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

Pratistha Pradhan, Narendra Swaroop, Arun Alfred David and Tarence Thomas

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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. These findings were in line with that of Pandey et al., (2018) [10].

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%.

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].

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 Deb et al., (2013) [11].

| Village/Site | Depth (cm) | % Sand | % Silt | % Clay |
|--------------|------------|--------|--------|--------|
| Sindebong    |            |        |        |        |
| S1           | 0-15       | 25.2   | 36.5   | 38.3   |
|              | 15-30      | 24.4   | 32.6   | 43     |
| S2           | 0-15       | 34.3   | 42.2   | 23.5   |
|              | 15-30      | 36.5   | 39.4   | 24.1   |
| S3           | 0-15       | 26.7   | 34.2   | 39.1   |
|              | 15-30      | 29.7   | 31.8   | 38.5   |
| Lolay        |            |        |        |        |
| S1           | 0-15       | 51.2   | 18.3   | 30.5   |
|              | 15-30      | 44.7   | 20.1   | 35.2   |
| S2           | 0-15       | 53.6   | 17     | 29.4   |
|              | 15-30      | 43.9   | 21.9   | 34.2   |
| S3           | 0-15       | 59.2   | 22.3   | 18.5   |
|              | 15-30      | 43.7   | 20.1   | 36.2   |
| Dungra       |            |        |        |        |
| S1           | 0-15       | 32.3   | 36.5   | 31.2   |
|              | 15-30      | 29.5   | 38.1   | 32.4   |
| S2           | 0-15       | 36.5   | 42.2   | 23.5   |
|              | 15-30      | 43.7   | 24.1   | 32.2   |
| S3           | 0-15       | 23.5   | 37     | 39.5   |
|              | 15-30      | 25.2   | 39.5   | 35.3   |

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    |         |          |         |          |
| S1           | Olive brown | Very dark grayish brown | Brown | Very dark grayish brown |
| S2           | Olive brown | Very dark grayish brown | Brown | Very dark grayish brown |
| S3           | Pale brown | Dark grayish brown  | Light olive brown | Dark grayish brown |
| Lolay        |         |          |         |          |
| S1           | Light olive brown | Brown | Olive yellow | Yellowish brown |
| S2           | Light olive brown | Brown | Yellowish brown | Dark yellowish 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          |
| Sindebong    |                               |                                 |                |                |
| S1           | 0.83                          | 0.95                            | 2.22           | 2.22           |
| S2           | 0.86                          | 0.95                            | 2              | 2.22           |
| S3           | 1                             | 1                               | 2.5            | 2.5            |
| Mean         | 1.05                          | 1.11                            | 2.5            | 2.5            |
|              | SEm (±)                       | CD at 5%                         | SEm (±) CD at 5%|                |
| Due to depth | 0.012                         | -                               | 0.098          | 0.018          |
| Due to site  | 0.029                         | 0.001                           | 0.083          | 0.008          |

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    |         |          |         |          |
| S1           | 66.60   | 68.70    | 2.0     | 2.0      |
| S2           | 64.0    | 70.80    | 2.0     | 2.0      |
| S3           | 60.40   | 60.80    | 2.1     | 2.0      |
| Mean         |         |          |         |          |
|              | 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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