International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(4): 1718-1721

Received: 28-05-2020
Accepted: 30-06-2020

Assessment of physical properties of soil in Kalimpong district of West Bengal, India

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DOI: https://doi.org/10.22271/chemi.2020.v8.i4q.9859

Abstract
The objective of this study was to analyze various soil physical properties. Samples were taken from two profile depths *viz.,* 0-15 cm and 15-30 cm from three different villages in entisols of Kalimpong district. Data revealed that bulk density increases with depth and ranged from 0.83 to 1.11 g cm^{-3}. Texture varied from clay loam to sandy clay loam. Water holding capacity ranged from 60.40 to 71.05% and percentage pore space from 55.5 to 61.5%. Significant variation in soil physical properties was recorded both due to site and due to depth. Particle density and specific gravity remained unchanged for most of the soil. Soil colour varied from brown to yellowish brown colour in the dry condition while dark brown colour predominated in the wet condition. The results revealed that the soils were in good physical condition due to adoption of organic farming in Kalimpong.

Keywords: Physical properties, soil analysis, Kalimpong, bulk density, water holding capacity

Introduction
In order to characterize any soil and enhance good plant growth, estimation of physical properties is an indispensable criterion. Agriculture is one of the main occupations of the people living in rural Kalimpong. Hence, maintaining the physical condition of the soil becomes a prerequisite for enhancement of agricultural production since most physical properties can be managed by cultural practices. The soils in Kalimpong are under organic farming. The agricultural yield of major crops in the Himalayan region has been stagnant over the last few decades (Shrestha *et al*., 2017) [1]. Various factors have been identified as the major cause for poor productivity which includes inadequate irrigation and improper cultivation (Joshi *et al.*, 2013) [2]. The majority of terrace farms are managed traditionally using simple tools, limited animal draft power and relatively abundant household labour. As a result, many terraces are not as productive as farms that have appropriate mechanization and irrigation. Where agricultural practices pose a risk of erosion, more feasible methods of cultivation such as bench terracing and contour trenching are adopted to stabilize sloppy lands. Such awareness has led to an ever growing curiosity in the measurement of constraints so as to follow sustainable cultivation practices to adapt to the changing environment. The present investigation was therefore conducted owing to scarcity of information on layered physical characteristics of soil in the Kalimpong district and to serve as a database for making suitable modifications to farming practices for the enhancement of crop productivity.

Materials and Methods
Soil Sampling
Soil samples were collected from agricultural fields of three different villages' *viz.*, Sindebong, Lolay and Dungra. Three different sites were taken in each village and each site represented two profile depths *viz.*, 0-15 cm and 15-30 cm. Eighteen samples were collected in totality with six samples representing one village each and nine samples representing one profile depth. Samples were collected using *khurpi* by random selection. The samples were air dried and all the unwanted materials were removed. Large clods were crushed by hand and wooden mallet and then ground using wooden mortar and pestle. Grinding was followed by sieving for which 2.0 mm sieve was used. Sieved soil samples were stored in air-tight plastic bags and tagged for estimation of physical properties.

Analysis of physical parameters

Soil textural analysis of particles less than 2 mm was performed by the Hydrometer method (Bouyoucos, 1927) [3]. The samples were matched against standard Munsell soil colour chart (Munsell, 1971) to obtain hue, value and chroma combinations for soil colour. The bulk density, particle density, pore space and water holding capacity was determined by the Graduated 100 ml Measuring Cylinder Method (Muthuvel *et al*., 1992) [5]. Specific gravity of soil was determined by the relative density bottle or pycnometer method as laid out by Black (1965) [6].

Results and Discussion

Soil texture

The soil texture (Table 1) in Sindebong and Dungra was found to be dominantly clay loam while in Lolay it was sandy clay loam. The sand content in the soils ranged from 23.5 to 59.2%, silt from 17 to 42.2% and clay from 18.5 to 39.5%. Similar finding was reported by Majumdar *et al.*, (2014) [7].

Soil colour

Soil colour (Table 2) varied from brown to yellowish brown colour in the dry condition while dark brown colour predominated in the wet condition. Dark colour corresponds to high organic matter content. The results were found in line with that of Ram *et al*., (2016) [8].

Bulk density and Particle density (g cm^{-3})

The maximum bulk density (Table 3) recorded was 1.11 g cm^{-3} in both Lolay and Dungra which indicated that the soil is widely composed of clay and aggregated loams. The minimum bulk density was recorded in Sindebong which was 0.83 g cm^{-3} and indicated the presence of high organic matter. Bulk density was found to increase with increase in depth in some sites due to increase in compaction. The maximum particle density (Table 3) recorded was 2.85 g cm^{-3} in both Lolay and Dungra which indicated that the soil has low organic matter content and minimum particle density was recorded in Sindebong which was 2.0 g cm^{-3} and indicated the presence of high organic matter, about 15 to 20%. Particle density was found to increase with increase in depth in all the sites and varied from 2.39 to 2.59 g cm^{-3} which is indicative of clay content. Similar results were obtained by Wankhade *et al.*, (2015) [9].

Pore space and Water holding capacity (%)

The range of values obtained for pore space (Table 3) was 55.5 to 61.0% which is indicative of clayey soils. Pore space was found to decrease with increase in depth. These findings were in line with that of Pandey *et al.*, (2018) [10].

The water holding capacity (Table 4) ranged from 60.40 to 71.05%. It indicates high clay content. The variations in water holding capacity is attributed to variation in sand, silt and clay content and organic carbon content. These findings were in line with that of Deb *et al.*, (2013) [11].

Specific gravity

The specific gravity (Table 4) ranged from 2.0 to 2.3 in the soils of study area which is indicative of porous particles and high organic matter content. These findings were in line with that of Sujatha *et al.*, (2016) [12].

Table 1: Soil texture in different villages of Kalimpong at 0-15 and 15-30 cm depth

Village/Site	Depth (cm)	% Sand	% Silt	% Clay	Textural class
Sindebong					
S_1	0-15	25.2	36.5	38.3	Clay loam
S_1	15-30	24.4	32.6	43	Clay loam
S_2	0-15	34.3	42.2	23.5	Loam
S_2	15-30	36.5	39.4	24.1	Loam
S_3	0-15	26.7	34.2	39.1	Clay loam
S_3	15-30	29.7	31.8	38.5	Clay loam
Lolay					
S_1	0-15	51.2	18.3	30.5	Sandy clay loam
S_1	15-30	44.7	20.1	35.2	Sandy clay loam
S_2	0-15	53.6	17	29.4	Sandy clay loam
S_2	15-30	43.9	21.9	34.2	Sandy clay loam
S_3	0-15	59.2	22.3	18.5	Sandy loam
S_3	15-30	43.7	20.1	36.2	Sandy clay loam
Dungra					
S_1	0-15	32.3	36.5	31.2	Clay loam
S_1	15-30	29.5	38.1	32.4	Clay loam
S_2	0-15	36.5	42.2	23.5	Clay loam
S_2	15-30	43.7	24.1	32.2	Sandy clay loam
S_3	0-15	23.5	37	39.5	Clay loam
S_3	15-30	25.2	39.5	35.3	Clay loam

Table 2: Soil colour of different villages in dry and wet condition of soil in Kalimpong

Village/Site	0-15 cm		15-30 cm	
	Dry	Wet	Dry	Wet
Sindebong				
S_1	Olive brown	Very dark grayish brown	Brown	Very dark grayish brown
S_2	Olive brown	Very dark grayish brown	Brown	Very dark grayish brown
S_3	Pale brown	Dark grayish brown	Light olive brown	Dark grayish brown
Lolay				
S_1	Light olive brown	Brown	Olive yellow	Yellowish brown
S_2	Light olive brown	Brown	Yellowish brown	Dark yellowish brown

S_3	Brownish yellow	Dark yellowish brown	Yellowish brown	Brown
Dungra				
S_1	Yellowish brown	Dark brown	Yellowish brown	Dark brown
S_2	Yellowish brown	Dark brown	Yellowish brown	Dark brown
S_3	Yellowish brown	Dark brown	Yellowish brown	Dark brown

Table 3: Bulk density (g cm^{-3}), Particle density (g cm^{-3}) and Pore space (%) of soil in different villages of Kalimpong at 0-15 and 15-30 cm depth

Village/Site	Bulk density (g cm^{-3})		Particle density (g cm^{-3})		Pore space (%)	
	0-15	15-30	0-15	15-30	0-15	15-30
Sindebong						
S_1	0.83	0.95	2.22	2.22	62.5	57.1
S_2	0.86	0.95	2	2.22	57.1	56.5
S_3	1	1	2.5	2.5	61.0	61.0
Lolay						
S_1	1.11	1.11	2.85	2.85	60.0	60.0
S_2	1.05	1.11	2.5	2.85	63.1	55.5
S_3	1.11	1.11	2.5	2.85	61.5	55.5
Dungra						
S_1	1.05	1	2	2.5	57.8	50.0
S_2	1.11	1.11	2.5	2.5	55.5	55.5
S_3	1.11	1.11	2.5	2.85	61.1	55.5
Mean	1.05	1.02	2.39	2.59	59.9	56.2
	SEm (±)	CD at 5%	SEm (±)	CD at 5%	SEm (±)	CD at 5%
Due to depth	0.012	-	0.098	0.018	1.833	0.012
Due to site	0.029	0.001	0.083	0.008	0.769	-

Table 4: Water holding capacity (%) and Specific gravity of soil in different villages of Kalimpong at 0-15 and 15-30 cm depth

Village/Site	Water holding capacity (%)		Specific gravity	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Sindebong				
S_1	66.60	68.70	2.0	2.0
S_2	64.0	70.80	2.0	2.0
S_3	60.40	60.80	2.1	2.0
Lolay				
S_1	67.40	62.50	2.1	2.1
S_2	69.70	62.70	2.1	2.1
S_3	65.80	64.10	2.3	2.2
Dungra				
S_1	63.40	64.10	2.0	2.1
S_2	70.70	71.05	2.1	2.2
S_3	66.60	65.80	2.2	2.3
Mean	66.06	65.61	2.1	2.1
	SEm (±)	CD at 5%	SEm (±)	CD at 5%
Due to depth	0.225	-	0.005	-
Due to site	0.948	-	0.031	0.010

Conclusion

It can be concluded from the analysis of soil samples that the soils of Kalimpong have good physical condition which favours the cultivation of most crops. Lighter soil colour was observed in the surface layer while the subsurface was characterized by darker colour. Soil texture showed high clay percentage. The bulk density values were considerably low and increased with increase in depth. The particle density also increased with depth. Low specific gravity values indicate high organic matter content. Good water holding capacity and pore space percentage is indicative of high clay content and thus makes Kalimpong terrace farms suitable for paddy cultivation.

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