg kg^{-1} (Table 3). Considering on 0.2 mg Cu kg^{-1} soil as a critical limit the available Cu in paddy growing areas was sufficient in the horizons of all the pedons. Available Cu was positively correlated (r=+0.557*) with organic carbon as accumulation of more organic carbon could have fixed more copper. Similar findings were also reported by Choudhury *et al.* (2019).

The available Mn in paddy growing soils varied from 1.27 to 33.45 mg kg^{-1} with a mean of 16.16 mg kg^{-1} (Table 3). The available Mn in all the pedons of paddy growing areas was found to be adequate except pedon 4 as per the critical limit of 2.0 mg Mn kg^{-1} soil. In general the higher Mn in surface horizons might be due to comparatively higher biological activity and the chelating of organic compounds released during the decomposition of organic matter left after harvest of crop. However, the higher Mn (*i.e.*, above critical limit) in subsurface horizons might be derived from the parent material. It is further supported by a positive correlation between available manganese with organic carbon (r = +0.153**). Similar findings were made by Dinesh*et al.* (2020).

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CONCLUSIONS

Paddy growing soils of Vepurikota micro-watershed of Chittoor district, Andhra Pradesh were classified into Inceptisols (VerticHaplustepts) and Alfisols (TypicNatrustalfs and TypicHaplustalfs).These soils were slightly acidic to strongly alkaline, non-saline and low in organic carbon. They were low in available nitrogen and medium to high in available P_2O_5, low to high in available K_2O and deficient to sufficient in available S. The DTPA extractable Cu was found to be sufficient in surface and sub-surface horizons of all the pedons. The available Zn was deficient to sufficient in all the pedons in both surface and sub-surface horizons and the available Fe and Mn were found to be sufficient and above the critical limits except pedon 4. Hence, judicious use of organics with inorganics not only sustains soil fertility of paddy growing soils but also the productivity of paddy growing soils in Vepurikota micro-watershed of Chittoor district in Andhra Pradesh.

REFERENCES

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1. Borse AA, Nagaraju MSS, Dash B, Sahu N, Ingle S.N and Srivastava R..Characterization and Evaluation of Land Resources for Management of Barela Village in Seoni district, Madhya Pradesh using High Resolution Satellite Data and GIS. *Agropedology*.2018. 28 (01):48-59.
2. Choudhury S, Patel JM, Gavit CS, Gadhavi B.K and Saxena Mitul. Vertical distribution of available nutrients in soils of paddy and sugarcane growing areas of

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Navsari district in Gujarat. *International Journal of Chemical Studies*. 2019. 7(6): 810-814.

3. Dinesh, Bhat, M A, Sahoo J and Sharma M.K. Vertical distribution of nutrients vis-a-vis soil properties in different geomorphic units of North-Eastern Haryana, India. *Indian Journal of Ecology*. 2020. 47(1): 58-67.
4. Jackson, M.L. Soil Chemical Analysis. Prentice Hall of India Private Limited, New Delhi. 1973.
5. Leelavathy GP, and Naidu MVS. Vertical distribution of nutrients in groundnut growing soils in semiarid region of Yerpedumandal in Chittoor district, Andhra Pradesh. *International Journal of Chemical Studies*. 2020. 8(4):1852-1856.
6. Lindsay W.L and Norvell W.A. Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of American Journal*. 1978.43: 421-428.
7. Mohan MM, Giridharakrishna T, Naidu MVS, Prabhakara Reddy G and Ramana K.V. Soil site suitability evaluation for rice in soils of Tirupati division of Chittoor district, Andhra Pradesh. *International Journal of Agriculture Sciences*.2020. 12(20):10298-10300.
8. Muhr G.R, Datta NP, Sankarasubramoney H., Laley, V.K. and Donahue, R.L. Critical soil test values for available N, P and K in different soils. In Soil Testing in India. 2nd Edition, USAID mission to India, New Delhi.1965. 52-56.
9. Nazir G, Sharma VK, Suri D and Anjali. Depth-Wise Fertility Status of Cultivated Soils in Low and Mid Hill Regions of Himachal Pradesh. *International Journal of Plant & Soil Science*.2021. 33(2): 22-30.
10. Pathariya, P., Dwivedi, B.S., Dwivedi, A.K., Thakur, R.K.,Singh, Muneshwar and Sarvade, S. Potassium balanceunder soybean–wheat cropping system in a 44-year old longterm fertilizer experiment on a Vertisol. Communications inSoil Science and Plant Analysis.2022. 53(2): 214–226.
11. Prasad, S.N andSakal, R. (1991). Availability of iron in calcareous soils in relation to soil properties. *Journal of the Indian Society of Soil Science*.39:658-661.
12. Raghu RS, Prasad PRK, Ramana KV, Sujani Rao Ch, Venkateswarlu B, Rao, V. S and Naidu,M. V. S. Characterization of Vertisols in Semi-arid Tropical Region of Chinnapalem Village of Guntur District in Andhra Pradesh. *International Journal of Plant & Soil Science*.2022. 34(10): 47-67.

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13. Sadanshiv SN, Nagaraju MSS and Thelkar, S. I.Vertical distribution of available macro and micronutrients in Nagalvadi micro-watershed of Wardha district, Maharasthra. Journal of soils and Crops. 2017. 27(2):26-29.
14. Sarvade, S., Gupta, B., & Singh, M. Soil carbon storage potential of different land use systems in upstream catchment area of GobindSagar reservoir, Himachal Pradesh. Indian Journal of Soil Conservation.2016. 44(2), 112-119.
15. Sarvade, S., Loriya, N., Singh, I., Panwar, P and Kaushal, R. Agroforestry role in sustainable management of degraded watersheds. In: Applied Agricultural Practices for Mitigating Climate Change. Rohitashw Kumar, Vijay P Singh, Deepak Jhajhana, RassoulMirabbasi. 2019a. CRC Press .Vol.2, Pp-133-149.
16. Sarvade, S., Upadhyay, V.B., Kumar, M., and Imran Khan, M. Soil and Water Conservation Techniques for Sustainable Agriculture. In Sustainable Agriculture, Forest and Environmental Management, Springer, Singapore. 2019b. pp. 133-188.
17. Sarvade, S., Gautam, D.S., Upadhyay, V.B., Sahu, R.K., Shrivastava, A.K., Kaushal, R., Singh, R., &Yewale, A.G. Agroforestry and soil health: an overview. In: Agroforestry for Climate Resilience and Rural Livelihood. Inder Dev, Asha Ram, Naresh Kumar, Ramesh Singh, Dhiraj Kumar, A.R. Uthappa, A.K. Handa, O.P. Chaturvedi (eds). Scientific Publishers, Jodhpur, Rajasthan, India.2019c. pp-275-297.
18. Sarvade, S., Mishra, H. S., Kaushal, R., Chaturvedi, S., &Tewari, S. Wheat (*Triticumaestivum* L.) yield and soil properties as influenced by different agri-silviculture systems of Terai Region, Northern India. International Journal of Bio-resource and Stress Management, 2014. 5(3), 350-355.
19. Selvaraj, S and Naidu, M. V. S. Characteristics, classification and evaluation of soils for different land uses in Reniguntamandal of Chittoor district in Andhra Pradesh. *Journal of the Indian Society of Soil Science*. 2012. *60*(3), 225-229.
20. Sharma RP, Singh R.S and Sharma, S.S. Vertical Distribution of Plant Nutrients in Alluvial Soils of Aravalli Range and Optimization of Land Use. *International Journal of Pharmaceutical and Chemical Sciences.* 2013. 2(3):1377-1389.
21. Supriya K, Naidu MVS, Kavitha P. and Srinivasa Reddy M. Characterization, classification and evaluation of soils in semi- arid region of Mahanandimandal in Kurnool district of Andhra Pradesh. *Journal of the Indian Society of Soil Science*. 2019. 67(2): 125- 136.

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22. Tandon, H.L.S. Secondary and Micronutrient in Agriculture-Guide bookcum-Directory, FDCO, New Delhi. 1991.

23. Thangasamy A, Naidu, MVS, Ramavatharam N. and Reddy C. R. Characterization, classification and evaluation of soil resources in Sivagiri micro watershed of Chittoor district in Andhra Pradesh for sustainable land use planning. *Journal of the Indian Society of Soil Science*. 2005.53(1): 11-21.

Vedadri, U.and Naidu, M.V.S. Characterization, classification and evaluation of soils in semi-arid ecosystem of Chillakurmandal in SPSR Nellore district of Andhra Pradesh. *Journal of the Indian Society of Soil Science*. 2018. 66(1): 9-19.

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