PHYSICAL AND CHEMICAL PROPERTIES OF SOIL OF DIFFERENT VILLAGES OF DISTRICT SOLAN, HIMACHAL PRADESH

ABSTRACT

The research was conducted to assess the physical and chemical properties of soils from twenty-one villages of Solan district, Himachal Pradesh within its geographical coordinates ranging from the latitude 30°44’53” to 31°22’01” N and longitude 76°36’10” to 77°15’14” E, during 2023-2024 ~~at the Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P~~), India. The villages represent diverse landforms, including contour farming, plains, and slopes. Soil samples were collected from two depths, 0-15 and 15-30 cm, and analysed them using standard laboratory protocols. The predominant soil texture was sandy loam, bulk density ranges from 1.22 to 1.39 Mg m^{-3}, particle density from 2.42 to 2.67 Mg m^{-3}, and percent pore space varied between 40.50% and 46.68%, while the percent water holding capacity ranges from 37.65% to 45.53%. Soil pH ranged ~~between~~ from 6.61 to 7.47. Electrical conductivity was measured between 0.18 and 0.34 dS m^{-1}, indicating non-saline conditions. Organic carbon content was medium (0.30%) to high~~, 0.30 to~~ (0.61%). The available nitrogen content ranged from 232.68 to 279.64 Kg ha^{-1}, available phosphorus from 37.23 to 64.54 Kg ha^{-1}, and available potassium from 262.14 to 365.34 Kg ha^{-1}. These findings provide valuable insights into the soil health of the region, with implications for agricultural practices and land management.

(Please write justification for conducting a research and conclusion)

Keywords: Solan district**,** soil physical-chemical parameters, landform types.

INTRODUCTION

Soil is an essential natural resource vital in sustaining life and impacting national economies. It undergoes weathering processes on Earth's surface, encompassing physical, chemical, and biological elements **(Naqvi *et al.*, 2015).** The significance of soil lies in its ability to support terrestrial food production by providing crucial elements for plant growth, including water, nutrients, oxygen, anchorage, and temperature regulation. This ensures the sustainability and productivity of ecosystems and agriculture **(Eni *et al.*, 2012)**. As a living system, soil performs a multitude of ecological functions. It serves as a medium for plant growth, acts as a habitat for organisms, conserves biodiversity, maintains water and air quality, provides raw materials, and serves as a platform for various structures **(Weil and Brady, 2017)**. The characteristics of soil and its management practices have a direct impact on ecosystem health and productivity. They? Soils play a vital role in producing food, fodder, fiber, fuel, and forest products, as well as in maintaining biodiversity and environmental quality **(Kumar *et al.*, 2022)**. Soil supports vegetation by supplying moisture and nutrients, while vegetation, in turn, protects soil from erosion and enhances fertility through the decomposition of litter **(Eni *et al.*, 2012)**. This mutual interaction helps to preserve biodiversity and global environmental quality **(Kumar *et al.*, 2017)**. Soil properties, which are influenced by both natural and human factors, such as texture, mineralogy, carbon, and nutrient storage, pH, and water-holding capacity, are crucial for making informed decisions regarding crop production and land use **(Kusro *et al.*, 2022)**. Environmental factors, such as climate, landscape features, and topography, also have a significant impact on the spatial variation of soil **(Ollinger *et al.*, 2002)**. Understanding these properties is essential for optimal land utilization and assessing the resilience of crops.

(Please state the research problem, your objective)

MATERIALS AND METHODS

The 42 representative soil samples were collected from 21 different villages in Solan district, Himachal Pradesh. These samples were taken from 0-15 and 15-30 cm depth. The latitude range of the district is 30°44'53" to 31°22'01" N, while the longitude ranges from ~~is~~ 76°36'10" to 77°15'14" E. The sampling process utilized a khurpi implement to excavate V-shaped soil samples ~~holes~~ in randomly selected farmers' fields, ensuring a random distribution of the samples. The collected soil samples were then analysed for various parameters including soil texture, bulk density (Mg m^{-3}), particle density (Mg m^{-3}), percent pore space, percent water holding capacity (unit?), pH, electrical conductivity (dS m^{-1}), percent organic carbon, available nitrogen (unit?), phosphorus (unit?), and potassium (Kg ha^{-1}). The analysis was performed following standard procedures as outlined by Bouyoucos (1927), Muthuvel *et al.*, (1992), Jackson (1958), Wilcox (1950), Walkley and Black (1947), Subbiah and Asija (1956), Olsen *et al.*, (1954), and Toth and Prince (1949). The data collected during the investigation was analysed using a completely randomized design, following the "Analysis of Variance technique" introduced by Fisher (1960).

(Avoid to much space)

Table 1. GPS coordinates of the study area. (Better to represent the study area using GIS map)

Area	Sample Id	Latitude (ºN)	Longitude (ºE)
Contour farming	CS_1	30°55'39.0"	77°04'43.2"
	CS_2	30°55'31.6"	77°07'01.7"
	CS_3	30°57'51.0"	76°58'40.7"
	CS_4	30°53'51.8"	77°10'06.6"
	CS_5	30°58'16.4"	76°58'03.4"
	CS_6	31°00'21.9"	76°55'42.6"
	CS_7	30°59'07.5"	76°58'50.8"
Sloppy area	SS_1	31°01'38.7"	76°55'42.5"
	SS_2	31°04'50.2"	76°56'37.6"
	SS_3	31°04'39.0"	76°58'03.0"
	SS_4	30°59'33.2"	76°57'32.4"
	SS_5	31°00'21.1"	76°58'15.5"
	SS_6	31°04'02.8"	76°55'53.8"
	SS_7	30°58'14.6"	77°06'20.3"
Plain area	PS_1	30°57'11.1"	76°47'58.7"
	PS_2	30°58'22.2"	76°44'39.8"
	PS_3	30°58'30.9"	76°46'35.9"
	PS_4	30°57'28.9"	76°45'30.4"
	PS_5	30°53'41.9"	76°51'23.4"
	PS_6	30°53'26.4"	76°52'52.9"
	PS_7	30°53'03.3"	30°53'03.3"

RESULT AND DISCUSSION

The study evaluates soil properties across contour farming, sloppy areas, and plains, covering texture, bulk and particle density, pore space, water holding capacity, pH, electrical conductivity, organic carbon, and nutrient levels. Statistical analysis (F-test) (instead write the confidence level) reveals significant differences in bulk density, particle density, electrical conductivity, organic carbon, and nutrient contents among landforms. However, percent pore space, water holding capacity, and soil pH show non-significant differences.

Table 2 indicates that soil texture varies across different terrains, sandy loam was found in contour farming and sloppy regions, characterized by a high sand content (63.65% to 74.21%), moderate silt content (19.36% to 28.79%), and relatively low clay content (5.14% to 11.32%). On the other hand, plain regions exhibit a sandy clay loam texture with slightly lower sand content (53.39% to 57.07%), varied silt content (13.17% to 22.41%), and higher clay content (21.05% to 32.18%). (Need re-writing) (Bring Table 2 here)

The data from Table 3 illustrates significant variations in soil physical properties such as bulk density, particle density, percent pore space, and percent water holding capacity across different terrains: contour farming, sloppy areas, and plain areas, at 0-15 and 15-30 cm depth. (Bring Table 3 here)

The maximum bulk density of 1.37 and 1.40 Mg m^{-3}, was observed in the plain area (PS_2), while the minimum bulk density of 1.22 and 1.25 Mg m^{-3} was found in the contour farming area (CS_1), respectively. **(Need re-writing)** This indicates that bulk density increases with depth, which is consistent with the decrease in organic carbon levels. A similar observation was recorded by **Kumar *et al*., (2023).**

The maximum particle density of 2.56 and 2.60 Mg m^{-3} was found in the sloppy area (SS_2), while the minimum of 2.42 and 2.46 Mg m^{-3} was found in the contour farming area (CS_1), respectively. **(Need re-writing)** The higher particle density values suggest a denser soil composition may vary within these regions, possibly due to differences in erosion patterns or organic matter content. A similar observation was recorded by **Kumar *et al*., (2023**

The maximum percent pore space was 46.68 and 45.38% found in the contour farming area (CS_2), while the minimum was 41.75 and 40.84% found in the plain area (PS_6) and in the sloppy area (SS_2), respectively. **(Need re-writing)** Pore space decreases with increasing depth due to greater compaction in the subsurface. Surface soils have significantly more macro-pores and micro-pores compared to subsurface soils, primarily due to the higher organic matter content at the surface. A similar observation was recorded by **Tiwari *et al*., (2023)**.

Similarly, the maximum percent water holding capacity was 45.53 and 44.27% in the found contour farming area (CS_5), while the minimum 39.42% and 37.53% were found in the sloppy area (SS_1), respectively. **(Need re-writing)** Water holding capacity decreases with depth due to soil compaction and reduced pore space, impacting moisture retention. A similar observation was recorded by **Tiwari *et al*., (2023)**.

~~The data from Table 4 illustrates significant variations in soil chemical properties such as pH, electrical conductivity (EC), and percent organic carbon in different terrains: contour farming, sloppy areas, and plain areas, at a 0-15 and 15-30 cm depth~~. (Bring table 4 here)The maximum soil pH of 7.45 and 7.48, was found in plain areas (PS_3, PS_5 and PS_1, PS_3), while the minimum of 6.61 and 6.64 was found in contour farming areas (CS_3, CS_5, and CS_1, CS_3), respectively. **(Need re-writing)** The increase in soil pH with depth is primarily attributed to the accumulation and decomposition of organic matter, which releases alkaline compounds such as carbonates and bicarbonates. This phenomenon is further influenced by microbial activity, which converts organic materials into humic substances that can raise soil pH over time. A similar observation was recorded by **Devi *et al*., (2023)**.

The maximum electrical conductivity of soil 0.34 and 0.32 dS m^{-1}, was found contour farming area (CS_7), while the minimum 0.21 and 0.18 dS m^{-1} was found in the plain area (PS_1), respectively. **(Need re-writing)** Plain regions generally support most crops, but vegetable-based systems in contour farming areas exhibit higher salt accumulation compared to cereal-based systems in the plain. Other studies have also reported similar observations by **Singh *et al*., (2021) and Kumar *et al*., (2023)**.

The maximum percent organic carbon in soil 0.54 and 0.52%, was found in contour farming (CS_3), while the minimum 0.32 and 0.29% were found in the plain area (PS_2), respectively. **(Need re-writing)** Vegetable-based cropping systems in contour farming areas typically have higher organic carbon due to practices like incorporating farmyard manure and organic residues, enhancing decomposition, and enriching soil organic carbon levels in surface layers. A similar observation was recorded by **Kakar *et al*., (2018)**.

~~Table 5 illustrates significant variations in soil nutrient content such as available nitrogen, phosphorus, and potassium levels across different terrains: contour farming, sloppy areas, and plain areas, at a 0-15 and 15-30 cm depth.~~ (Bring Table 5 here)The maximum available nitrogen in the soil at 279.64 and 269.68 Kg ha^{-1}, was found sloppy area (SS_7), while the minimum 242.59 and 232.68 Kg $ha^{-1}$was found in the plain area (PS_2), respectively. **(Need** re-writing) Available nitrogen levels decrease with increasing profile depth, likely due to the reduction in organic matter content. A similar observation was recorded by **Kumar and Paliyal (2016)**.

The maximum available phosphorus in the soil at 64.54 and 60.35 Kg ha^{-1}, was found in contour farming (CS_1), while the minimum 40.25 and 37.23 Kg ha^{-1} were found in the plain area (PS_5), respectively. **(Need re-writing)**Higher available phosphorus levels in surface soil are often due to favourable soil pH and high organic matter content, particularly in higher topographic positions. A similar observation was recorded by **Devi et al., (2023).**

Similarly, the maximum available potassium in soil at 365.34 and 353.56 Kg ha^{-1}, was found in contour farming (CS_1), while the minimum 271.36 Kg ha^{-1} and 262.14 Kg ha^{-1} was found in plain area (PS_5), respectively. **(Need re-writing)**Surface soil shows high available potassium levels due to organic residue breakdown and potassium fertilizer application, while subsurface soil has decreased availability. A similar observation was recorded by **Devi *et al.*, (2023)**.

CONCLUSION

The study found substantial differences in soil properties between contour farming, sloppy areas, and plains in Solan district, Himachal Pradesh. Contour and sloppy terrain have sandy loam textures with significant sand concentrations, whereas plains have sandy clay loam textures with more clay. The bulk and particle densities rise with depth, indicating soil compaction. Contour farming areas have greater pore space and water-holding capacity, whereas plains have a higher pH and less electrical conductivity. Contour farming regions have the highest concentrations of organic carbon, as well as higher quantities of nitrogen, phosphate, and potassium. These findings highlight the importance of specialized soil management practices across different terrains.

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Table 2. Percent sand, silt, and clay and their texture of soil of different villages of Solan District Himachal Pradesh.

Area	Selected villages	Sand %	Silt %	Clay %	Texture
Contour farming	**CS_1**	74.21	20.21	5.58	Sandy Loam
	CS_2	73.68	21.18	5.14	Sandy Loam
	CS_3	70.12	24.32	5.56	Sandy Loam
	CS_4	70.59	24.23	5.18	Sandy Loam
	CS_5	68.59	25.32	6.09	Sandy Loam
	CS_6	71.12	22.14	6.74	Sandy Loam
	CS_7	69.32	19.36	11.32	Sandy Loam
Sloppy area	**SS_1**	65.52	27.37	7.11	Sandy Loam
	SS_2	63.65	27.20	9.15	Sandy Loam
	SS_3	64.39	28.79	6.82	Sandy Loam
	SS_4	67.26	24.28	8.46	Sandy Loam
	SS_5	65.16	23.61	11.23	Sandy Loam
	SS_6	67.48	24.10	8.42	Sandy Loam
	SS_7	69.56	21.79	8.65	Sandy Loam
Plain area	**PS_1**	56.54	22.41	21.05	Sandy Clay Loam
	PS_2	53.39	20.60	26.01	Sandy Clay Loam
	PS_3	55.58	20.79	23.63	Sandy Clay Loam
	PS_4	54.65	13.17	32.18	Sandy Clay Loam
	PS_5	55.05	21.48	23.47	Sandy Clay Loam
	PS_6	56.59	21.09	22.32	Sandy Clay Loam
	PS_7	57.07	20.29	22.64	Sandy Clay Loam

Table 3. Bulk density (Mg m^{-3}), particle density (Mg m^{-3}), pore space (%), and water holding capacity (%) of soil at 0-15 and 15-30 cm depths of different villages of Solan district, Himachal Pradesh.

Area	Selected villages	Bulk density (Mg m^{-3})		Particle density (Mg m^{-3})		Pore space (%)		Water holding capacity (%)	
		0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Contour farming	**CS_1**	1.22	1.25	2.42	2.46	45.31	43.52	44.32	42.87
	CS_2	1.23	1.26	2.43	2.47	46.68	45.38	45.44	43.98
	CS_3	1.25	1.28	2.45	2.49	45.82	44.36	43.26	41.66
	CS_4	1.24	1.27	2.44	2.47	44.85	43.36	43.75	42.15
	CS_5	1.27	1.30	2.47	2.50	46.58	45.06	45.53	44.27
	CS_6	1.24	1.28	2.45	2.49	46.24	44.75	45.28	43.98
	CS_7	1.26	1.29	2.46	2.49	45.61	42.94	43.58	41.98
Sloppy area	**SS_1**	1.28	1.31	2.53	2.57	44.28	42.93	39.61	37.69
	SS_2	1.31	1.34	2.56	2.60	42.32	40.84	40.45	38.45
	SS_3	1.30	1.33	2.55	2.59	44.06	42.84	41.95	39.65
	SS_4	1.28	1.31	2.52	2.56	42.91	41.06	39.96	37.53
	SS_5	1.29	1.33	2.53	2.57	43.65	41.72	40.65	37.95
	SS_6	1.27	1.31	2.51	2.56	42.94	41.18	39.42	37.65
	SS_7	1.26	1.29	2.46	2.50	44.57	42.73	42.48	39.93
Plain area	**PS_1**	1.35	1.38	2.60	2.64	42.54	40.87	40.39	38.41
	PS_2	1.37	1.40	2.62	2.66	44.16	42.86	42.25	39.96
	PS_3	1.36	1.39	2.61	2.65	43.67	41.86	41.44	39.74
	PS_4	1.36	1.38	2.61	2.64	42.56	40.85	40.86	38.52
	PS_5	1.37	1.39	2.63	2.67	42.58	40.75	40.76	38.47
	PS_6	1.34	1.36	2.58	2.62	41.75	40.50	39.23	37.65
	PS_7	1.35	1.37	2.59	2.63	44.54	42.76	42.49	40.18
F test		S	S	S	S	NS	NS	NS	NS
S. EM (±)		0.008	0.008	0.008	0.009	0.804	0.703	0.709	0.739
C.D. @ 5%		0.023	0.022	0.023	0.025	NS	NS	NS	NS

Table. 4. Soil pH, electrical conductivity (dS m^{-1}), and organic carbon (%) at 0-15 and 15-30 cm depths of different villages of Solan district, Himachal Pradesh.

Area	Selected villages	pH		Electrical conductivity (dS m^{-1})		Organic carbon (%)	
		0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Contour farming	CS_1	6.63	6.65	0.33	0.31	0.50	0.48
	CS_2	6.62	6.67	0.30	0.28	0.52	0.50
	CS_3	6.61	6.64	0.31	0.29	0.54	0.52
	CS_4	6.63	6.66	0.33	0.31	0.48	0.46
	CS_5	6.61	6.64	0.31	0.29	0.47	0.45
	CS_6	6.64	6.68	0.32	0.30	0.49	0.47
	CS_7	6.63	6.67	0.34	0.32	0.41	0.39
Sloppy area	SS_1	7.08	7.12	0.29	0.26	0.43	0.41
	SS_2	6.96	6.99	0.24	0.21	0.42	0.40
	SS_3	6.85	6.89	0.25	0.22	0.36	0.34
	SS_4	6.73	6.77	0.26	0.23	0.37	0.35
	SS_5	6.75	6.78	0.25	0.22	0.38	0.36
	SS_6	6.82	6.86	0.28	0.25	0.40	0.38
	SS_7	6.62	6.65	0.24	0.21	0.46	0.44
Plain area	PS_1	7.43	7.48	0.21	0.18	0.35	0.32
	PS_2	7.42	7.46	0.22	0.19	0.32	0.29
	PS_3	7.45	7.48	0.23	0.20	0.33	0.31
	PS_4	7.42	7.46	0.24	0.21	0.36	0.33
	PS_5	7.45	7.47	0.26	0.23	0.33	0.30
	PS_6	7.42	7.45	0.25	0.22	0.30	0.27
	PS_7	7.43	7.47	0.28	0.25	0.34	0.31
F test		NS	S	S	S	S	S
S. EM (±)		0.216	0.014	0.009	0.007	0.020	0.006
C.D. @ 5%		NS	0.041	0.027	0.021	0.058	0.018

Table 5. Available nitrogen, phosphorus, and potassium in soil (Kg ha^{-1}) at 0-15 and 15-30 cm depths of different villages of Solan district, Himachal Pradesh.

Area	**Selected villages**	**Available nitrogen (Kg ha^{-1})**		**Available phosphorus (Kg ha^{-1})**		**Available potassium (Kg ha^{-1})**	
		0-15 cm	**15-30 cm**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**
Contour farming	**CS$_1$**	279.27	268.18	64.54	60.35	365.34	353.56
	CS$_2$	278.86	268.94	60.19	56.12	364.45	350.36
	CS$_3$	270.04	261.63	61.83	56.91	356.45	342.05
	CS$_4$	277.32	268.04	63.23	59.01	362.76	349.12
	CS$_5$	265.38	255.37	62.32	58.23	358.64	345.68
	CS$_6$	276.32	264.87	64.38	59.49	363.44	352.36
	CS$_7$	275.13	266.95	59.97	55.82	360.25	344.52
Sloppy area	**SS$_1$**	262.59	249.61	50.17	45.25	325.96	314.36
	SS$_2$	253.96	241.28	46.83	42.65	311.88	304.04
	SS$_3$	256.62	249.06	48.25	43.33	334.25	325.52
	SS$_4$	262.24	250.23	52.81	48.36	326.16	312.64
	SS$_5$	258.09	247.14	51.36	47.22	314.08	303.58
	SS$_6$	264.96	255.87	56.55	52.47	327.79	314.61
Plain area	**SS$_7$**	279.64	269.68	58.26	53.89	349.14	335.23
	PS$_1$	247.36	238.82	45.37	42.16	289.12	281.08
	PS$_2$	242.59	232.68	40.26	36.64	276.04	265.62
	PS$_3$	250.4	239.76	42.84	39.31	282.92	263.61
	PS$_4$	246.94	236.17	41.56	37.65	283.52	275.44
	PS$_5$	248.27	235.54	40.25	37.23	271.36	262.14
	PS$_6$	252.35	244.12	47.65	44.08	309.18	298.63
	PS$_7$	249.8	237.3	46.65	43.39	297.52	286.72
F test		S	S	S	S	S	S
S. EM (±)		0.817	1.009	0.800	0.888	0.925	1.294
C.D. @ 5%		2.332	2.880	2.284	2.536	2.639	3.692

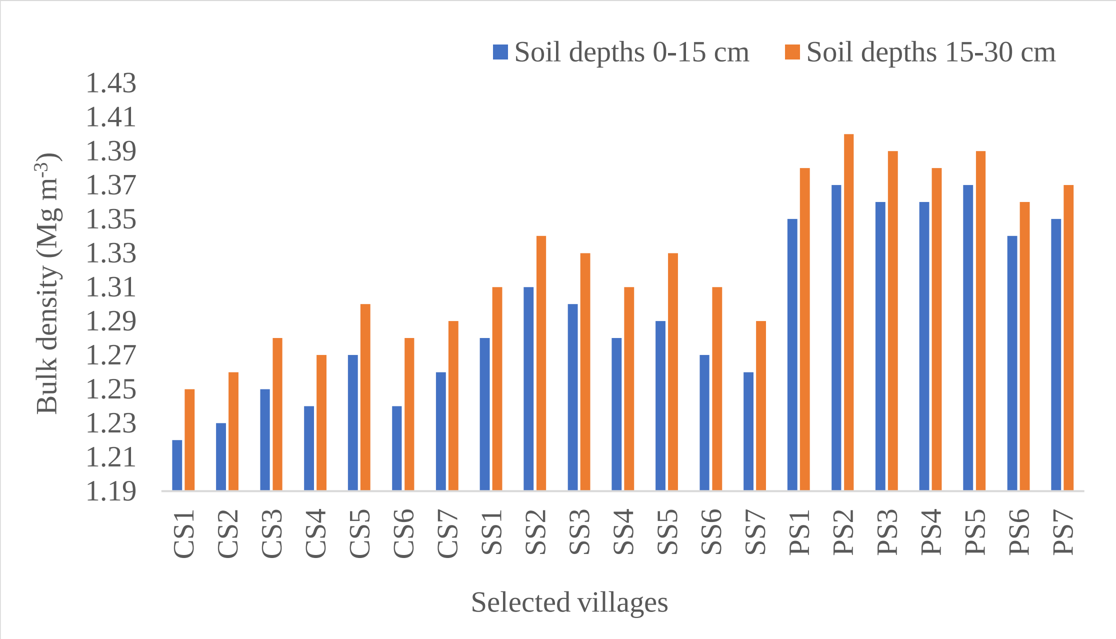

Figure 1. Graphical representation of the bulk density of soil (Mg m^{-3}) at 0-15 and 15-30 cm depths of different villages of Solan district, Himachal Pradesh.

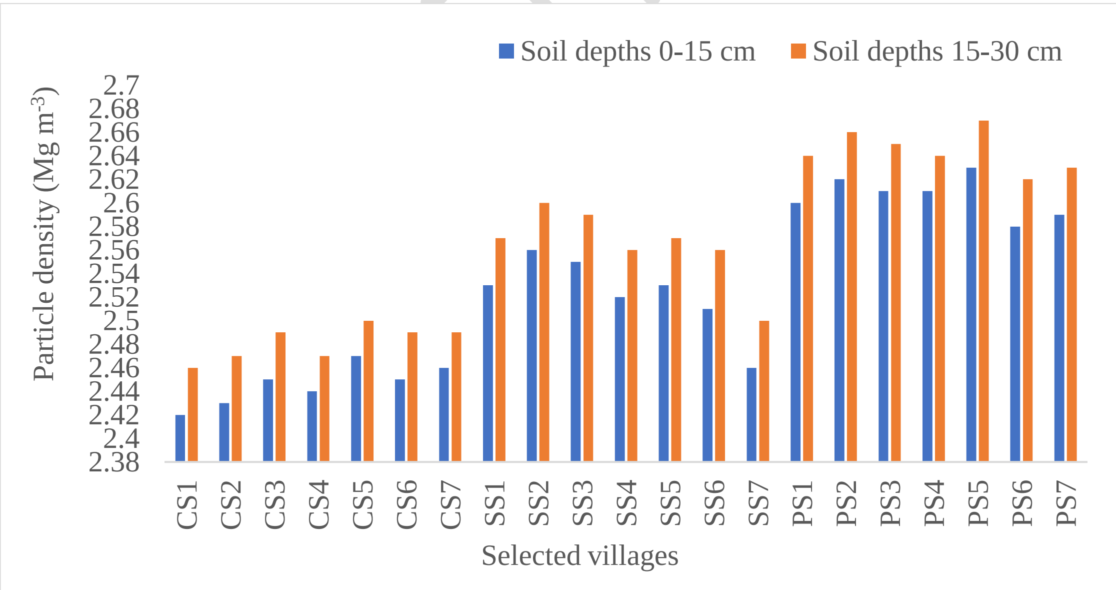

Figure 2. Graphical representation of particle density of soil (Mg m^{-3}) at 0-15 and 15-30 cm depths of different villages of Solan district, Himachal Pradesh.

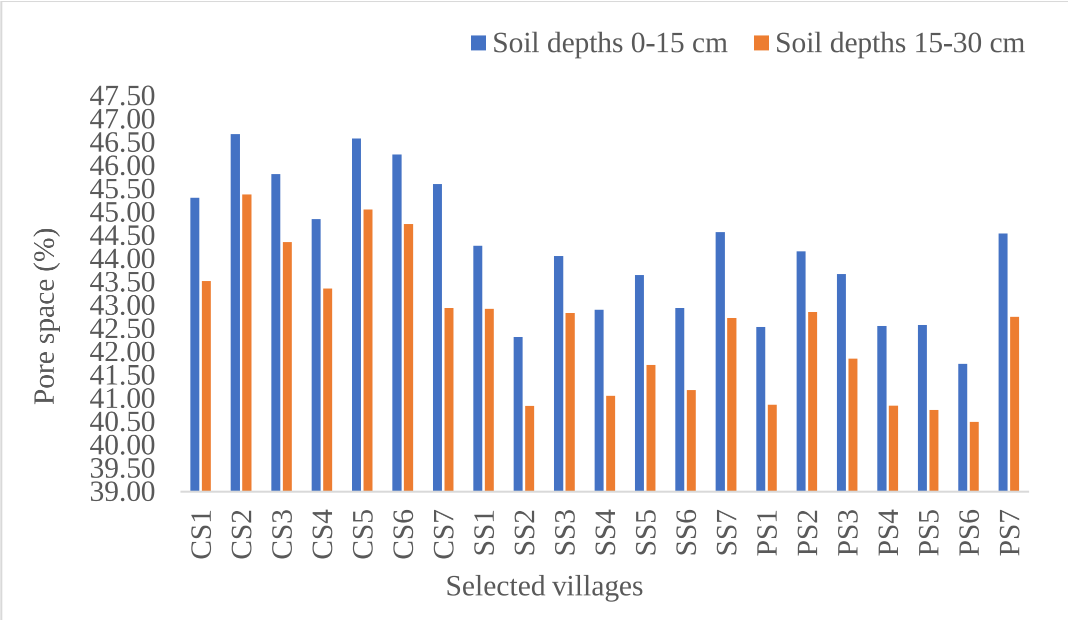

Figure 3. Graphical representation of pore space of soil (%) at 0-15 and 15-30 cm depths of different villages of Solan district, Himachal Pradesh.

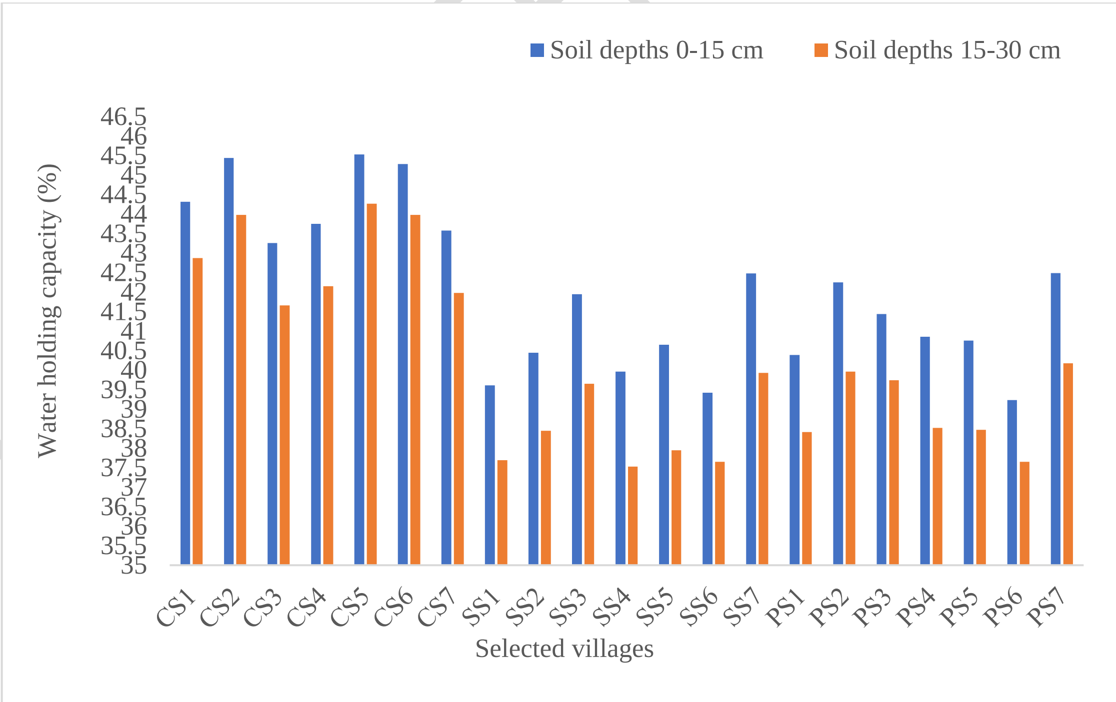

Figure 4. Graphical representation of water holding capacity of soil (%) at 0-15 and 15-30 cm depths of different villages of Solan district, Himachal Pradesh.

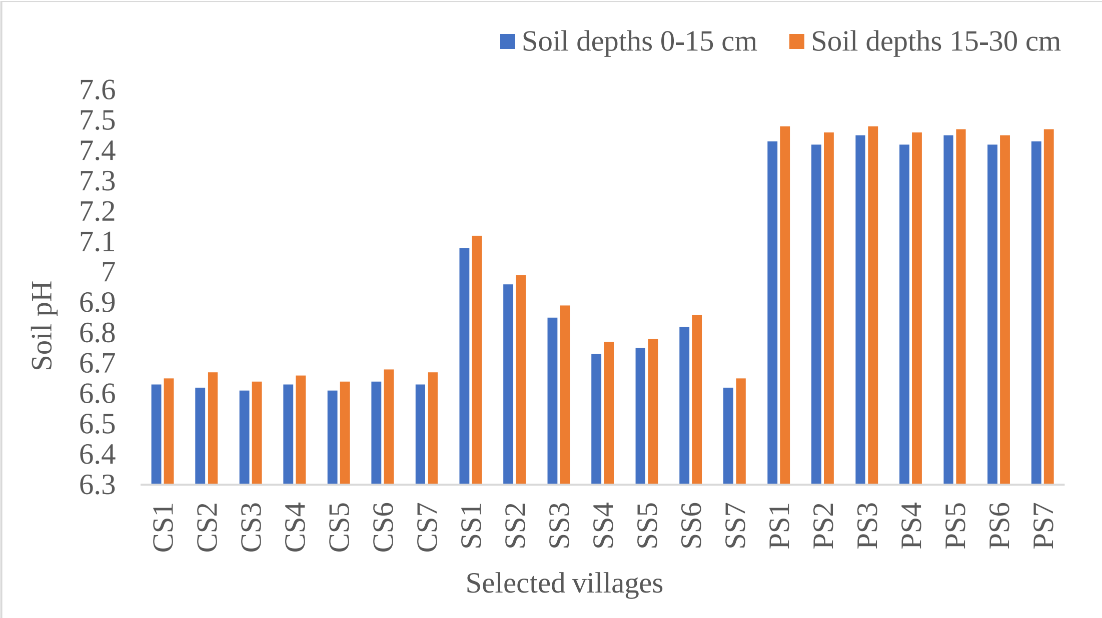

Figure 5. Graphical representation of soil pH at 0-15 and 15-30 cm depths of different villages of Solan district, Himachal Pradesh.

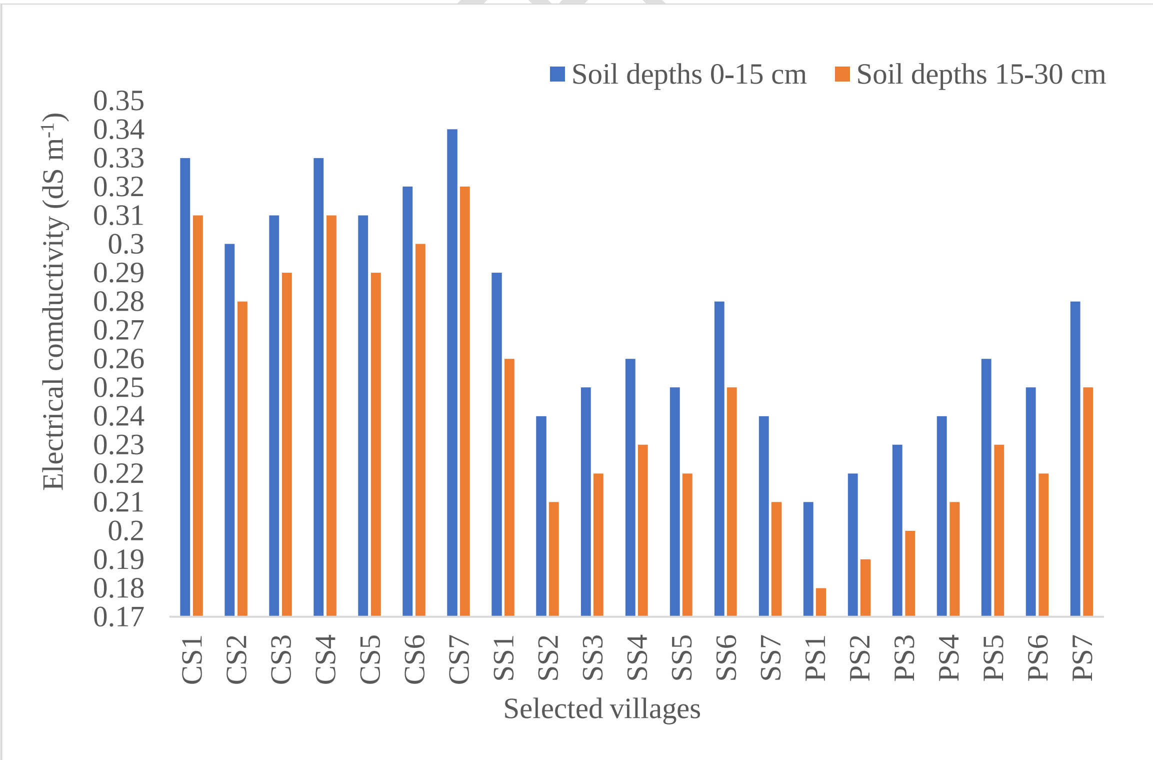

Figure 6. Graphical representation of electrical conductivity of the soil (dS m^{-1}) at 0-15 and 15-30 cm depths of different villages of Solan district, Himachal Pradesh.

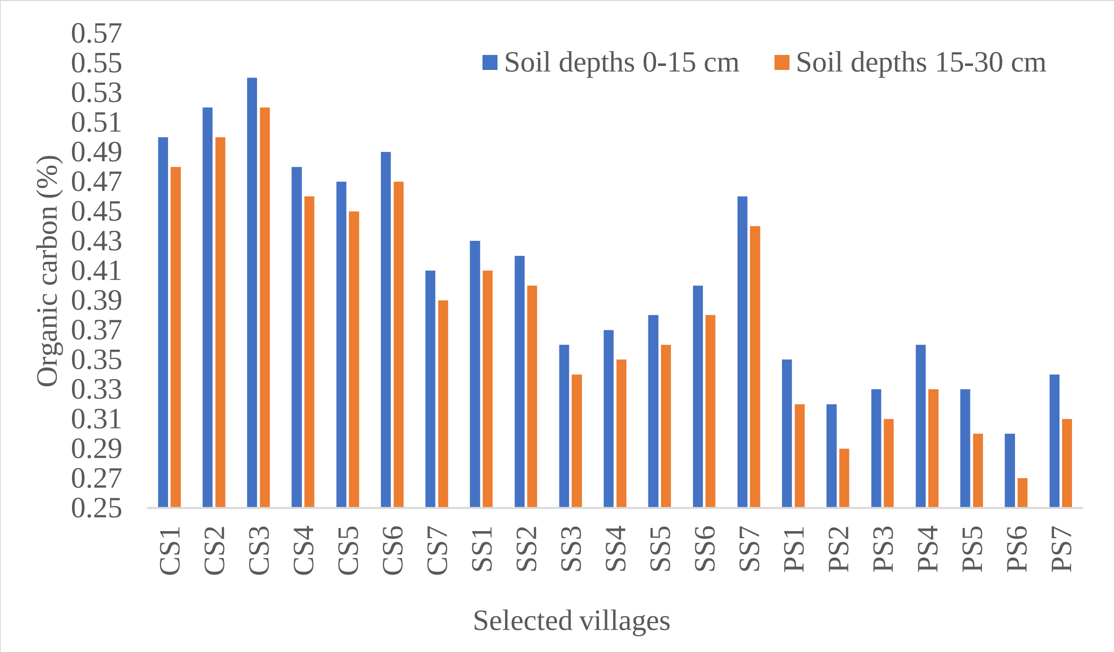

Figure 7. Graphical representation of soil organic carbon (%) at 0-15 and 15-30 cm depths of different villages of Solan district, Himachal Pradesh.

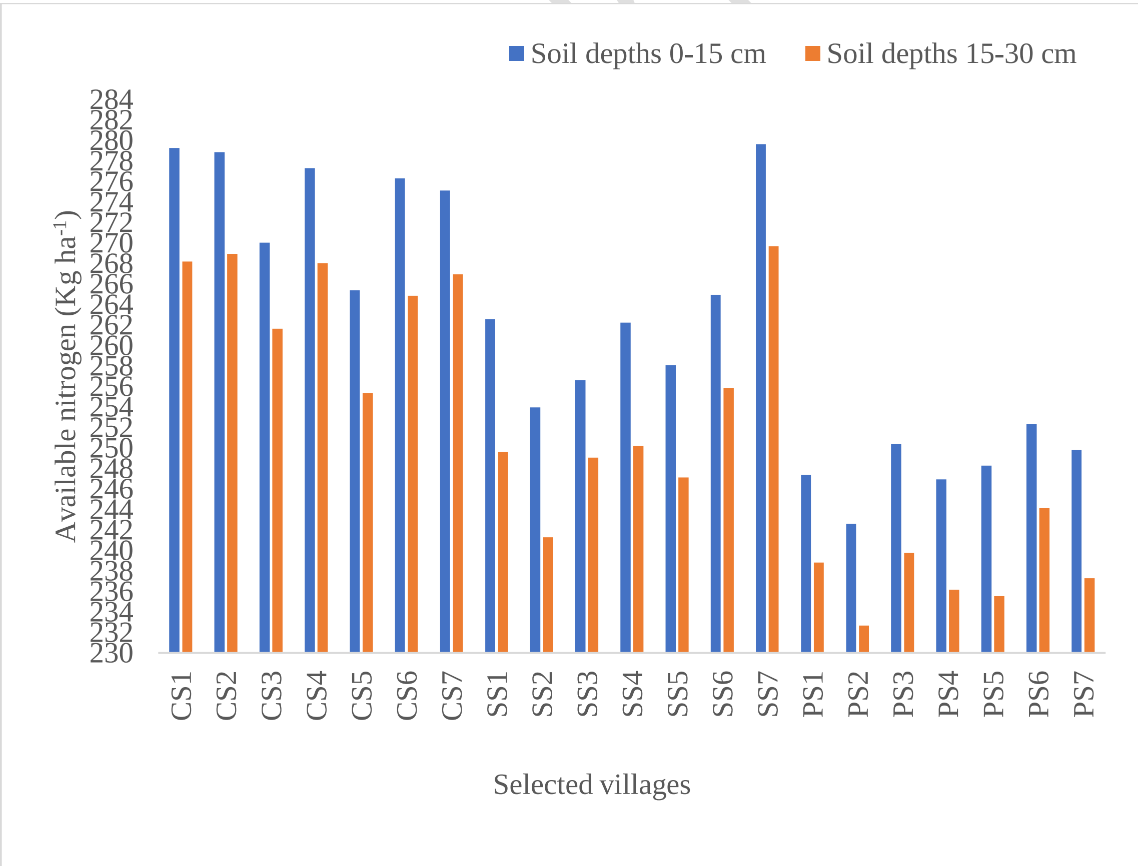

Figure 8. Graphical representation of available nitrogen in soil (Kg ha^{-1}) at 0-15 and 15-30 cm depths of different villages of Solan district, Himachal Pradesh.

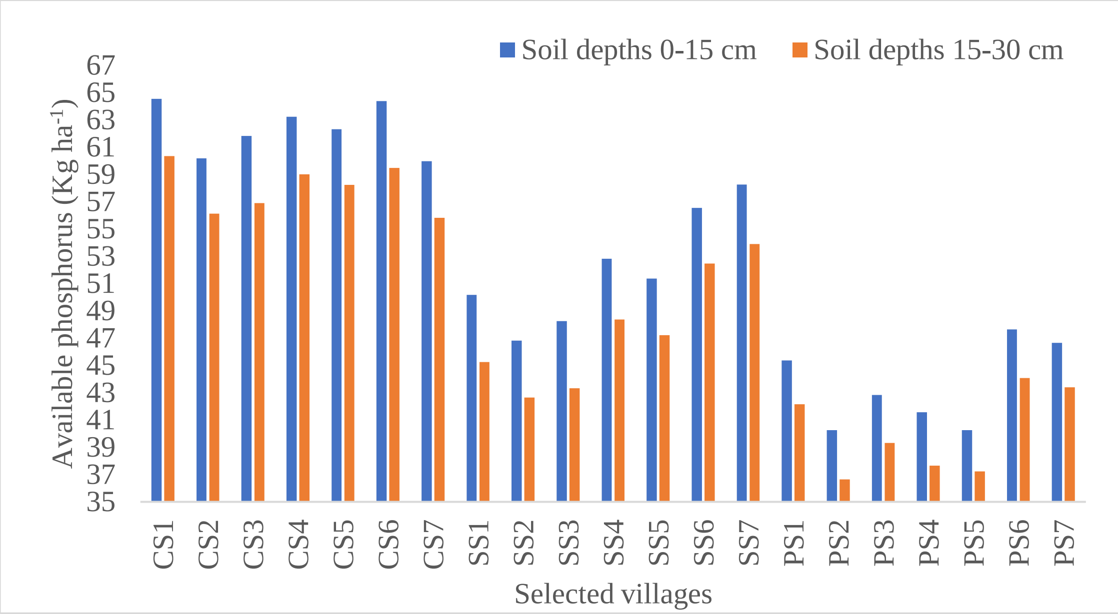

Figure 9. Graphical representation of available phosphorus in soil (Kg ha^{-1}) at 0-15 and 15-30 cm depths of different villages of Solan district, Himachal Pradesh.

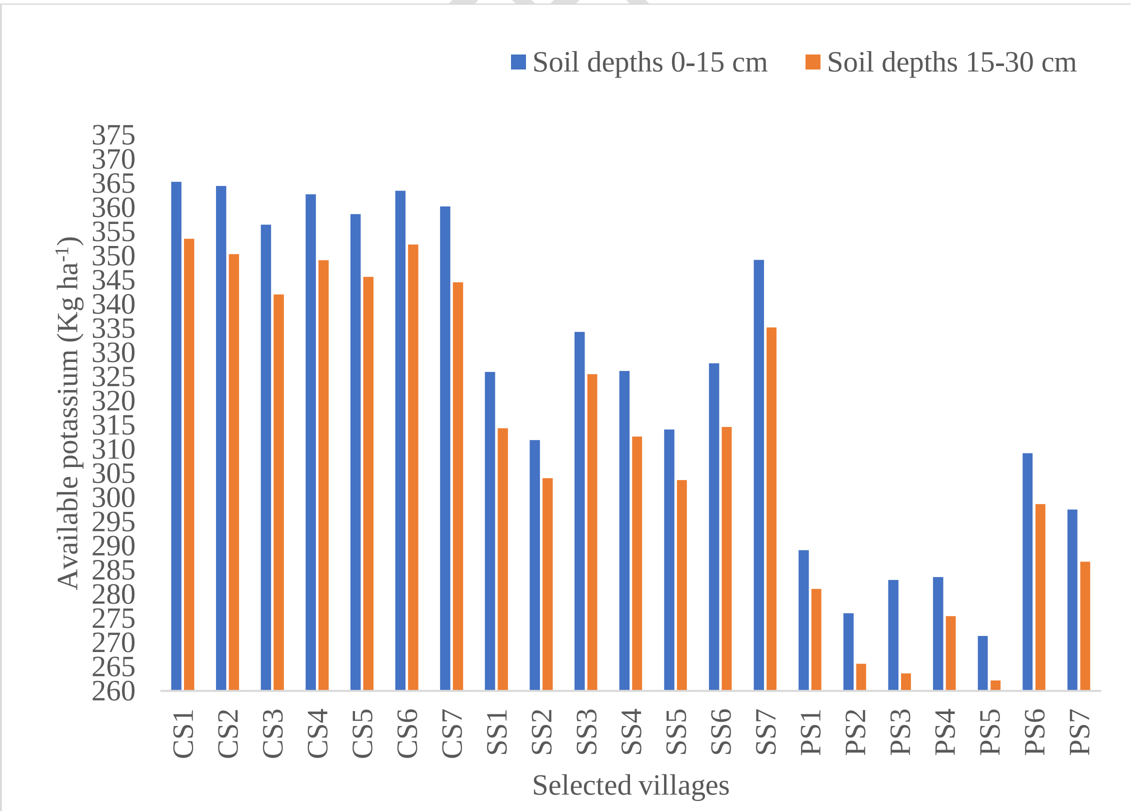

Figure 10. Graphical representation of available potassium in soil (Kg ha^{-1}) at 0-15 and 15-30 cm depths of different villages of Solan district, Himachal Pradesh.