

## Short Research Article

### Vertical distribution of available nutrients in Boudh Block of Boudh district Catena

Comment [.1]: The manuscript should be proofread by Native Speaker.

#### Abstract

An investigation was conducted to analyse the distribution of available plant nutrients and to examine the relationships between soil properties and available nutrient status in soil profiles of Eastern India. Three soil profiles were exposed under three different topographic positions. In all the pedons, soil [reaction \(pH\)](#) was increasing and electrical conductivity (EC) was unevenly distributed with soil depth. The status of available nitrogen (N) was decreasing with soil depth and phosphorus ([P](#)) was increased with depth of soil, organic carbon ([OC](#)) was unevenly distributed with the depth of soil, sulphur was also unevenly distributed with depth of soil which is comparable with the ~~organic carbon~~[OC](#). There is similar trend between ~~soil reaction~~[pH](#) and ~~phosphorus~~[P](#).

**Keywords-** Available nutrients, pedon, soil profile, topography

#### 1.0 Introduction

Comment [.2]: ?

Understanding the vertical distribution of plant nutrients in soils is important since the roots of the majority of crops extend beyond the surface layers and obtain some of the nutrients they need from there. The soil fertility and crop production are greatly influenced by the features of the soil profile as they are conditioned by the many processes and elements of soil development. Understanding the prevalent soil formation (soil genesis) causes and processes is very necessary in order to evaluate soil characteristics; this requires a detailed and scientific research of soil profiles (Vedadri and Naidu, 2018). Without the careful use of macro and micro nutrient fertilisers to address the current shortages, crop production cannot be increased further. Therefore, it is crucial to have a thorough understanding of how plant nutrients are distributed vertically in soil in order to recommend the right fertiliser schedule for various crops and ensure maximum production. The availability and distribution of plant nutrients, both in surface soils and subsurface soils, are significantly impacted by topographic variations (Dorjiet *al.*, 2014). In order to explore the vertical distribution of plant nutrients in various topographic locations, this research was carried out in a well-formed catena (toposequence) located in Eastern India with varied topographic positions.

## 2.0 Materials and Methods

Formatted: Highlight

The selected study area was located in Boudh block of boudh district. Based on slope and elevation, the study area has been divided into three major physiographic units such as upland 108m above mean sea level (N 20°49'04.7" E 84°15'43.1"), Medium land 157m above sea level (N20°44'42.1" E84°13'28.2") and low land 114m above mean sea level (N20°48'56.7" E84°15'55.5") total three profiles are excavated. Soil depth of pedons 1, 2, 3 were found to be 87, 67 and 97 cm, respectively. Soil samples from different genetic horizons were collected, processed and preserved for laboratory studies. The soil samples were analysed for textural class by Bouyoucos Hydrometer method, pH(1:2) and EC(1:2), organic carbon (Jackson, 1973), available nitrogen (Subbiah and Asija, 1956), phosphorus (Bray and Kurtz, 1945), potassium (Hanway and Heidel, 1952), and sulphur (Chesnin and Yien, 1950).

## 3.0 Results and discussion

Formatted: Highlight

### 3.1 Physical and chemical characteristics

Particle size distribution: In pedon 1, a gradual increase in clay content was observed from surface to the depth of 87 cm, which can be attributed to the presences of eluvation process. In pedon 2, there is an equal distribution of clay content. In pedon 3, gradual increases up to 39 cm (Table 1), and there is decreased in clay content with equal distribution on up to 97 cm this says there is absents of eluvation process (Das *et al.*, 2019).

Comment [.3]: ?

Formatted: Highlight

**3.2 Soil reaction:** The surface soil of pedon 1 was found to be acidic with a pH value of 5.08 which increased with soil depth up to a value of 6.54 almost near to neutral at the lower most horizon 87 cm. The surface soils of pedon 2 were found to be slightly acidic with a pH value of 6.31 which increased with soil depth up to a value of 6.76 almost neutral at lower most horizon 67 cm. The surface soils of pedon 3 were found to be strongly acidic with 4.74 pH value and gradually increased with depth with 6.05 pH value. The increases in soil pH with increasing soil depth could be attributed to leaching of basic cation from upper horizons towards the lower horizons mostly during intensive rainfall. Specially in lower land area i.e., pedon 3 due to heavy leaching of bases dues to leaching and rains. Electronic conductivity (EC) almost nominal in all Pedons (Table 1).

Comment [.4]: Incomplete sentence.

### 3.3 Organic Carbon content

There is uneven distribution of organic carbon (OC) in pedon 1, 2 and 3. In pedon 3, there is high content of 3.45 g kg<sup>-1</sup> followed we can observe from the results there is uneven

distribution of ~~organic carbon~~OC content this implies there is uneven distribution of decomposition of crop residues in every year in the surface horizons (Khandayat *et al.*, 2018 and Das *et al.*, 2019) observations are mentioned in Table 1.

Comment [.5]: Please rewrite.

#### 4.0 Distribution of available nutrients

Formatted: Highlight

**4.1 Available nitrogen:** In pedon 1, the highest amount of available ~~nitrogen~~(N)(201.6 kg ha<sup>-1</sup>) was found in the surface horizon (0-13 cm) and the lowest (100.8 kg ha<sup>-1</sup>) in the third and fourth layer (28-44 ~~cm~~ and 44-64 cm) and there is slight increase in final layer 112.0 kg ha<sup>-1</sup>. In pedon 2, the highest amount of available N was found in the surface (0-26 cm) and lower layer (39-67 cm), 257.6 ~~kg ha<sup>-1</sup>~~ and 257 kg ha<sup>-1</sup>, respectively. In pedon 3, highest amount of available ~~nitrogen~~N was found in upper layer (0-13cm) 190.4 kg ha<sup>-1</sup>, lowest amount recorded in lower layer (77-97 cm) 100.8 kg ha<sup>-1</sup>. Nitrogen was positively correlated with ~~electronic conductivity~~(EC), ( $r = 0.747^{**}$ ) (Table 3). Available N tended to decrease with soil depth, which might be due to the confinement of falling of plant residues and debris to rhizosphere of plants. In pedon 2, there is ~~a~~-almost equal distribution of available ~~nitrogen~~N. (Sharma *et al.*, 2013 and Das *et al.*, 2019). (Table 2). (Sharma *et al.*, 2013 and Das *et al.*, 2019).

Formatted: Subscript

Formatted: Subscript

Comment [.6]: Please rewrite.

**4.2 Available phosphorus:** In pedon 1, the highest amount of available phosphorus (~~P~~) was recorded in lower layer (44-64 cm) 105.69 kg ha<sup>-1</sup>. Low amount was recorded in upper layer (0-13 cm) 29.03 kg ha<sup>-1</sup>. This shows the clear relation with soil pH as the upper layer of soil was 5.08 acidic pH available ~~phosphorous~~P was low, in contrast the soil pH was 6.54 in lower layer shows high availability of the available ~~phosphorus~~P. In pedon 2, the highest amount of available ~~phosphorus~~P was recorded in lowest layer (39-67cm) 121.50 kg ha<sup>-1</sup>. Low amount of soil available ~~phosphorus~~P recorded in upper layer (0-26 cm) 96.31 kg ha<sup>-1</sup>, overall ~~phosphorus~~P available is high in all layers this is due to neutral range of pH (Table 1). In pedon 3, the highest amount of available ~~phosphorous~~P was recorded in lower layer (26-39 cm) 121.99 kg ha<sup>-1</sup>. Low amount of available ~~phosphorous~~P was recorded in upper layer (0-13 cm) 52.13 kg ha<sup>-1</sup>. This is positively correlated with ~~Ex-Ca~~exchangeable calcium (Ca) ( $r = 0.518^{*}$ ) and with pH ( $r = 0.647^{**}$ ) (Table 3). The availability is of high and low available ~~phosphorous~~P was closely related to soil pH (Table 1).

**4.3 Available potassium:** In pedon 1, the lowest amount of available potassium (~~K~~) (248.3 kg ha<sup>-1</sup>) was found in the surface horizon (0-13 cm) and the highest amount available ~~potassium~~K (114.6 kg ha<sup>-1</sup>) found in the lower horizon (64-87 cm). In pedon 2, highest amount of available ~~potassium~~

K (444.6 kg ha<sup>-1</sup>) found in the upper horizon (0-26 cm), lowest amount of available potassium-K (361.8 kg ha<sup>-1</sup>) found in lower horizon (26-39 cm). In pedon 3, highest amount of available potassium-K (204.4 kg ha<sup>-1</sup>) found in 51-64 cm, lowest amount of available potassium-K (100.70 kg ha<sup>-1</sup>) found in lower horizon (77-97 cm). Ppotassium was positively correlated with pH (r = 0.704\*\*), EC (r = 0.515\*) and exchangeableEx Ca (r = 0.657\*\*) (Table 3). In overall observation found that availability of potassium-K is eorelatedcorrelated with clay percentage (Table 1). (Saini and Grewal, 2014 and Das *et al.*, 2019).

**4.4 Available sulphur:** In pedon 1, highest amount of available sulphurS (79.43 kg ha<sup>-1</sup>) found in 28-44 cm horizon, lowest amount of available sulphur-S (62.00 kg ha<sup>-1</sup>) found in upper

Horizon depth (cm)	Sand (%)	Silt (%)	Clay (%)	pH	EC (dSm <sup>-1</sup> )	Organic carbon (g kg <sup>-1</sup> )
<u>Pedon 1. (Upland)</u>						
0-13	72.50	17.50	10.00	5.08	0.61	0.75
13-28	72.50	17.50	10.00	5.31	0.19	0.75
28-44	72.50	17.50	10.00	5.15	0.12	2.85
44-64	67.50	12.50	20.00	5.67	0.16	0.15
64-87	59.00	16.00	25.00	6.54	0.24	0.30
<u>Pedon 2. (Medium land)</u>						
0-26	69.00	11.00	20.00	6.31	0.29	1.20
26-39	69.00	11.00	20.00	6.16	0.96	0.40
39-67	59.00	21.00	20.00	6.76	0.63	2.25
<u>Pedon 3. (Lowland)</u>						
0-13	74.00	16.00	10.00	4.74	0.15	3.45
13-26	69.00	16.00	15.00	5.34	0.12	1.05
26-39	69.00	6.00	25.00	5.55	0.12	0.30
39-51	64.00	16.00	20.00	5.83	0.15	3.00
51-64	69.00	11.00	20.00	6.16	0.15	4.50
64-77	69.00	11.00	20.00	6.14	0.15	2.70
77-97	69.00	11.00	20.00	6.05	0.11	3.00

horizon 0-13 cm. In pedon 2, highest amount available sulphur-S (103.22 kg ha<sup>-1</sup>) found in 26-39 cm; lowest amount of available sulphur-S (89.15 kg ha<sup>-1</sup>) found in upper horizon 0-26 cm. In pedon 3, highest amount of available sulphur-S (185.00 kg ha<sup>-1</sup>) found in upper horizon (0-13 cm), low available sulphur-S (104.56 kg ha<sup>-1</sup>) found in 39-51 cm horizon. Sulphur was positively correlated to Organic carbon-C (r = 0.535\*) (Table 3). There is uneven distribution of sulphur-S in profile this quite related to the organic carbonOC content (Table 1. and Table 2).

Depth (cm)					(dSm <sup>-1</sup> )	(g kg <sup>-1</sup> )
<b>Pedon 1. (Upland)</b>						
0-13	72.5	17.5	10	5.08	0.607	0.75
13-28	72.5	17.5	10	5.31	0.189	0.75
28-44	72.5	17.5	10	5.15	0.117	2.85
44-64	67.5	12.5	20	5.67	0.16	0.15
64-87	59	16	25	6.54	0.235	0.3
<b>Pedon 2. (Medium land)</b>						
0-26	69	11	20	6.31	0.286	1.2
26-39	59	21	20	6.16	0.963	2.4
39-67	59	21	20	6.76	0.619	2.25
<b>Pedon 3. (Lowland)</b>						
0-13	74	16	10	4.74	0.146	3.45
13-26	69	16	15	5.34	0.116	1.05
26-39	69	6	25	5.55	0.108	0.3
39-51	64	16	20	5.83	0.149	3.0
51-64	69	11	20	6.16	0.152	4.5
64-77	69	11	20	6.14	0.147	2.7
77-97	69	11	20	6.05	0.113	3.0

**Table 1. Depth wise distribution of particle size, soil pH and organic carbon in representative pedons of Boudh block**

Comment [7]: ?

**4.5 Exchangeable Calcium and Magnesium:** In pedon 1, highest amount of exchangeable Ca (1020 meq 100 g<sup>-1</sup>) found in lower layer (64-87cm) and exchangeable magnesium (Mg) (660 meq 100 g<sup>-1</sup>) found in third horizon (28-44 cm). In pedon 2, highest amount of exchangeable Ca (1290 meq 100 g<sup>-1</sup>) found in lower horizon (39-67 cm) and exchangeable Mg (200 meq 100 g<sup>-1</sup>) found in same lower horizon (39-27 cm). In pedon 3, highest amount of exchangeable Ca (800 meq 100 g<sup>-1</sup>) found in horizon (13-26 cm) found in horizon 13-26 cm and exchangeable Mg (650 meq 100 g<sup>-1</sup>) found in horizon 64-77 cm. (Table 2). Exchangeable Ca was positively correlated with pH ( $r = 0.576^*$ ) (Table 3). (Bunglaet *al.*, 2019).

~~Table 1. Depth wise distribution of particle size, soil pH and Organic carbon in representative pedons of Boudh block~~

Comment [8]: ?

**Table 2. Depth wise distribution of available nutrients in representative pedons of Boudh block**

Horizon dDepth (cm)	N	P	K	S	Ca	Mg
	kg ha <sup>-1</sup>				meq 100g <sup>-1</sup>	
Pedon-1 (Upland)						
0-13 em	201.60	29.03	114.60	62.00	430.00	290.00
13-28 em	112.00	47.91	122.40	66.36	230.00	110.00
28-44 em	100.80	98.34	131.00	79.43	660.00	660.00
44-64 em	100.80	105.69	211.80	76.41	710.00	80.00
64-87 em	112.00	103.11	248.30	68.03	1020.00	250.00
Pedon -2 (Medium land)						
0 - 26 em	257.60	96.31	444.60	89.15	760.00	160.00
26 - 39 em	246.40	115.08	361.80	103.22	910.00	180.00
39 - 67 em	257.60	121.50	377.10	95.85	1290.00	200.00
Pedon-- 3 (Lowland)						
0 - 13 em	190.40	52.13	177.40	185.00	240.00	50.00
13 - 26 em	134.40	98.83	152.70	156.85	800.00	70.00
26 - 39 em	145.60	121.99	191.80	109.26	430.00	40.00
39 - 51 em	123.20	116.67	194.20	104.56	460.00	40.00
51 - 64 em	112.00	108.05	204.40	125.68	450.00	120.00
64 - 77 em	123.20	92.08	167.10	130.04	150.00	650.00
77 - 97 em	100.80	100.70	182.30	124.00	450.00	50.00

Formatted: Left

Formatted Table

UNDER REVIEW

**Table 3. Correlation between soil properties**

Formatted: Left

	%Sand (%)	%Clay (%)	%Slit (%)	N (kg ha <sup>-1</sup> )	P (kg ha <sup>-1</sup> )	K (kg ha <sup>-1</sup> )	S (kg ha <sup>-1</sup> )	Ca (meq/100g <sup>-1</sup> )	Mg (meq/100g <sup>-1</sup> )	pH	E.C	OC content (g kg <sup>-1</sup> )
% Sand	1											
% Clay	-0.675**	1										
% Slit	-0.355	-0.448	1									
N (kg ha <sup>-1</sup> )	-0.302	-0.005	0.372	1								
P (kg ha <sup>-1</sup> )	-0.647**	0.785**	-0.210	-0.033	1							
K (kg ha <sup>-1</sup> )	-0.625**	0.496	0.129	0.737	0.478	1						
S (kg ha <sup>-1</sup> )	0.222	-0.057	-0.196	0.016	0.061	-0.100	1					
Ca (meq/100g <sup>-1</sup> )	-0.759**	0.364	0.457	0.430	0.518*	0.657**	-0.284	1				
Mg (meq/100g <sup>-1</sup> )	0.102	-0.208	0.139	-0.102	-0.083	-0.158	-0.228	-0.055	1			
pH	-0.789**	0.773**	-0.023	0.236	0.647**	0.704**	-0.223	0.576*	0.027	1		
E.C	-0.529*	0.006	0.632	0.747**	-0.014	0.515*	-0.281	0.488	0.036	0.288	1	
OC content (g kg <sup>-1</sup> )	0.082	-0.133	0.070	-0.023	0.129	-0.015	0.535*	-0.236	0.139	0.058	0.051	1

\* = 5% significances

\*\* = 1% Significances

1

UNDER PEER REVIEW



## REFERENCES

Bray, R.H. and Kurtz, Lt. (1945) Determination of total, organic and available forms of phosphorus in soils, *Soil Science*, **59**: 39-45.

Bungla, P., Pachaury, S.P., S., Srivastava, P.C., Pathak, A and Singh, R.K. (2019) Macro- and micro-nutrients status in some soils of Pithoragarh district of Uttarakhand. *Annals of Plant and Soil Research* **21 (2)**: 108-115

Chesnin, L. and Yien, C.H. (1950) Turbidimetric determination of available sulphates, *Proceedings of Soil Science Society of America* **14**: 149-51.

Dorji, T., Odeh, I.O.A. and Field, D.J. (2014) Vertical distribution of soil organic carbon density in relation to land use cover, altitude and slope aspect in the Eastern Himalayas, *Land* **3**: 1232-1250.

Giri, J.N., Sadanshiv, N.S. and Metkari, P.M. (2017) Status and distribution of available micronutrients along a toposequence at Bazargaon plateau, Maharashtra, *An Asian Journal of Soil Science* **12 (02)**: 300-306

Gomez, K. and Gomez, A. (1983) Statistical procedure for agricultural research, 2nd edition, an international rice research institute book, A Wiley-Interscience Publication.

Hanway, J.J. and Heidel, H. (1952) Soil analysis methods as used in Iowa State College, Soil Testing Laboratory, Iowa State College Bulletin **57**: 1-31.

Jackson, M.L. (1973) Soil Chemical Analysis, Prentice Hall of India. Private limited, New Delhi.

John, M.K., Chuah, H.H. and Ndufeld, J.H. (1975) Application of improved azomethine-H method to the determination of boron in soils and plants. *Analytical Letters* **8**: 559-568.

Prava kiran dash, Antaryami Mishra and subhashissaren. (2019) Vertical distribution of available nutrients in an Eastern Indian Catena, *Annals of Plant and Soil Research* **21(4)**: 320-325.

Saini, J. and Grewal, K.S. (2014) Vertical distribution of different forms of potassium and their relationship with different soil properties in some Haryana soil under different crop rotation, *Advances in Plants & Agriculture Research* **1(2)**: 4852.

Sharma, R.P., Singh, R.S. and Sharma, S.S. (2013) Vertical distribution of plant nutrients in alluvial soils of Aravalli range and optimization of Land Use, *International Journal of Pharmaceutical and Chemical Sciences* **2 (3)**: 1377-1398.

Srinivasan, R., Natarajan, A., kumar, K.S.A. and Kalaivanan, D. (2013) Distribution of available macro and micronutrients in cashew growing soils of Dakshina Kannada district of Coastal Karnataka, *Madras Agricultural Journal* **100** (1-3): 747-750.

Subbiah, B.V. and Asija, G.L. (1956) A rapid procedure for the determination of available nitrogen in soils, *Current Science* **25**: 259-260.

Vedadri, U. and Naidu, M. (2018) Characterisation, 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* **66**(1):9-19.

UNDER PEER REVIEW