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Assessment of Physico-chemical Properties of Soil from Different Blocks of Kandhmal District, Odisha, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A study was done to evaluate the physical and chemical characteristics of soils in 2022–23 in several Kandhmal districts of Odisha. The primary goals of this study were to investigate the physico-chemical characteristics of soil at various depths. To determine the availability of macronutrients in soil samples from Udayagiri, Raikia, and Tikabali blocks in Kandhmal District, Odisha, and to provide an assessment, 9 sampling locations were chosen. The depths at which soil samples were taken were 0–15, 15–30 and 30–45 cm, respectively. The soil colour (dry condition) varied from brownish yellow to yellow. The soil colour (wet condition) varied from dark reddish brown to dark brown. On practically every site, sand and loam dominated the soil texture. Bulk

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density varied between 1.01 and 1.49 Mg/m3). The range of the particle density was 2.14 to 2.52 Mg m^{-3}. Pore space varied between 47.64 and 41.11%. The range of the water-retaining capacity was 45.17 to 39.17%. The pH of the soil was 5.01 to 6.15, which indicates that it is moderately acidic. Between 0.17 and 0.41 dS m^{-1}, the electrical conductivity was found to be The range of the soil's organic carbon was 0.21 to 0.41%. The range of available nitrogen was 134–330 kg ha^{-1}. The range of available phosphorus was 3.56 to 23.82 kg ha^{-1}. From 108.39 to 256 kg ha^{-1}, there was potassium that was readily available. Between 3.32 and 4.02 cmol (p+) kg^{-1} of exchangeable calcium were present. The range of the exchangeable magnesium was 2.6 to 3.6 [cmol (p+) kg^{-1}]. are very sufficient on this soil. There is growing awareness of the importance of improving the soil's macronutrients for good soil health and optimal plant nutrition in order to achieve the highest possible economic yield and a soil that is suited for all important tropical and subtropical crops. Results suggest that farmers should adopt appropriate soil management techniques, such as conservation tillage and crop rotation, which will contribute to maintaining the soil's physical characteristics and ensure the sustainability of agricultural practises and the long-term health of the soil.

Keywords: Physico-chemical properties; nutrients distribution; Kandhmal; Odisha.

1. INTRODUCTION

The soil is a complex organism made up of about six constituents: inorganic materials, organic matter, soil organisms, soil moisture, soil solution, and soil air. The quantity, form, structure, size, pore spaces, organic matter content, and mineral makeup of the soil all affect its physical qualities. These physical characteristics include soil texture, bulk density, particle density, percentage of pore space, water holding capacity, soil structure, and soil colour [1]. "Knowledge of the vertical distribution of plant nutrients in soils is useful, as the roots of most crops go beyond the surface layers and draw part of their nutrient requirements from the subsurface layers. Soil profile characteristics as conditioned by different processes and factors of soil formation have great influence on soil fertility and crop productivity" [2]. "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" [3]. "Water retaining capacity provides useful information for irrigation scheduling, crop selection, groundwater contamination considerations, estimating runoff, and determining when plants will become stressed. Soil moisture available for plant growth makes up approximately 0.01%t of the world's stored water. The physical properties are also interlinked. Soil texture and structure greatly influence water infiltration, permeability, and water retaining capacity" [4]. You can take better care of your soil the more you understand it. Five separate morphological units make up the unusual terrain of the Indian state of Odisha. The Mountainous and Highlands Region, the Coastal Plains, the Western Rolling Uplands, the Central Plateaus, and the Flood Plains are some of these units. The present study of the Physico-chemical characteristics of soil collected from various locations in the district of Kandhmal, Odisha, was done in consideration of the significance of soil's physical and chemical properties. In the state of Odisha's physicol District, three blocks were used for the collecting of soil samples. each choosing three Villages. Samples will be takevillages. s of 0-15 cm, 1collectionnd 30-45 cm utilising a soil auger and a *Khurpi* knife at random locations inside each hamlet. By comparing the findings of the cu0–15t stu15–30th those of past susingnducted in the other regions of the state, an analysis of the Physico-chemical Properties of some of the soils from various locations of the Odisha state has been completed. Hence, a detailed study for the evaluation of soils is needed to realise the concept of physico-chemical analysis successfully.

2. MATERIALS AND METHODS

2.1 Study Area

Kandhmal District, which is in the centre of Odisha, is bordered to the north by Boudh District, to the south by Rayagada District, to the east by Ganjam and Nayagarh District, and to the west by Kalahandi District. In the summer, Kandhmal has a subtropical climate that is hot and dry. Winters are cold and dry. In the district, the highest temperature ever recorded was 45.50°C, and the lowest was 20°C. The measured yearly rainfall is 1522.95 mm.

2.2 Soil Sampling

In the Kandhmal district of Odisha, samples of the soil were taken from three separate blocks. Each block was divided into three different locations. Samples were taken randomly from three sites in each block using a soil auger, a *khurpi* and a knife at depths of 0–15, 15–30 and 30-45 cm. All of the samples were divided into four equal sections, from which two samples were taken. Only a half kilogramme of the samples were taken for soil analysis using the conning and quartering method.

2.3 Analysis of Physico-chemical Parameters

In the analysis of the soil samples, physical characteristics such as bulk density, particle density, pore space, and water holding capacity were used, while chemical parameters such as pH, electrical conductivity, organic carbon, and macronutrients (N, P, K, Ca, and Mg) were used. A hydrometer was used to determine the soil's textural class (Bouyoucos, 1927). The graduated measuring cylinder method was used to calculate bulk density, particle density, and water holding capacity [5]. After creating a 1:2.5 soil-water suspension, pH was calculated using a digital pH metre (Jackson, 1958). Digital conductivity metres were used to estimate electrical conductivity (Wilcox, 1950). Wet oxidation was used to measure the percentage of organic carbon (Walkley and Black, 1947). Available nitrogen was estimated by the alkaline potassium permanganate method using the Kjeldahl apparatus (Subbiah and Asija, 1956); available phosphorus was determined using Bray's extraction method (Bray and Kurtz, 1945); available potassium was determined using neutral normal ammonium acetate extraction followed by the flame photometric method (Toth and Prince, 1949); and exchangeable calcium and magnesium were determined using the EDTA method (Cheng and Bray, 1951).

3. RESULTS

3.1 Physical Properties

Sandy loam is the class of soil that was identified. In Sandy Loam, the proportions of sand, silt, and clay ranged from 63.5 to 75.0 sand, 11.10 to 18.00 silt, and 15.10 to 22.10 clay. Similar findings were published in 2016 by Behera et al. Bulk density ranged from 1.01 mg/m3 to 1.49 Mg/m3, with S7 (1.49 Mg m^{-3}) in the Tikabali Block having the highest bulk density. This shows that aggregated loams and clay make up the majority of the soil. Due to increased subsurface compaction, it was discovered that bulk density increased with depth [6]. The particle density ranged from 2.14 to 2.52 Mg m^{-3}, with S9 (2.52 Mg m^{-3}) from the Tikabali Block having the highest particle density. According to the mineral makeup of the soil particles, particle density varies [7].

The range of the pore space (%) was 47.64% to 41.11%. The G. Udayagiri Block's site S1 (47.64%) had the highest percentage of pore space. In the villages, it was discovered that pore space decreased as depth increased. The porosity of the soil is increased by the addition of organic matter. The same outcome was achieved by Sahu et al. (2014). S1 from the G. Udayagiri Block has the highest water holding capacity (45.17%), ranging from 45.17 to 39.17%. The organic matter content and soil texture both affect how much water a given amount of soil can hold. WRC's depth trend is erratic because of the finer fraction's illuviation and eluviation in several horizons. According to Chaudhari et al. [8].

3.2 Chemical Properties

The pH scale read between 5.01 and 6.15. The highest value was observed in S7 from the Tikabali Block, 6.15, thereby showing that the soil is a bit acidic (2017) (Mishra et al.) Between 0.17 and 0.41 dS m^{-1}, the electrical conductivity was found to be The Tikabali Block's S7 had the highest value, 0.41 (dS m^{-1}), and the soil was determined to be normal. Therefore, all of the soil in the research region is suitable for growing any kind of crop due to its high soluble content. Satyanarayana and others, 2021 The range of organic carbon content was determined to be low to medium, with a value of total organic carbon (%) ranging from 0.21 to 0.44%. Due to the fact that subsoil contains decomposed organic matter that has undergone chemical and biological changes, whereas surface soil contains undecomposed and partially degraded organic matter (Singh et al., 2016), the organic carbon decreases with increasing depth [9-11].

Table 1. Soil texture and soil colour of Kandhmal District

Block Name & Site	Soil Colour		Soil Texture
	Range (Dry Condition)	Range (Wet Condition)	
G. Udayagiri			
S1	Yellowish red	Dark reddish brown	Clay Loam
S2	Reddish yellow	Brownish yellow	Sandy Loam
S3	Reddish yellow	Brownish yellow	Clay Loam
Raikia			
S4	Brownish yellow	Dark brown	Sandy Loam
S5	Brownish yellow	Brown	Sandy Loam
S6	Yellowish brown	Yellowish-brown	Sandy Clay Loam
Tikabali			
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^{-3})			Particle Density (Mg m^{-3})		
	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
G.udayagiri						
S_1	1.01	1.10	1.25	2.14	2.18	2.27
S_2	1.11	1.31	1.42	2.25	2.34	2.47
S_3	1.05	1.17	1.33	2.17	2.27	2.34
Raikia						
S_4	1.11	1.19	1.31	2.26	2.31	2.39
S_5	1.18	1.33	1.45	2.34	2.42	2.46
S_6	1.16	1.25	1.41	2.31	2.37	2.41
Tikabali						
S_7	1.25	1.33	1.49	2.27	2.33	2.38
S_8	1.12	1.23	1.37	2.26	2.34	2.38
S_9	1.16	1.21	1.39	2.33	2.41	2.52
	F-Test	**S. Em. ±**	**C.D @5%**	**F-Test**	**S. Em. ±**	**C.D @5%**
Depth (0-15 cm)	S	0.0168	0.0500	S	0.0267	0.0794
Depth (15-30 cm)	S	0.0165	0.0491	S	0.0426	0.1268
Depth (30-45 cm)	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
G.udayagiri						
S_1	45.17	43.19	41.78	47.64	45.54	43.93
S_2	44.15	42.03	40.35	46.32	44.01	42.81
S_3	43.31	41.17	39.17	45.21	43.63	41.11
Raikia						
S_4	44.19	42.81	40.18	46.13	44.61	42.11
S_5	42.76	40.78	39.37	44.32	43.04	41.85
S_6	43.83	41.34	39.27	45.12	43.31	41.93
Tikabali						
S_7	44.13	42.30	40.39	46.39	44.11	42.71
S_8	43.39	41.78	40.19	45.12	43.20	41.51
S_9	43.07	41.35	39.73	45.84	43.07	41.13
	F-Test	**S. Em. ±**	**C.D @5%**	**F-Test**	**S. Em. ±**	**C.D @5%**
Depth (0-15 cm)	NS			NS		
Depth (15-30 cm)	NS			NS		
Depth (30-45 cm)	NS			NS		

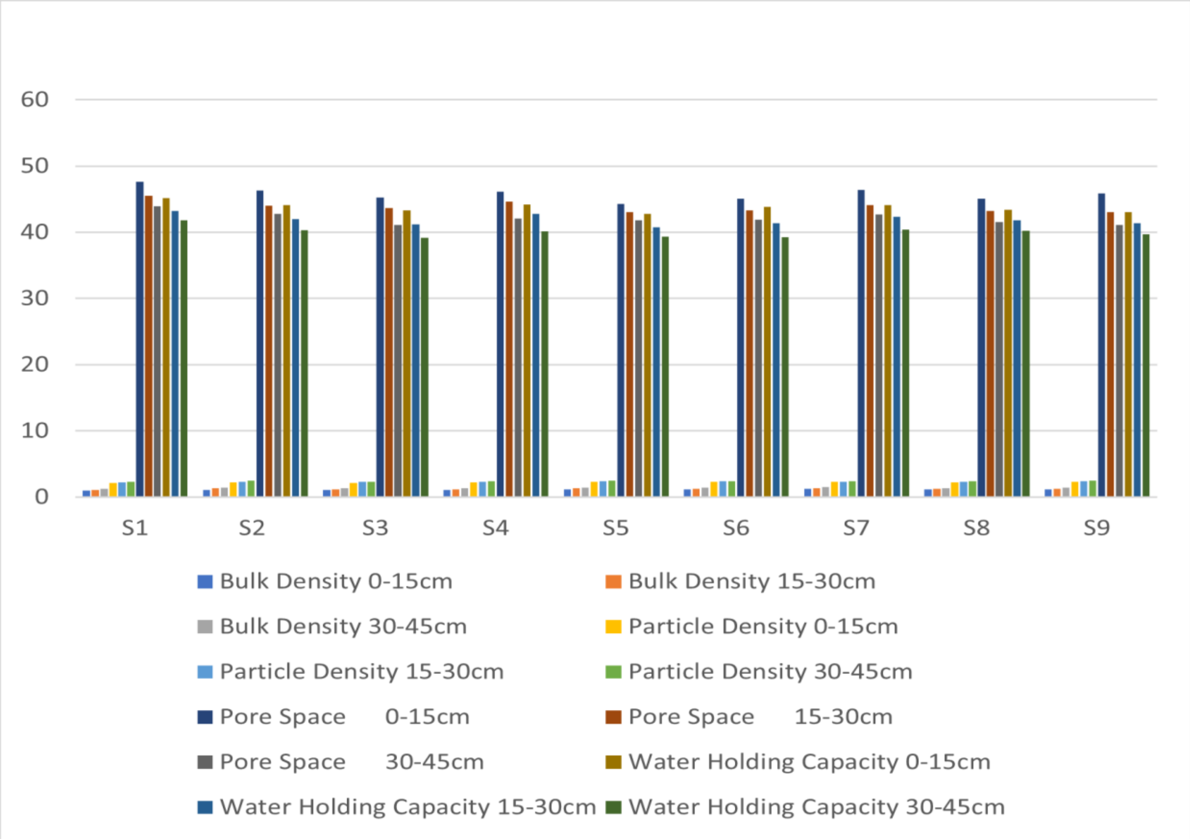

Fig. 1. Bulk density, particle density, water holding capacity and pore space

Table 4. Estimation of soil pH (1:2.5), EC (dS m^{-1}) and organic carbon (%)

Block Name Sites	pH			EC (dS m^{-1})			OC (%)		
	0-15 cm	**15-30 cm**	**30-45 cm**	**0-15 cm**	**15-30 cm**	**30-45 cm**	**0-15 cm**	**15-30 cm**	**30-45 cm**
G.udayagiri									
S_1	5.07	5.01	5.16	0.17	0.20	0.23	0.44	0.41	0.39
S_2	5.67	5.88	5.79	0.21	0.24	0.26	0.41	0.39	0.37
S_3	6.12	6.07	6.08	0.24	0.28	0.31	0.42	0.39	0.35
Raikia									
S_4	5.31	5.45	5.19	0.29	0.34	0.38	0.35	0.32	0.30
S_5	5.57	5.96	5.68	0.31	0.37	0.39	0.33	0.31	0.29
S_6	5.98	6.05	5.93	0.32	0.36	0.38	0.29	0.26	0.23
Tikabali									
S_7	6.15	5.88	6.07	0.33	0.37	0.41	0.28	0.24	0.23
S_8	5.43	5.11	5.18	0.24	0.28	0.32	0.26	0.24	0.21
S_9	5.47	5.26	5.57	0.26	0.29	0.34	0.27	0.25	0.22
	F-Test	**S. Em. ±**	**C.D @5%**	**F-Test**	**S.Em. ±**	**C.D @5%**	**F-Test**	**S.Em. ±**	**C.D @5%**
Depth (0-15 cm)	S	0.0684	0.2034	S	0.004	0.0147	S	0.0052	0.0155
Depth (15-30 cm)	S	0.0728	0.2163	S	0.005	0.0147	S	0.0051	0.0152
Depth (30-45 cm)	S	0.1041	0.3093	S	0.005	0.0161	S	0.0032	0.0097

3.3 Primary Nutrients

The range of soil's available nitrogen content was 134 to 330 kg ha^{-1}. Between 134 and 330 kg ha-1 of nitrogen were available. The maximum value discovered was 330 (kg ha^{-1}) in S_1 at a depth of 0–15 cm, and the smallest value discovered was 134 (kg ha^{-1}) in S_7 at a depth of 30–45 cm. Due to its positive correlation with organic matter content, which also declines with depth and may be caused by a greater pH with depth, available nitrogen diminishes as depth increases (Rajmani et al., 2020). The range of the soil's available phosphorus content was 3.56 to 23.82 kg ha-1. The range of phosphorous availability (kg ha^{-1}) was 3.56 to 23.82(kg ha^{-1}) [12-14]. The highest value, 23.82 (kg ha^{-1}), was discovered in S_2 at a depth of 0–15 cm, and the lowest value, 3.56 (kg ha^{-1}), was discovered in S_9 at a depth of 30–45 cm. Phosphorous availability declines as depth rises. The presence of organic matter and a favourable soil pH may be contributing factors to the higher level of available phosphorus in surface soil (Wani et al. 2017). The range of soil's available potassium concentration was 108.39 to 256 kg ha^{-1}. In all the villages, the potassium content was found to be Moderate. The range of available potassium in kilogrammes per hectare was 108.39 to 256. The largest value discovered was 256 (kg ha^{-1}) in S_1 at a depth of 0–15 cm, and the lowest value discovered was 108.39 (kg ha^{-1}) in S_7 at a depth of 30–45 cm. With increasing depth, less potassium is readily available. The release of labile potassium from organic wastes and the use of potassium fertilisers may be responsible for the increased availability of potassium in surface soil (Wani et al. 2017).

3.4 Secondary Nutrients

The exchangeable calcium [cmol (p+) kg^{-1}] ranged from 3.32 to 4.02 [cmol (p+) kg^{-1}]. The maximum value found is 4.02 [cmol kg^{-1}] in S4 from the Raikia Block, and the minimum value found is 3.32 [cmol (p+) kg^{-1}]. S1 at 0–15 cm depth Exchangeable calcium Increases the soil pH as its availability increases in the soil (Malvath et al., 2018). The exchangeable magnesium [cmol (p+) kg^{-1}] ranged from 2.6 to 3.6 [cmol (p+) kg^{-1}]. The maximum value found is 3.6 [cmol (p+) kg^{-1}] in S4 from the Raikia Block, and the minimum value found is 2.6 [cmol (p+) kg^{-1}]. S1. Exchangeable magnesium increases the soil pH as its availability increases (Malvath et al., 2018). Calcium and magnesium are very sufficient in this soil [15,16].

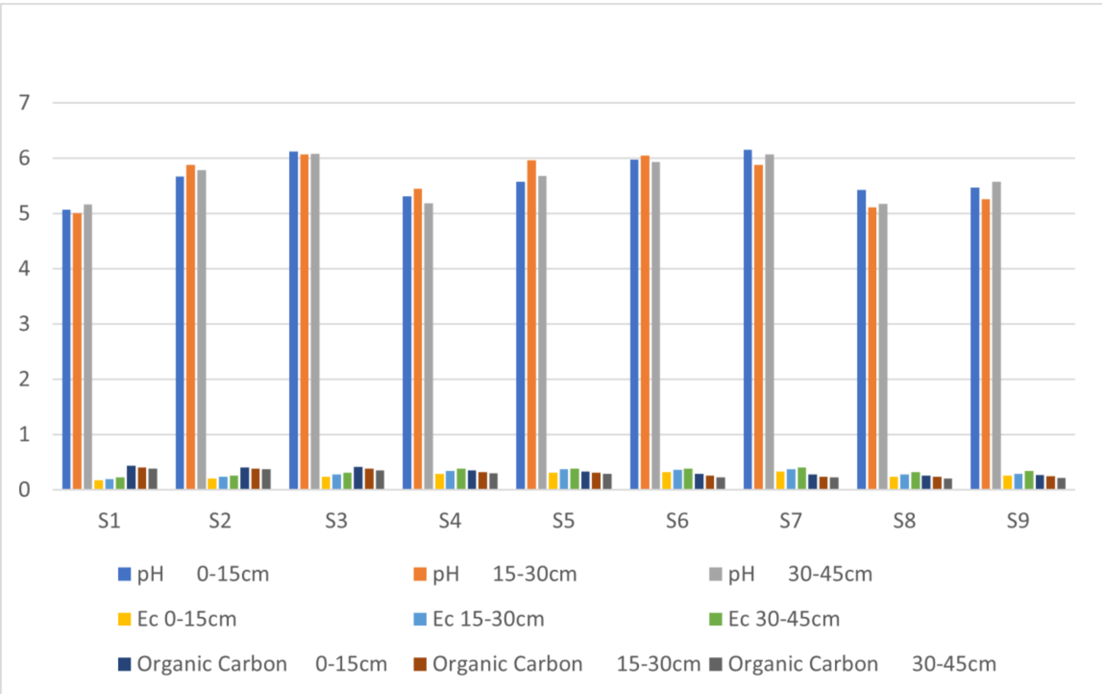

Fig. 2. pH, EC and organic carbon

Table 5. Evaluation of available nitrogen (kg ha^{-1}), available phosphorous (kg ha^{-1}) andavailable potassium (kg ha^{-1})

Block Name Sites	Nitrogen (kg ha^{-1})			Phosphorous (kg ha^{-1})			Potassium (kg ha^{-1})		
	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**
G.udayagiri									
S_1	330	291	244	13.34	13.02	8.90	256.00	38.70	231.30
S_2	310	281	249	23.82	19.76	16.83	243.87	221.79	208.13
S_3	299	272	251	12.01	11.25	8.63	231.80	214.96	206.33
Raikia									
S_4	302	284	263	9.34	8.52	7.15	239.89	23.71	204.11
S_5	280	261	236	12.34	9.89	8.62	212.57	97.60	185.31
S_6	220	196	184	10.97	8.42	6.31	140.54	128.98	115.31
Tikabali									
S_7	185	147	134	6.63	6.27	5.03	118.70	12.85	108.39
S_8	220	186	168	12.56	10.87	8.34	154.65	46.00	138.80
S_9	210	181	173	4.52	4.05	3.56	138.70	29.87	113.67
	F-Test	**S.Em. ±**	**C.D @5%**	**F-Test**	**S.Em. ±**	**C.D @5%**	**F-Test**	**S.Em. ±**	**C.D @5%**
Depth (0-15 cm)	S	4.4077	13.096	S	0.2299	0.6832	S	3.2699	9.7156
Depth (15-30 cm)	S	2.9722	8.8311	S	0.1271	0.3776	S	2.7880	8.2835
Depth (30-45 cm)	S	2.5122	7.4641	S	0.1267	0.3767	S	2.6794	7.9611

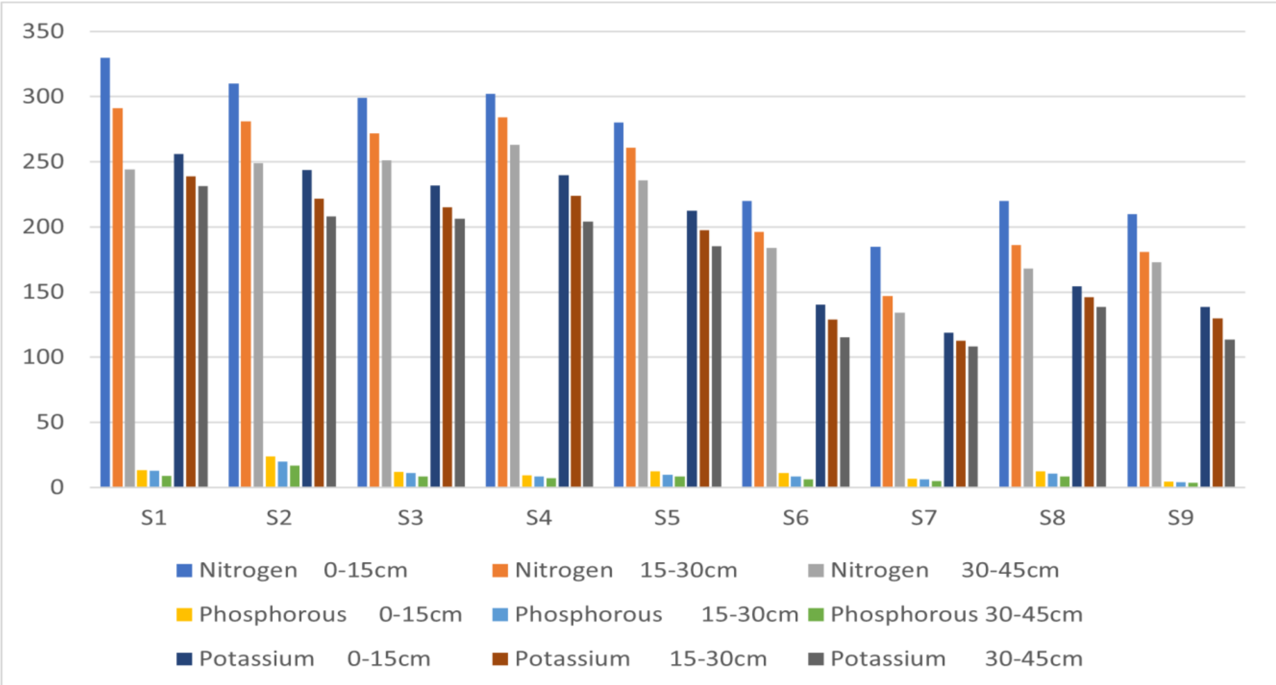

Fig. 3. Available nitrogen, available phosphorous and available potassium

Table 6. Evaluation of exchangeable calcium and magnesium [cmol kg^{-1}]

Block Name & Sites	Exchangeable calcium [cmol kg^{-1}]			Exchangeable magnesium [cmol kg^{-1}]		
	0-15 cm	**15-30 cm**	**30-45 cm**	**0-15 cm**	**15-30 cm**	**30-45 cm**
G. udayagiri						
S_1	3.32	3.52	3.61	2.6	2.8	2.9
S_2	3.54	3.73	3.94	2.7	2.8	3.2
S_3	3.45	3.64	3.81	2.7	3.1	3.3
Raikia						
S_4	3.81	3.92	4.02	3.1	3.3	3.6
S_5	3.71	3.84	3.98	2.9	3.1	3.3
S_6	3.69	3.77	3.92	3.1	3.3	3.4
Tikabali						
S_7	3.78	3.86	3.95	3.2	3.3	3.4
S_8	3.68	3.76	3.81	3.1	3.2	3.3
S_9	3.57	3.62	3.87	3.0	3.1	3.2
	F-Test	**S. Em. ±**	**C.D @5%**	**F-Test**	**S. Em. ±**	**C.D @5%**
Depth (0-15 cm)	S	0.0591	0.1757	S	0.0412	0.1224
Depth (15-30 cm)	S	0.0445	0.1324	S	0.0424	0.1260
Depth (30-45 cm)	S	0.0674	0.2003	S	0.0517	0.1536

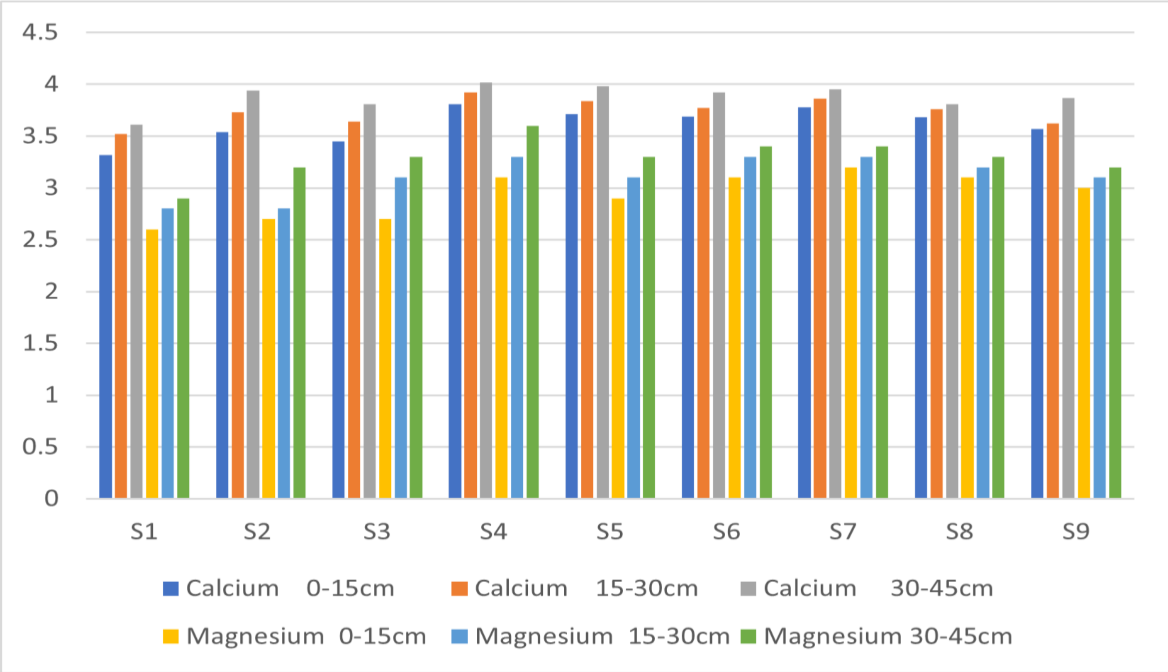

Fig. 4. Exchangeable calcium and magnesium [cmol kg^{-1}]

4. CONCLUSION

According to the trial's findings, the soils in three blocks in the district range from sandy loam to clay loam with significant BD, PD, and pore space. Although it has a moderately acidic electrical conductivity that is advantageous for plant growth, it also has low to medium levels of organic carbon, low to medium levels of nitrogen, low levels of phosphorus, and medium to high levels of potassium. The application of organic and inorganic fertilisers helps reduce the nutrient shortage. It indicates that the soils are suitable for growing crops including potato cultivation, mustard, paddy, turmeric, and maize. Farmers are urged to follow acceptable management practises and supply proper nourishment to soil health in accordance with the standards of the central and state governments for crop cultivation and are obliged to maintain their Soil Health Cards. In order to combat the effects of soil pollution, periodic inventories should be kept.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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