

# ASSESSMENT OF PHYSICO-CHEMICAL PROPERTIES OF SOIL FROM DIFFERENT BLOCKS OF KANDHMAL DISTRICT, ODISHA

## Abstract

An investigation was conducted to analyze the physical properties of soils From different blocks of Kandhmal district, Odisha carried out 2022-23. The prime objectives of this study were to carry out the physico-chemical properties of soil at different depths of various sites of G. Udayagiri, Raikia, Tikabali blocks of Kandhmal District, Odisha to determine the availability of macro nutrient in soil of these soil samples and provide the assessment9 sampling locations were selected. Soil samples were collected with depth of 0-15 cm, 15-30 cm and 30-45 cm respectively. The Soil colour (Dry Condition) of soil varied from Brownish yellow, yellow. Soil colour (Wet Condition) of the soil varied Dark reddish brown, Dark brown. The soil texture was dominantly sandy loam in almost every site. The bulk density ranged from 1.01 to 1.49( $\text{Mg m}^{-3}$ ). The practical density ranged from 2.14 to 2.52( $\text{Mg m}^{-3}$ ). The pore space ranged from 47.64 to 41.11(%). The water holding capacity ranged from 45.17 to 39.17(%). The soil pH ranged from 5.01 to 6.15 Indicating Moderately Acidic in nature. The electrical conductivity ranged from 0.17 to 0.41( $\text{dS m}^{-1}$ ). The soil organic carbon ranged from 0.21 to 0.41(%). The Available nitrogen ranged from 134 to 330 ( $\text{kg ha}^{-1}$ ). The Available Phosphorous ranged from 3.56 to 23.82 ( $\text{kg ha}^{-1}$ ). The Available Potassium ranged from 108.39 to 256 ( $\text{kg ha}^{-1}$ ). The Exchangeable calcium ranged from 3.32 to 4.02 [ $\text{cmol (p}^+) \text{ kg}^{-1}$ ]. The Exchangeable Magnesium ranged from 2.6 to 3.6 [ $\text{cmol (p}^+) \text{ kg}^{-1}$ ], are very sufficient in this soil. There is an including awareness of the need to pay greater attention in the role of macronutrients enhancement in the soil for good soil health and proper nutrition of plant so as to attain optimum economic yield and soil is suitable for all major tropical and sub-tropical crops. Results suggest that farmers should adopt appropriate soil management techniques, such as crop rotation and conservation tillage, which will contribute to maintain the soil physical characteristics to ensure the sustainability of agricultural practices and the long-term health of the soil.

**Keywords:** Physico-chemical properties, nutrients distribution, Kandhmal, Odisha

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## INTRODUCTION

The soil is a complex organization being made up of some six constituents' namely inorganic matter, organic matter, soil organisms, soil moisture, soil solution and soil air. The physical properties of the soil depend upon the amount, shape, structure, size, pore spaces, organic matter, and mineral composition of soil. These physical properties are soil texture, bulk density particle density, percent pore space, water holding capacity, soil structure, soil colour" (Barthwal et al.,2019). "Knowledge of vertical distribution of plant nutrients in soils is useful, as roots of most of the crops go beyond the surface layers and draw part of their nutrient requirement from the sub surface layers. Soil profile characteristics as conditioned by different processes and factors of soil formation have great influence on soil fertility and crop productivity" (Dash et al.,2019). "Bulk density is the weight of dry soil per unit volume, while particle density is the weight of dry soil solids per unit volume. High bulk density indicates low porosity, compaction, and poor soil health. It reduces vegetation, increases erosion risk, and causes waterlogging on flat surfaces. Particle density is inversely proportional to bulk density. Porosity refers to the volume of soil voids filled with water and air. It is influenced by particle size, shape, and packing. Particle density is not affected by pore space, size, or arrangement of soil particles" (Prince DG 2008). "Water retaining capacity provides useful information for irrigation scheduling, crop selection, ground water contamination considerations, estimating runoff and determining when plants will become stressed. Soil moisture available for plant growth makes up approximately 0.01 percentage of world's store water. The physical properties are also interlinked. Soil texture and structure greatly influence water infiltration, permeability, and water retaining capacity" (Vega DA 2012). The more you know about your soil, the better you can care for it. The state of Odisha in India has a unique geography that is divided into five distinct morphological units. These units include the Mountainous and Highlands Region, Coastal Plains, Western Rolling Uplands, Central Plateaus, and Flood plains. Keeping in view of importance of soil's physical and chemical properties, the present study of Physico-chemical properties of soil collected from various locations of district of Kandhmal, Odisha undertaken. The soil sample collection is from 3 blocks of Kandhmal District in the state of Odisha. Each selecting 3 villages. Samples will be collected randomly from a site of each village using soil auger, Khurpi Knife by composite sampling method at a depth of 0-15cm, 15-30cm, 30-45 cm. A comparison of the Physico-chemical Properties of some of the soils of different regions of the Odisha state

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has been undertaken by comparing the results of the present study with the studies done earlier in the other regions of the state. Hence, a detailed study for evaluation of soils is needed to realize the concept of Physico-chemical analysis successfully.

## MATERIALS AND METHODS

### Study Area

Kandhmal District is located in central Odisha and is bounded by Boudh District on the north, Rayagada District on the south, Ganjam and Nayagarh Districts on the East and Kalahandi District on the west. Kandhmal experiences sub-tropical hot and dry climate in summer. Dry and cold climate in winter. The maximum temperature recorded in the district is 45.5°C and minimum temperature is 2°C. The average annual rainfall recorded is 1522.95 mm.

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### Soil Sampling

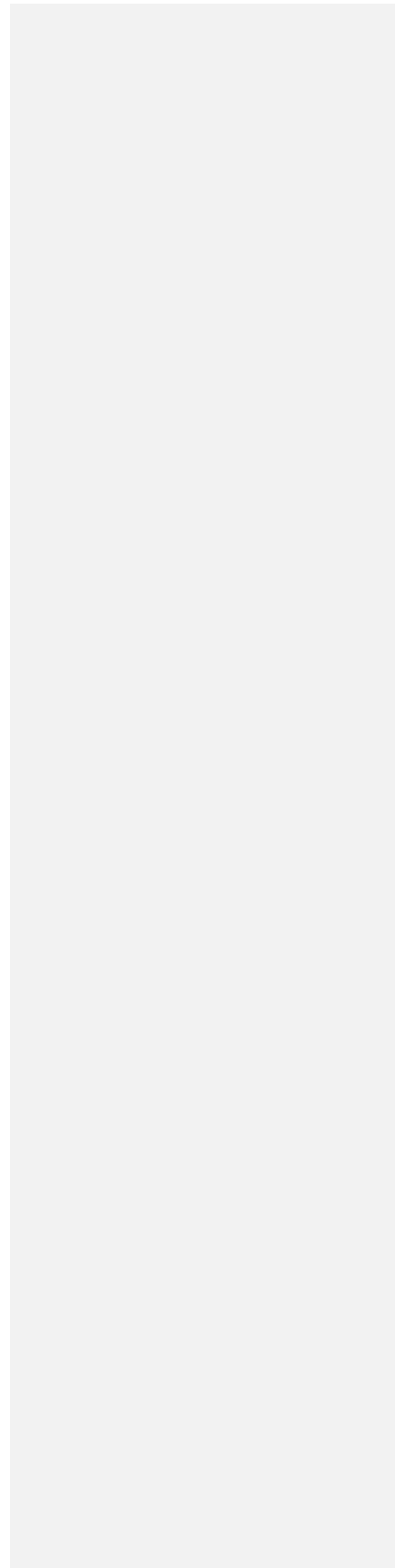
Soil samples were collected from 3 different Blocks of Kandhmal district in Odisha. Three different locations selected from each block. Samples were collected randomly from three sites of each block using soil auger, Khurpi, Knife by composite sampling method at depths of 0-15cm, 15-30cm, 30-45cm. All the samples were divided into four parts and then among them two samples are collected and only half kg sample is being taken for the soil analysis by the coning and quartering method.

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### Analysis of Physico-chemical Parameters

Analysis of the soil samples were under the methods, the physical parameters include Soil Colour, Soil Texture, Bulk Density, Particle Density, Pore Space, Water Holding Capacity, whereas chemical parameters include pH, Electrical Conductivity, Organic Carbon, Macronutrients (N, P, K, Ca, Mg.) Soil textural class was determined by using Hydrometer (Bouyoucos, 1927). Bulk density, Particle density, Water holding capacity was determined by using Graduated Measuring Cylinder method (Muthuaval *et al.*, 1992). pH was estimated with the help of Digital pH meter after making 1:2.5 soil water suspension (Jackson, 1958). Electrical Conductivity was estimated with the help of Digital Conductivity meter (Wilcox, 1950). Percent Organic Carbon was estimated by Wet Oxidation method (Walkley and Black, 1947). Available Nitrogen was estimated by Alkaline Potassium Permanganate method, using Kjeldahl apparatus (Subbiah and Asija, 1956), Available Phosphorus was estimated by Bray's extraction method (Bray and Kurtz, 1945), Available Potassium was estimated by Neutral normal Ammonium Acetate extraction followed by Flame photometric method (Toth and Prince, 1949), Exchangeable Calcium and Magnesium were estimated by EDTA method (Cheng and

Bray, 1951).



## RESULTS

### Physical Properties

The Soil Textural classes identified as Sandy Loam. The sand, silt and clay percentage varied from 63.5 to 75.0 sand, 11.10 to 18.00 silt and 15.10 to 22.10 clay in Sandy Loam. Similar results reported by (Behera et al.2016). Bulk Density was varied from the 1.01  $\text{Mg m}^{-3}$  to 1.49  $\text{Mg m}^{-3}$  and the highest Bulk Density was found in S<sub>7</sub> (1.49  $\text{Mg m}^{-3}$ ) which sites from Tikabali Block. Which indicates that the soil is widely composed of Clay and aggregated Loams. Bulk density was found to increase with increase in depth due to increase in compaction in the subsurface comparatively (Prusty et al.2019). The Particle Density varied from 2.14  $\text{Mg m}^{-3}$  to 2.52  $\text{Mg m}^{-3}$  and the highest Particle Density was found in S<sub>9</sub> (2.52  $\text{Mg m}^{-3}$ ) which site from the Tikabali Block. Particle density of soil varies according to the mineral composition of the soil particle (Mohanta et al.2021).

The Pore Space (%) ranged from 47.64% to 41.11%. The highest Pore Space % was found at site S<sub>1</sub> (47.64%) from the G. Udayagiri Block. Pore space was found to decrease with increase in depth in the villages. Addition of organic matter increases the porosity of the soil. Same result was done by (Sahu et al.,2014). The Water Holding Capacity (%) ranged from 45.17 to 39.17% and S<sub>1</sub> from the G. Udayagiri Block hold the water best at 45.17%. The variation of water retaining capacity of soil is due to soil texture and organic matter content in the soil. The irregular trend of WRC with depth due to illuviation and eluviation of finer fraction in different horizons. Similarly reported by Chaudhari et al. (2013).

**Table 1:** Soil texture and soil colour of Kandhmal District

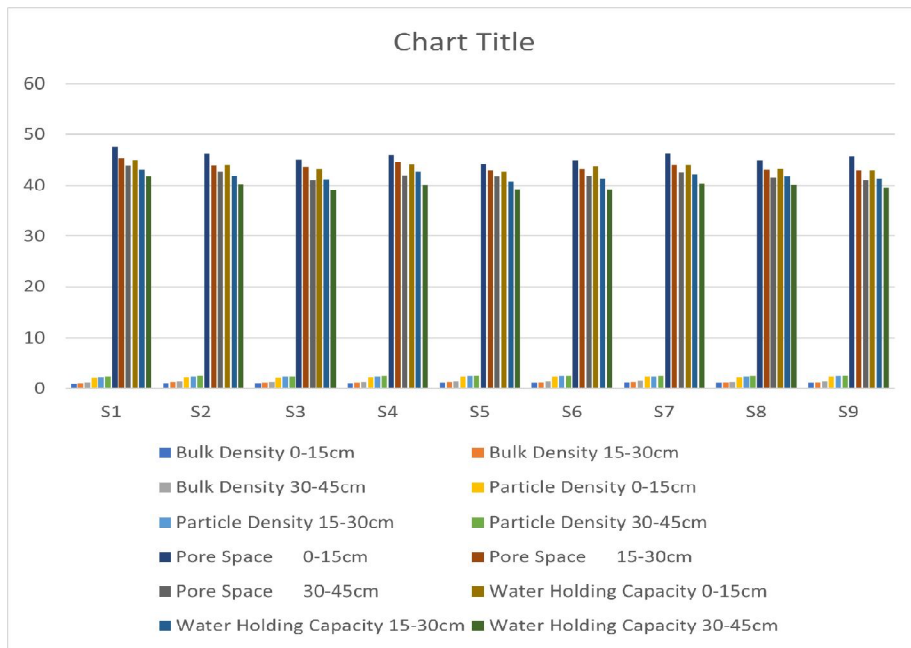
Block Name & Site	Soil Colour		Soil Texture
	Range (Dry Condition)	Range (Wet Condition)	
<b>G. Udayagiri</b>			
S1	Yellowish red	Dark reddish brown	Clay Loam
S2	Reddish yellow	Brownish yellow	Sandy Loam
S3	Reddish yellow	Brownish yellow	Clay Loam
<b>Raikia</b>			
S4	Brownish yellow	Dark brown	Sandy Loam
S5	Brownish yellow	Brown	Sandy Loam
S6	Yellowish brown	Yellowish-brown	Sandy Clay Loam
<b>Tikabali</b>			
S7	Yellowish brown	Dark brown	Sandy Loam
S8	Yellowish brown	Dark brown	Sandy Loam
S9	Brown	Strong brown	Sandy Loam

**Table 2:** Evaluation of Bulk density and Particle density of Soils of Kandhmal District

Block Name & Sites	Bulk Density (Mg m <sup>-3</sup> )			Particle Density (Mg m <sup>-3</sup> )		
	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
<b>G.udayagiri</b>						
S <sub>1</sub>	1.01	1.10	1.25	2.14	2.18	2.27
S <sub>2</sub>	1.11	1.31	1.42	2.25	2.34	2.47
S <sub>3</sub>	1.05	1.17	1.33	2.17	2.27	2.34
<b>Raikia</b>						
S <sub>4</sub>	1.11	1.19	1.31	2.26	2.31	2.39
S <sub>5</sub>	1.18	1.33	1.45	2.34	2.42	2.46
S <sub>6</sub>	1.16	1.25	1.41	2.31	2.37	2.41
<b>Tikabali</b>						
S <sub>7</sub>	1.25	1.33	1.49	2.27	2.33	2.38
S <sub>8</sub>	1.12	1.23	1.37	2.26	2.34	2.38
S <sub>9</sub>	1.16	1.21	1.39	2.33	2.41	2.52
	<b>F-Test</b>	<b>S. Em. ±</b>	<b>C.D @5%</b>	<b>F-Test</b>	<b>S. Em. ±</b>	<b>C.D @5%</b>
<b>Depth (0-15 cm)</b>	S	0.0168	0.0500	S	0.0267	0.0794
<b>Depth (15-30 cm)</b>	S	0.0165	0.0491	S	0.0426	0.1268
<b>Depth (30-45 cm)</b>	S	0.0255	0.0758	S	0.0269	0.0801

**Table 3:** Estimation of Water Holding Capacity, Pore Space (%) of Soils of Kandhmal District

Block Name & Sites	Water Holding Capacity (%)			Pore Space (%)		
	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
<b>G.udayagiri</b>						
S <sub>1</sub>	45.17	43.19	41.78	47.64	45.54	43.93
S <sub>2</sub>	44.15	42.03	40.35	46.32	44.01	42.81
S <sub>3</sub>	43.31	41.17	39.17	45.21	43.63	41.11
<b>Raikia</b>						
S <sub>4</sub>	44.19	42.81	40.18	46.13	44.61	42.11
S <sub>5</sub>	42.76	40.78	39.37	44.32	43.04	41.85
S <sub>6</sub>	43.83	41.34	39.27	45.12	43.31	41.93
<b>Tikabali</b>						
S <sub>7</sub>	44.13	42.30	40.39	46.39	44.11	42.71
S <sub>8</sub>	43.39	41.78	40.19	45.12	43.20	41.51
S <sub>9</sub>	43.07	41.35	39.73	45.84	43.07	41.13
	<b>F-Test</b>	<b>S. Em. ±</b>	<b>C.D @5%</b>	<b>F-Test</b>	<b>S. Em. ±</b>	<b>C.D @5%</b>
<b>Depth (0-15 cm)</b>	NS			NS		
<b>Depth (15-30 cm)</b>	NS			NS		
<b>Depth (30-45 cm)</b>	NS			NS		



**Fig 1:** Bulk density, Particle density, Water Holding Capacity and Pore Space

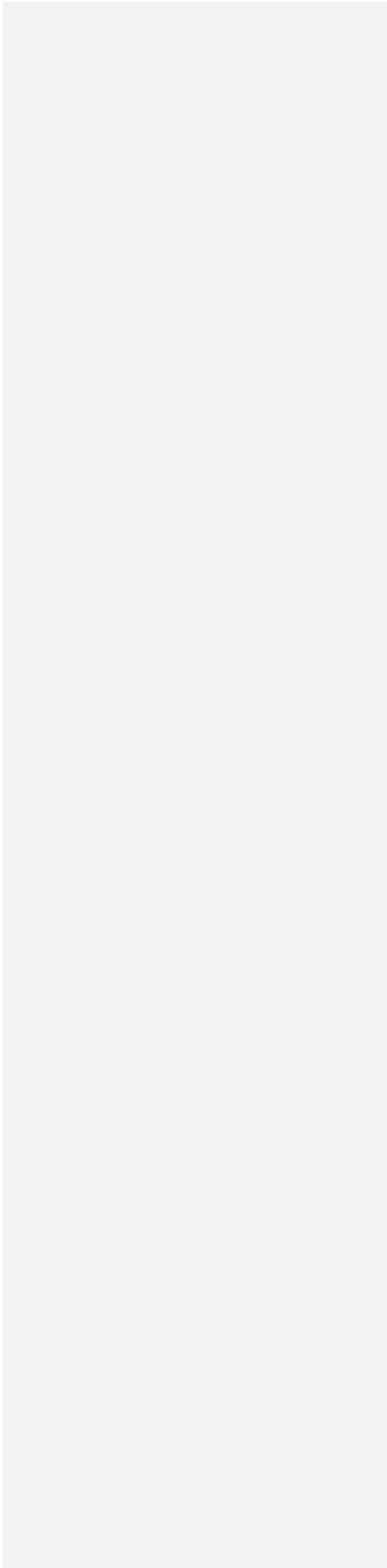
### Chemical Properties

The pH value ranged from 5.01 to 6.15. The maximum value found is 6.15 in S<sub>7</sub> from the Tikabali Block. thereby indicating at soil are moderately Acidic. (Mishra *et al.*, 2017) The electrical conductivity ranged from 0.17 to 0.41(dS m<sup>-1</sup>). The maximum value found is 0.41 (dS m<sup>-1</sup>) in S<sub>7</sub> from the Tikabali Block and the soil was found to be normal. Hence all the soil under the study area is safe for all type of crop production with respect to the soluble content. (Satyanarayana *et al.*,2021) The value of total Organic Carbon(%) varied from 0.21 to 0.44% and the range of organic carbon content was found low to medium. The organic carbon decreases with increasing depth due to the fact that surface soil contains undecomposed and partial decomposed organic matter while subsoil contains decomposed Organic matter which has undergone chemical and biological changes (Singh *et al.*,

**Table 4:** Estimation of soil pH (1:2), EC (dsm<sup>-1</sup>) and Organic Carbon (%)

Block Name Sites	pH			EC (ds m <sup>-1</sup> )			OC (%)		
	0-15 cm	15-30 cm	30-45cm	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
<b>G.udayagiri</b>									
S <sub>1</sub>	5.07	5.01	5.16	0.17	0.20	0.23	0.44	0.41	0.39
S <sub>2</sub>	5.67	5.88	5.79	0.21	0.24	0.26	0.41	0.39	0.37
S <sub>3</sub>	6.12	6.07	6.08	0.24	0.28	0.31	0.42	0.39	0.35
<b>Raikia</b>									
S <sub>4</sub>	5.31	5.45	5.19	0.29	0.34	0.38	0.35	0.32	0.30
S <sub>5</sub>	5.57	5.96	5.68	0.31	0.37	0.39	0.33	0.31	0.29
S <sub>6</sub>	5.98	6.05	5.93	0.32	0.36	0.38	0.29	0.26	0.23
<b>Tikabali</b>									
S <sub>7</sub>	6.15	5.88	6.07	0.33	0.37	0.41	0.28	0.24	0.23
S <sub>8</sub>	5.43	5.11	5.18	0.24	0.28	0.32	0.26	0.24	0.21
S <sub>9</sub>	5.47	5.26	5.57	0.26	0.29	0.34	0.27	0.25	0.22
	<b>F-Test</b>	<b>S. Em. ±</b>	<b>C.D @5%</b>	<b>F-Test</b>	<b>S.Em. ±</b>	<b>C.D @5%</b>	<b>F-Test</b>	<b>S.Em. ±</b>	<b>C.D @5%</b>
<b>Depth (0-15 cm)</b>	S	0.0684	0.2034	S	0.004	0.0147	S	0.0052	0.0155

<b>Depth (15-30 cm)</b>	S	0.0728	0.2163	S	0.005	0.0147	S	0.0051	0.0152
<b>Depth (30-45 cm)</b>	S	0.1041	0.3093	S	0.005	0.0161	S	0.0032	0.0097



### Primary Nutrients

The Available Nitrogen content of soil ranged from 134 to 330 kg ha<sup>-1</sup>. The Available nitrogen (kg ha<sup>-1</sup>) ranged from 134 to 330 (kg ha<sup>-1</sup>). The maximum value found is 330 (kg ha<sup>-1</sup>) in B1V1 at 0-15cm depth and the minimum value found is 134 (kg ha<sup>-1</sup>) B3V1 at 30-45cm depth. Available nitrogen decreases with the increasing depth due to the fact it is positively correlated with organic matter content which decreases with depth and might be due to higher pH to depth (Rajmani *et al.*, 2020). The Available Phosphorous content of soil ranged from 3.56 to 23.82 kg ha<sup>-1</sup>. The Available Phosphorous (kg ha<sup>-1</sup>) ranged from 3.56 to 23.82 (kg ha<sup>-1</sup>). The maximum value found is 23.82 (kg ha<sup>-1</sup>) in B1V2 at 0-15cm depth and the minimum value found is 3.56 (kg ha<sup>-1</sup>) B3V3 at 30-45cm depth. Available Phosphorous decrease with the increasing depth. Higher level of Available Phosphorous in surface soil could be attribute of favourable soil pH and organic matter content (Wani *et al.*, 2017). Available Potassium content of soil ranged from 108.39 to 256 kg ha<sup>-1</sup>. The potassium content was found Medium in range in all the villages. The Available Potassium (kg ha<sup>-1</sup>) ranged from 108.39 to 256 (kg ha<sup>-1</sup>). The maximum value found is 256 (kg ha<sup>-1</sup>) in B1V1 at 0-15cm depth and the minimum value found is 108.39 (kg ha<sup>-1</sup>) B3V1 at 30-45cm depth. Available Potassium decreases with the increasing depth. The high content of available Potassium on surface soil may be attributed to the release of labile K form organic residues and application of Potassium fertilizers (Wani *et al.*, 2017)

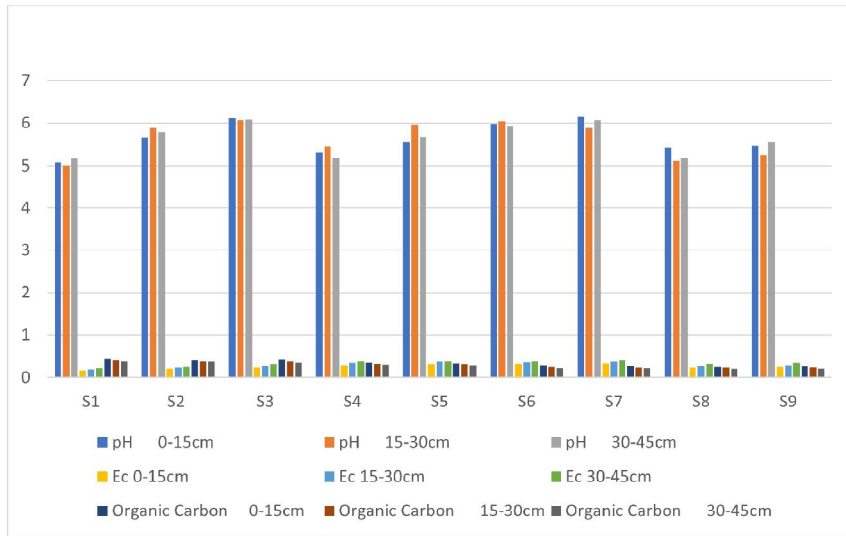
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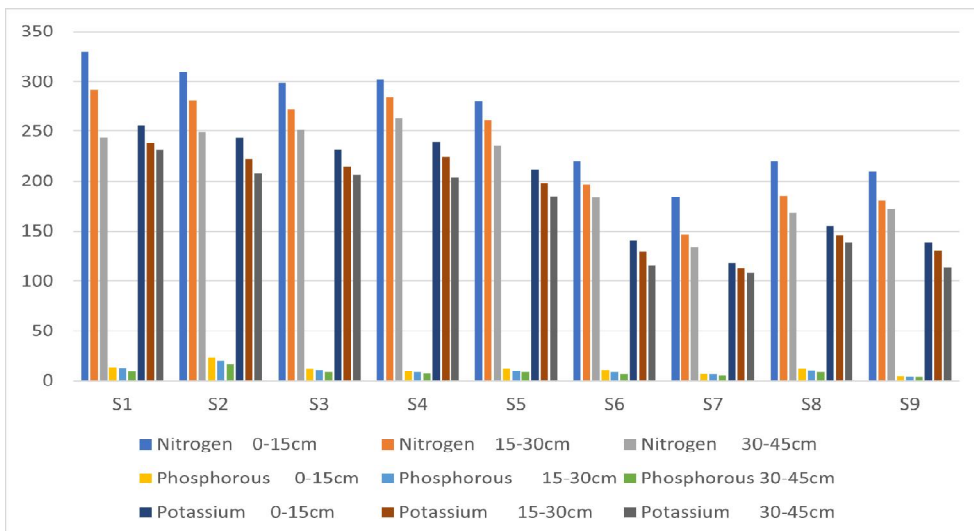
**Table 5:** Evaluation of Available Nitrogen (Kg ha<sup>-1</sup>), Available Phosphorous (Kg ha<sup>-1</sup>) and Available Potassium (Kg ha<sup>-1</sup>)

Block Name Sites	Nitrogen (Kg ha <sup>-1</sup> )			Phosphorous (Kg ha <sup>-1</sup> )			Potassium (Kg ha <sup>-1</sup> )		
	0-15 cm	15-30 cm	30-45cm	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
<b>G.udayagiri</b>									
S <sub>1</sub>	330	291	244	13.34	13.02	8.90	256.00	238.70	231.30
S <sub>2</sub>	310	281	249	23.82	19.76	16.83	243.87	221.79	208.13
S <sub>3</sub>	299	272	251	12.01	11.25	8.63	231.80	214.96	206.33
<b>Raikia</b>									
S <sub>4</sub>	302	284	263	9.34	8.52	7.15	239.89	223.71	204.11
S <sub>5</sub>	280	261	236	12.34	9.89	8.62	212.57	197.60	185.31
S <sub>6</sub>	220	196	184	10.97	8.42	6.31	140.54	128.98	115.31
<b>Tikabali</b>									
S <sub>7</sub>	185	147	134	6.63	6.27	5.03	118.70	112.85	108.39
S <sub>8</sub>	220	186	168	12.56	10.87	8.34	154.65	146.00	138.80
S <sub>9</sub>	210	181	173	4.52	4.05	3.56	138.70	129.87	113.67
	<b>F-Test</b>	<b>S.Em. ±</b>	<b>C.D @5%</b>	<b>F-Test</b>	<b>S.Em. ±</b>	<b>C.D @5%</b>	<b>F-Test</b>	<b>S.Em. ±</b>	<b>C.D @5%</b>
<b>Depth (0-15 cm)</b>	S	4.4077	13.096	S	0.2299	0.6832	S	3.2699	9.7156
<b>Depth (15-30 cm)</b>	S	2.9722	8.8311	S	0.1271	0.3776	S	2.7880	8.2835
<b>Depth (30-45 cm)</b>	S	2.5122	7.4641	S	0.1267	0.3767	S	2.6794	7.9611



**Fig 2:** pH, EC and Organic Carbon

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**Fig 3:** Available Nitrogen, Available Phosphorous and Available Potassium

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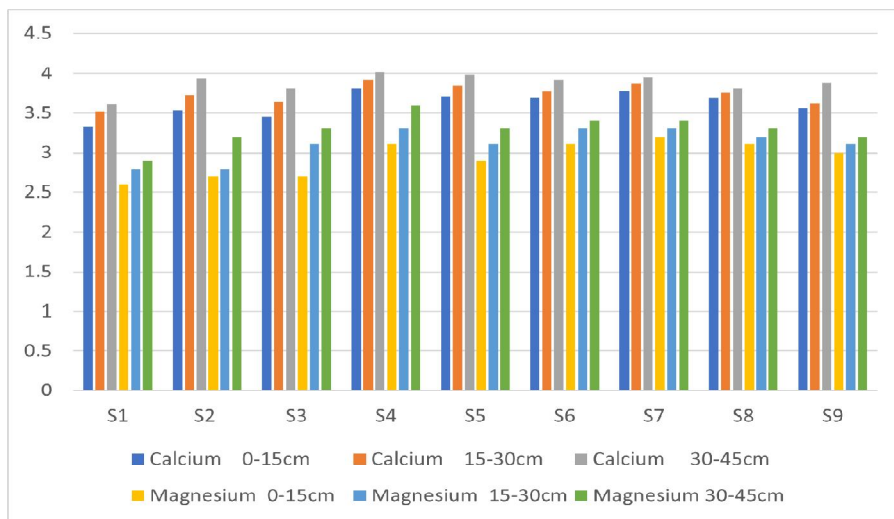
## Secondary Nutrients

The Exchangeable calcium [cmol (p<sup>+</sup>) kg<sup>-1</sup>] ranged from 3.32 to 4.02 [cmol (p<sup>+</sup>) kg<sup>-1</sup>]. The maximum value found is 4.02[cmol kg<sup>-1</sup>] in S<sub>4</sub> from the Raikia Block and the minimum value found is 3.32[cmol (p<sup>+</sup>) kg<sup>-1</sup>] S<sub>1</sub> at 0-15cm depth. Exchangeable calcium Increases the soil pH as its availability increases in soil (Malvath *et al.*,2018) The Exchangeable Magnesium [cmol (p<sup>+</sup>) kg<sup>-1</sup>] ranged from 2.6 to 3.6 [cmol (p<sup>+</sup>) kg<sup>-1</sup>]. The maximum value found is 3.6 [cmol (p<sup>+</sup>) kg<sup>-1</sup>] in S<sub>4</sub> from the Raikia Block the minimum value found is 2.6 [cmol (p<sup>+</sup>) kg<sup>-1</sup>] S<sub>1</sub>. Exchangeable Magnesium increases the soil pH as its availability increase in soil. (Malvath *et al.*,2018) Calcium and Magnesium are very sufficient in this soil.

**Table 6:** Evaluation of Exchangeable Calcium and Magnesium [c mol Kg<sup>-1</sup>]

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Block Name & Sites	Exchangeable Calcium [c mol kg <sup>-1</sup> ]			Exchangeable Magnesium [c mol Kg <sup>-1</sup> ]		
	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
<b>G.udayagiri</b>						
S <sub>1</sub>	3.32	3.52	3.61	2.6	2.8	2.9
S <sub>2</sub>	3.54	3.73	3.94	2.7	2.8	3.2
S <sub>3</sub>	3.45	3.64	3.81	2.7	3.1	3.3
<b>Raikia</b>						
S <sub>4</sub>	3.81	3.92	4.02	3.1	3.3	3.6
S <sub>5</sub>	3.71	3.84	3.98	2.9	3.1	3.3
S <sub>6</sub>	3.69	3.77	3.92	3.1	3.3	3.4
<b>Tikabali</b>						
S <sub>7</sub>	3.78	3.86	3.95	3.2	3.3	3.4
S <sub>8</sub>	3.68	3.76	3.81	3.1	3.2	3.3
S <sub>9</sub>	3.57	3.62	3.87	3.0	3.1	3.2
	<b>F-Test</b>	<b>S. Em. ±</b>	<b>C.D @5%</b>	<b>F-Test</b>	<b>S. Em. ±</b>	<b>C.D @5%</b>
<b>Depth (0-15 cm)</b>	S	0.0591	0.1757	S	0.0412	0.1224
<b>Depth (15-30 cm)</b>	S	0.0445	0.1324	S	0.0424	0.1260
<b>Depth (30-45 cm)</b>	S	0.0674	0.2003	S	0.0517	0.1536



**Fig 4:** Exchangeable Calcium and Magnesium [c mol Kg<sup>-1</sup>]

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## CONCLUSION

It is concluded from the trial that the soils of three blocks of the district are sandy loam to clay loam with adequate BD, PD and pore space. It is moderately Acidic electrical conductivity as favourable for plant growth but with some management practices, with low to medium organic carbon content and nitrogen is low to medium, phosphorus are low and medium to high Potassium. The deficiency of the nutrients can be mitigated by the use of organic and inorganic fertilizers. It shows that the soils are good for cultivation of Turmeric, Paddy, Maize, Beans, Mustard, potato horticulture crops etc. Farmers are required to maintain Soil Health Card according to the guidelines of central and state government for crop cultivation and advise to adopt suitable management practices and provide proper nutrition to soil health. Time to time inventory should be maintained to overcome the pollution effect in their respective soil.

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## Acknowledgement

I would like to express my sincere thanks to my Advisor Dr. Tarence Thomas HOD and Professor, department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, SHUATS, Prayagraj, for his diligent guidance and constructive suggestions at every step during my work. I thank him for his creative criticism and valuable suggestions for improving the quality of this work. I also extend my gratitude to all the teaching and non-teaching staff of our department because without them I would not be able to complete my work.

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