

Original Research Article**VERTICAL DISTRIBUTION OF AVAILABLE NUTRIENTS IN SOME SOILS OF MID CENTRAL TABLE LAND IN AGRO CLIMATIC ZONE OF ODISHA****ABSTRACT :**

To understand the importance of plants in structuring the vertical distributions of soil nutrients, we explored nutrient distributions in the top meter of soil. Hypothesizing that vertical nutrient distributions are dominated by plant cycling relative to leaching, weathering dissolution, and atmospheric deposition. Therefore, an objective of vertical distribution of available nutrients in some soils of mid central table land in Agro climatic zone of Odisha has been taken. Four profiles have been dug in two different altitude (Upper and Lower) of dhenkanal sadar and Gandia blocks of Dhenkanal district. It have been found that phosphorus and sulphur are deficient where is necessary of liberal application for higher crop productivity in two blocks of the Dhenkanal District where as liberal amount of boron should be applied in low lands of Gandia block. Similarly liberal amount of potassium application is necessary in upland of Gandia block. To maintain the soil health, judicious application of organic matter is required in upland of Dhenkanal Sadar block and Gandia Block in Central table land agro climatic zone of Odisha. The variability in nutrient status in the vertical distribution of soil profile has a long term bearing on the production and productivity of field crops, vegetables, orchard plantation and agro forestry in different blocks of Dhenkanal District which constitutes a major portion of mid different land use planning can be done on the basis of physico-chemical properties and nutrient status of different horizons of upland and low land soil of the district.

Introduction

Knowledge of vertical distribution of plant nutrients in soil is useful as roots of most of the crop plants go beyond the surface layer and draw part of their nutrient requirements from the surface layers. Several workers have studied the horizon wise levels of plant nutrients in soil profiles of different series. However most of the workers have limited their studies on fertility status of surface layer only. Very few have studied layer wise fertility status of sub-surface layer which is very important for effective nutrient application. It is also helpful in understanding the inherent capacity of the soil to supply essential nutrient to the plants. Moreover roots of many crop plants move down below the surface layers and draw part of their nutrient requirement from the sub surface layer of the soil (Kumar *et al.*, 1996; Sangwan and Singh, 1993). Brar and Sekhan (1987) and Pal and Mukhopadhyay (1992) observed that the vertical distribution of potassium is of considerable importance as many deep rooted crops known to absorb potassium from the sub surface layers. Therefore, the information of vertical distribution of potassium is of considerable importance.

To understand the importance of plants in structuring the vertical distributions of soil nutrients, Jobbagy and Jackson (2001) explored nutrient distributions in the top meter of soil. Hypothesizing that vertical nutrient distributions are dominated by plant cycling relative to leaching, weathering dissolution, and atmospheric deposition, they examined three predictions: (1) that the nutrients that are most limiting for plants would have the shallowest average distributions across ecosystems, (2) that the vertical distribution of a limiting nutrient would be shallower as the nutrient became more scarce, and (3) that along a gradient of soil types with increasing weathering-leaching intensity, limiting nutrients would be relatively more abundant due

to preferential cycling by plants. They also found that most of the nutrients are dominant in surface soil and decreasing with increasing depth.

As the interface between the atmosphere, biosphere, and lithosphere, soil undergoes an intense vertical exchange of materials resulting in steep chemical and physical gradients from surface to bedrock. Soil stratification is the most visible result of this exchange, and its extensive observation and synthesis form the basis of pedogenetic and taxonomic study (Hilgard 1906; Jenny 1941; Soil Survey Staff 1975; Buol *et al.* 1989). The type, thickness, and position of horizons can yield information about soil forming factors such as climate, topography, and vegetation type (Jenny 1941; Marion *et al.* 1985; Honeycutt *et al.* 1990). Likewise, the vertical distribution of soil nutrients should yield similar insights into nutrient inputs, outputs, and cycling processes (Smeck 1973; Kirby 1985). Most knowledge about the role of plant cycling on the distribution of nutrients comes from studies on horizontal nutrient patterns (Noy-Meir 1973).

According to *Patil and Patel (1983)* in the present strategy of high yielding and intensive cropping system fertilizer application based on soil test assumed great significance for the purpose of fertilizer recommendation. Generally the soil samples are collected from the surface(0-15 cm) layer. The findings of Department of agricultural chemistry, Gujarat agricultural University, Junagada indicate that the sub surface soil fertility also contributes greatly towards the yield of groundnut whose roots have been observed to proliferate to a depth of 45 cm. They also opined that the sub surface soil fertility had greater contribution than that of surface ones towards the production of groundnut. Hence the above study provides evidence that sub surface fertility status of soil has to be taken into account while making fertilizer recommendation of different crops.

Rice and groundnut are the most important crops of Odisha though several deep rooted crops of pulses and other oil seeds, sugarcane besides fruits and vegetables are also grown. In the study of Singh *et al.* (1997) showed the more than 30% of the roots of dry matter to be present in the depth of 25-40 cm even for rice which is normally taken as surface feeder.

With these background, we have conducted a study of vertical distribution of available nutrients in the mid central table land agro climatic zone of Odisha.

STUDY AREA:

Dhenkanal District lies between $85^{\circ} 58'$ E to $86^{\circ} 20'$ E longitude and between $20^{\circ} 29'$ N to $21^{\circ} 11'$ N latitude which is come in the mid central table land agro climatic zone of Odisha. It occupies a central position in the geo-political map of Odisha state in India. The mid central table land agro climatic zone consist of Dhenkanal and Anugul Districts. The climatic condition of the zone is hot and dry in sub humid with a mean annual rain fall of 1421mm. The climate is hot with high humidity in April and May and cold during December and January. The monsoon generally breaks in the month of June. The mean summer temperature is 38.7° C and mean winter temperature 14° C. The district has 8 numbers of blocks consisting of 1215 numbers of villages covering total area of 4452 sq km (Mishra *et al.*,



2014).The main crops of the district are rice, groundnut, sesamum, greengram, horsegram, sugarcane, vegetable and fruits.

The district mainly consisting of red and laterite soils through patches of yellow soils are found in some parts of the district. River *Bramhani* , the second biggest river of Odisha flows through this district and alluvial soil are found on the both of the river banks, which are very suitable for vegetable cultivation during summer. So as per older system of classification though red, laterite and alluvial soils are present, as per the soil taxonomy these are classified as *Alfisols, Inceptisols and Entisols*.(Sahu and Mishra 2005). The red colour of the soil is due to the high iron oxides content. The laterite soil have been formed by the process of laterization because of intense leaching of bases due to high rain fall. The alluvial soils are products of the process of the pedogenic process of illuviation mostly by the river Bramhani and its tributaries. The relief of the district consists of high hills, valleys with dense forest. The pedogenic process of colluvation has also take place in these types of topography. The colluvial deposit are found in the foot slope of most of the hills which are mostly used for cultivation of rice in the Kharif season followed by pulses and vegetables in the Rabi- Summer season. The area has deciduous natural forests and grasses. As the area is irrigated by Brahmani command area rice is grown both in kharif and rabi in different land types.

MATERIALS AND METHODS :

A details soil survey of the area was conducted as per soil survey manual of (1970) and soil survey manual of USDA(1995) and guidelines for soil profile description by Food and Agriculture Organisation (1977). Soil profiles of sizes 2m x 1.5m up to a depth of 1.5 to 2 m opened from two different land types of 2 blocks in the districts. The particle size analysis to determine the sand, silt, clay was carried out by Boycous Hydrometer method (Piper 1950). The pH of 1:2 soil water suspension was determined by means of glass electrode wing digital pH meter 'SYSTRONICS' and electrical conductivity of the same suspension was determined by 'SYTRONICS' conductivity meter.



Figure 1: Upper land profile of Sankhua village of Gandia block



Figure2 : Low land profile of Deogaon block of Dhenkanal Sadar block

Organic carbon was determined by Walkley and Black's rapid titration method (Jackson 1973). Available phosphorous was determined by Olsen's method (Olsen *et al.* 1954). Available potassium was determined by neutral normal ammonium acetate method using digital flame photometer 'SYTRONICS' (page *et al* 1982). Available boron was done by hot water extraction method and available sulphur was done by 0.15% CaCl_2 method.

RESULT AND DISCUSSION

All the four pedons having sandy to sandy loam in surface horizons but sand percent decreased with decreasing height. At the same time, clay percent increase with decreasing height. Surface soils of the four pedons are acidic in nature ($\text{pH} < 7$). pH increases with decreasing height but electrical conductivity showed contrasting results.

Organic carbon is comparatively higher in surface horizons of upper land than lower land. The higher amount of organic carbon in the surface layers is due to addition of organic matter like farm yard manure and incorporation of stubble left after harvesting of paddy. The irregular amount of organic carbon down the depth in pedon-2 is because of slope wash in the hill bottom lands in different period of times due to the pedogenic process of colluvation.

The available nitrogen is comparatively higher in the surface horizons of all the soil profiles, which is because of the higher amount of organic carbon in those horizons. Similar result found by Jobbagy and Jackson (2001). All the horizons are different in available nitrogen.

The available phosphorus content is higher in the surface horizon and decreases down the depth in the soil profiles. Similar result found by Jobbagy and Jackson (2001). It is because of the addition of large quantities of phosphorus for paddy cultivation. The surface horizon of pedons are ranged from medium to low in available phosphorus All the sub surface horizons are low in available phosphorus.

The comparatively higher amount of potassium in the sub surface horizon of all the profiles except pedon 4 is because of the development of the soil from the residual parents material which mostly consist of feldspars and micas which are mostly potash bearing minerals.

Potassium content of surface horizon of pedon 1 and 2 are high; rest two are varied between medium and low.

The available sulphur content in all the horizons are below the critical limit which could be attributed to lower content of organic carbon in these horizons.

The available Boron content of the surface horizon of all the soil profile is above the critical limit except the pedon 2 which is below the critical limit. Sulphur is deficient in all the sub horizons of all the soil profiles, while boron is deficient in pedon 4.

It can be concluded that liberal application of phosphorus and sulphur is necessary for higher crop productivity in two blocks of the Dhenkanal District where as liberal amount of boron should be applied in low lands of Gandia block. Similarly liberal amount of potassium application is necessary in upland of Gandia block. To maintain the soil health, liberal application of organic matter is required in upland of Dhenkanal Sadar block and upland of Gandia Block in Central table land agro climatic zone of Odisha. The variability in nutrient status in the vertical distribution of soil profile has a long term bearing on the production and productivity of field crops, vegetables, orchard plantation and agro forestry in different blocks of Dhenkanal District which constitutes a major portion of mid different land use planning can be done on the basis of physico-chemical properties and nutrient status of different horizons of upland and low land soil of the district.

PEDON-1 : UPPER LAND ALTITUDE -230 FEET, BLOCK- DHENKANAL SADAR, VILLAGE-SANKHUA
Latitude -20°41.224' Longitude -85°42.355'

Sl. No.	SAMPL E No.	DEPTH (M)	HORIZON	(%)			PH (1:2)	EC (dS m ⁻¹)	OC (g Kg ⁻¹)	AVAILABLE NUTRIENTS			
				SAND	SILT	CLAY				N (Kg ha ⁻¹)	P ₂ O ₅ (Kg ha ⁻¹)	K ₂ O (Kg ha ⁻¹)	S (ppm)
1	1	0-13	O	88.00	10.80	1.20	5.20	0.031	0.521	277.50	10.58	408.57	5.05
2	2	13-28	AP	83.00	14.80	2.20	5.20	0.026	0.212	278.75	9.57	431.42	2.52
3	3	28-43	A	75.00	18.80	6.20	5.24	0.028	0.308	201.25	9.56	454.27	3.83
4	4	43-59	AB	74.00	19.80	6.20	5.43	0.023	0.289	200.00	7.32	417.98	1.13
5	5	59-79	E	69.00	22.80	8.20	5.79	0.023	0.347	218.75	5.06	403.20	3.39
6	6	79-107	BE	67.60	23.80	8.60	5.92	0.025	0.212	138.75	4.50	428.73	4.70
7	7	107-132	Bt1	65.60	26.80	7.60	6.07	0.021	0.328	153.75	4.50	460.99	2.26
8	8	132-162	Bt2	61.60	29.80	8.60	6.04	0.019	0.328	175.00	3.81	606.14	1.74
9	9	162-180	BC	62.60	28.80	8.60	6.31	0.018	0.193	145.00	2.81	592.70	0.61

PEDON-2 : LOW LAND ALTITUDE -181 FEET, BLOCK- DHENKANAL SADAR, VILLAGE-TARAVA
Latitude -20°41.719' Longitude -85°37.570'

Sl. No.	SAMPL E No.	DEPTH (M)	HORIZON	(%)			PH (1:2)	EC (dS m ⁻¹)	OC (g Kg ⁻¹)	AVAILABLE NUTRIENTS			
				SAND	SILT	CLAY				N (Kg ha ⁻¹)	P ₂ O ₅ (Kg ha ⁻¹)	K ₂ O (Kg ha ⁻¹)	S (ppm)
1	1	0-16	AP	87.80	5.20	7.00	6.22	0.034	0.328	172.50	10.58	283.58	3.05
2	2	16-32	A	90.80	4.20	5.00	6.24	0.034	0.057	168.75	8.44	306.43	3.48
3	3	32-45	AB	90.80	4.20	5.00	6.37	0.033	0.057	105.00	5.06	297.02	2.61
4	4	45-63	E	86.80	5.20	8.00	7.34	0.036	0.115	142.50	4.50	346.75	4.18
5	5	63-73	BE	88.80	4.20	7.00	7.50	0.034	0.057	137.50	3.93	309.12	4.35
6	6	73-89	Bt1	85.80	5.20	9.00	7.63	0.044	0.077	142.50	3.93	282.24	3.83
7	7	89-113	Bt2	78.80	10.00	11.00	7.72	0.049	0.173	131.25	3.38	306.43	5.22
8	8	113-131	Bt3	75.00	8.20	16.80	7.73	0.072	0.270	147.50	2.12	350.78	4.26
9	9	131-181	BC	73.00	9.20	17.80	7.81	0.091	0.270	137.50	2.12	362.88	2.96

PEDON-3 : UPPER LAND ALTITUDE -631 FEET, BLOCK-GANDIA, VILLAGE-DEOGAON
Latitude -20°42.087' Longitude -85°44.942'

Sl. No.	SAMPLE No.	DEPTH (M)	HORIZON	(%)			PH (1:2)	EC (dS m ⁻¹)	OC (g Kg ⁻¹)	AVAILABLE NUTRIENTS			
				SAND	SILT	CLAY				N (Kg ha ⁻¹)	P ₂ O ₅ (Kg ha ⁻¹)	K ₂ O (Kg ha ⁻¹)	S (ppm)
1	1	0-15	O	81.40	6.60	12.00	5.31	0.016	0.901	386.25	19.72	69.88	2.87
2	2	15-30	AP	80.40	6.60	13.00	5.39	0.019	0.518	335.00	30.42	98.11	3.13
3	3	30-50	A	73.40	18.60	16.00	5.72	0.017	0.595	338.75	20.28	124.99	4.09
4	4	50-70	AB	68.40	10.60	21.00	6.10	0.017	0.518	343.75	9.01	123.64	3.22
5	5	70-85	E	64.40	15.60	20.00	6.43	0.017	0.461	327.50	9.58	146.49	3.74
6	6	85-110	BE	56.40	18.60	25.00	6.79	0.017	0.307	347.50	13.52	327.93	4.00
7	7	110-140	Bt1	60.00	14.60	25.40	6.68	0.018	0.326	363.75	9.02	233.85	6.53
8	8	140-190	Bt2	61.00	13.60	25.40	6.64	0.019	0.230	257.50	10.71	192.19	2.52
9	9	190-220	BC	66.00	6.60	21.40	6.47	0.021	0.211	267.50	7.33	201.60	2.18

PEDON-4 : LOWER LAND ALTITUDE-319 FEET , BLOCK-GANDIA, VILLAGE-DEOGAON
Latitude -20°45.126' Longitude -85°47.350'

Sl. No.	SAMPLE No.	DEPTH (M)	HORIZON	(%)			PH (1:2)	EC (dS m ⁻¹)	OC (g Kg ⁻¹)	AVAILABLE NUTRIENTS			
				SAND	SILT	CLAY				N (Kg ha ⁻¹)	P ₂ O ₅ (Kg ha ⁻¹)	K ₂ O (Kg ha ⁻¹)	S (ppm)
1	1	0-15	AP	72.00	10.60	17.40	6.81	0.019	0.345	350.00	25.35	275.52	4.35
2	2	15-28	A	69.00	11.60	19.40	7.30	0.019	0.369	155.00	18.03	336.00	2.87
3	3	28-50	AB	74.00	10.60	15.40	7.90	0.019	0.332	117.50	17.46	67.20	3.05
4	4	50-75	E	68.00	12.60	19.40	7.87	0.018	0.351	112.50	14.65	73.92	2.87
5	5	75-110	BE	69.00	10.40	20.60	8.03	0.019	0.351	82.50	11.83	81.98	3.13
6	6	110-125	Bt1	71.00	8.40	20.60	8.03	0.019	0.295	71.25	8.45	64.51	3.48
7	7	125-165	Bt2	69.00	9.40	21.60	8.15	0.019	0.295	97.25	7.88	52.42	4.79
8	8	165-180	Bt3	68.00	10.40	21.60	8.14	0.020	0.277	53.75	6.19	33.60	3.74
9	1	180-215	BC	70.00	10.60	19.40	8.81	0.019	0.271	50.00	5.35	35.52	3.35

References

- All India Soil and Land Use Survey Organization (1970). *Soil Survey Manual* (Second edition), IARI, New Delhi.
- Brar MS and Sekhon GS (1987). Vertical distribution of potassium in five benchmark soil series in Northern India. *J. Indian Soc. Soil Sci.* **35**:732-735.
- Buol SW, Hole FD and McCracken RJ (1989) *Soil Genesis and Classification*, third edition. Iowa State University Press, Ames, Iowa, US
- Food and Agriculture Organisation (1977) *Guidelines for Soil Profile Description* (Second edition). Soil Resources Development and Conv. Service, Land and Water Dev. Divn., Food and Agriculture Organisation of the United Nations, Rome.
- Hilgard E (1906) *Soils, Their Formation, Properties, Compositions, and Relations to Climate and Plant Growth in the Humid and Arid Regions*. Macmillan, New York, US
- Honeycutt CW, Heil RD and Cole CV (1990) Climatic and topographic relations of three Great Plains soils. I. Soil morphology. *Soil Sci. Soc. Am. J.* **54**: 469–475
- Jenny H (1941) *Factors of soil Formation*. McGraw-Hill, New York, US
- Jobbagy E and Jackson R (2001) The distribution of soil nutrients with depth: Global patterns and the imprint of plants, *Biogeochemistry* **53**: 51-77.
- Kirby MJ (1985) A basis for soil profile modelling in a geomorphic context. *J. Soil Sci.* **36**: 97–121
- Kumar TV, Reddy MS and Krishna VG (1996) .Vertical distribution of micronutrient cations in some soil profiles in northern Telengana of Andhra Pradesh. *J. Indian Soc. Soil Sci.* **44**:328 -330
- Marion GM and Schlesinger WH (1985) CALDEP: A regional model for soil CaCO₃ (caliche) deposition in the southwestern deserts. *Soil Science* **139**: 468–481
- Mishra Antaryami, Pattanaik Trupti Mayee, Das D and Das Mira (2014) Soil Fertility Maps Preparation Using GPS and GIS in Dhenkanal District, Odisha, India. *International Journal for Plant and Soil Sci.* **3**(8)
- Noy Meir I (1973) Desert ecosystems: environment and producers. *Ann. Rev. Ecol. Syst.* **4**: 25–41
- Pal SK and Mukhopadhyay AK (1992) Distribution of different forms of potassium in profiles of some Entisols. *J. Indian Soil. Soil Sci.* **40**:371-373.
- Patil RG and Patel MS (1983) Influences of available nutrients in surface and sub-surface soils on yield and nutrient uptake by Groundnut *J. Indian. Soc. Soil Sc.* **31**:160-161.
- Piper CS (1950). *Soil and Plant Analysis*, Inter Science Publishers, Inc. New York .

- Sahu GC and Mishra Antaryami (2005) Soils of Orissa and their management. Orissa review LXIII(4): 56-60.
- Sangwan B S and Singh K (1993) Vertical distribution of Zn, Mn, Cu, and Fe in semi arid soils of Haryana and their relationships with soil properties. *J. Indian Soc. Soil Sci.* **41**:463-467 .
- Singh R, Tripathy RP and Sharma JC (1997) Rooting pattern and yield of rice (*Oryza sativa* L.) as influenced by soil water regimes. *J. Indian Soc. Soil Sci.* **45**:693-697.
- Smeck NE (1973) Phosphorus: an indicator of pedogenic weathering processes. *Soil Science* 115: 199–206
- Soil Survey Staff (1975) Soil Taxonomy. USDA, Washington DC, US
- Soil Survey Staff (1995). *Soil Survey Manual* U.S. Dept. Agr. Handb. 18. Scientific Publishers. P.O.Box 91, Jodhpur-342001.