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Study of soil properties in different depths under homogeneous and heterogeneous forest stands of Cooch Behar, West Bengal

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Abstract
Understanding the effects of soil depth on the dynamics of soil properties under different land covers is essential to establish appropriate management options aiming at sustaining soil health and restoring degraded soils in the highlands. This study was conducted with an aim to analyse the spatial variability of soil properties with depth under forestland of pundibari, Cooch Behar, west Bengal. The soil samples were collected from surface (0-15 cm) and sub-surface soil (15-30 cm) in replicates and total 30 soil samples were collected from Rasomoti and Sonapur forest range. Among the chemical properties soil pH was studied and in terms of physical aspect, percentage of sand, silt and clay were calculated. Statistical analysis revealed significant variation in soil properties with along the selected land use. Topsoil layer had significantly greater amount of sand and silt concentrations than the subsoil layers. Outcomes indicated that their % was highest under heterogeneous plantation. However, clay concentration and soil pH revealed the reverse trends. Clay has no significant correlation with selected soil properties except with sand fraction in the sampled depths. Hence, the correlation among the selected soil properties also varies with soil depth. On an average the variation of soil properties was found to be higher in heterogeneous forest stand. In general, the spatial variability of soil properties indicates that they were strongly affected by external factors (agricultural treatments and soil management practices) and internal factors (soil type and depth).

Keywords: Soil pH, clay %, silt %, sand %, soil depths, heterogeneous, homogeneous

Introduction
Soil plays a crucial role in ecosystem functioning. It provides nutrient, water, and space for the plants. It forms the basis of life on earth (Brevik *et al.*, 2015) [1]. Soil differs in their properties such as texture or mineral composition and dynamic characteristics such as nutrient content or soil pH of humus content (karlen *et al.*, 2003) [2], Texture and mineral composition are largely independent from vegetation, while nutrient content and soil pH are affected by vegetation and in turn exert influence on plant growth and species composition (Oelmann *et al.*, 2009) [3]. According to Norfleet *et al.*, dynamic soil properties (soil pH, nutrient content, and base saturation) could change relative quickly within years due to biological process, vegetation cover and management practices. On other hand, stable soil properties (grain size distribution, mineral composition) change over longer period of time.
Due to interaction between natural and anthropogenic management system (Assefa and van Keulen, 2009) [11], soil undergoes vertical exchange of materials which in turn result in physical and chemical changes from surface soil to sub-soils (Brady and Weil, 1999) [12]. The addition of organic matter from plant growth to the top soil, weathering of rocks and minerals, decomposition of organic matter, and translocation of soluble components by leaching, which in turn responsible for the differentiation of soil layers (Foth, 1990) [13]. Ploughing and tillage for the purpose of cultivation, grazing may change the proportions of many soil properties with change in depths (Ali *et al.*, 1997; McCarthy *et al.*, 2013) [14, 19]. Ali *et al.*, 1997 [14] studied that soil weathering differentials between the soil profiles bring changes in clay, CEC, organic matter and K. Islam and Weil, 2000 [15] stated that tillage mechanically disintegrates soil particles and modifies soil conditions for plant growth and intensive leaching, and improves organic matter decomposition. Sheet erosion and intensive leaching process leads to higher concentration of clay content and lesser concentration of calcium, magnesium, potassium and sodium in the subsoil than the topsoil (Adeboye *et al.*, 2011) [16].

The associations among the soil properties also vary with the variation of depth. In surface soil layer, CEC is strongly associated with organic matter than clay (McAlister *et al.*, 1998) [18]. In the subsoil, since there is higher clay and relatively lower OM, CEC was strongly correlated with clay than organic matter (Jin *et al.*, 2011) [20]. These studies showed that soil properties react to depths across the various land uses.

According to Thompson *et al.*, 2005 [7] depth gradients in soil chemical and physical properties are influenced by biogenic, geogenic and pedogenic process. Soil properties get different with depth. The deeper the soil layers, the lower is the influence of plant cover and soil biota and higher is the influence of weathering (Ponce-Hernandez *et al.*, 1986) [9]. It has been found that all the soil characteristics with depth are mainly non-linear (kempen *et al.*, 2011) [10]. Deeper soil provides more nutrient and water to plants than shallow soil, also deeper soil gives support to herbaceous perennial woody plants while annual plants thrives well in shallow soil. Some soils may develop special soil horizon, which include clay pan (contains large amount of clay) and hardpan (contains calcium carbonate cements of soil particles).

Understanding the effects of soil depth on the dynamics of soil properties under different land covers is essential to establish appropriate management options aiming at sustaining soil health and restoring degraded soils in the highlands. Therefore, the objective of this study was to examine the effects of soil depth on some selected soil properties under the forest cover.

Materials and Methods

Study area

This study was conducted in northern part of Cooch Behar District of West Bengal, India. In order to fulfil the objective of the present study, forest (natural as well as plantation) land use was considered for soil sampling. Rasomati forest (tropical moist semi-evergreen forest), located at 26°27' N latitude and 88°19'E longitude with an elevation of 66 m above mean sea level, was selected for collection of forest soil samples.

This area comes under Pundibari forest range of Cooch Behar forest division, at the foothills of sub-Himalayan mountain belts. The average minimum and maximum temperature of this area varied from 23°C during winter (January) to 33°C during summer (July) (data of nearest station as obtained from ClimWat). On an average, the annual rainfall varies from 2000 mm to 3500 mm, bulk of which is being received during pre-monsoon and monsoon period i.e. May to September. This area belongs to warm and humid climate except a short spell of winter extending from December to February.

Total 15 treatments were used S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, R1, R2, R3, R4 and R5. Treatments S6, S7, R3, R4, and R5 come under heterogeneous (mixed species) plantation. S1, S3, S5, R1, R2 come under homogeneous plantation (Jarul species), S2, S4 come under Kainjal species, S8 and S9 come under Panisaj species while S10 comes under Som plantation.

Soil sampling

Soil sampling was done in the month of March, 2018 (pre-monsoon) from the forest and cultivated lands. 15 soil samples each for surface and sub-surface were collected from Rasomati and Sonapur belt of the forests. To exactly determine the sampling locations, hand-held GPS receiver (Garmin, Olathe, KS, USA) was used.

Soil analysis

A part of soil samples were kept in the refrigerator for the analysis of the biological parameter and the rest of the soils were air dried. This air dried soil was then passed through 5 mm sieve (used for aggregate analysis) and 2 mm sieve (used for physico-chemical analysis).

Estimation of soil pH

The pH of the samples was determined using a pH meter (Utech instrument pH 600) with glass electrode. The pH meter was first adjusted to temperature and then calibrated using three buffers of 4.0 ± 0.05, 7.0 ± 0.05 and 9.2 ± 0.05 pH. The pH was determined in 2:5: soil: water suspension. After 5 min of continuous stirring with a glass rod, the pH of the suspension was determined.

Estimation of Soil particle size distributions

Particle size distributions of the soils were determined following the International pipette method (Gee and Or, 2002). From the percent contents of sand, silt and clay, the textural class of the soil was determined with help of triangular textural diagram.

Result and Discussion

The physico- chemical properties indicated the presence of acidic soil in this area. The soil pH was found to be higher in the sub surface than the surface (fig1). This may be due to continuous addition of leaf litters and organic matter and their decomposition. The leaching of soluble salt may be another reason of low pH in top soil. The presence of hard pan (deposition of $caco_3$) may be the possible reason of higher pH in the bottom soil. In both the top and bottom soil, the pH value is highest under mixed species i.e., heterogeneous species.

The soils were sandy loam, silty loam or loamy in texture. The average clay content of the soil was 9.3%. Clay percentage in soil is important as it controls soil C fixation and residence time. The clay% is higher in bottom soil as compared to top soil (fig 2). In top soil the clay% is higher under panisaj plantation (S8, S9) while under bottom soil its % is higher in heterogeneous plantation (S7).

The silt percentage was highest in the soils. The top soil holds greater amount of silt and sand % as comparison to bottom soil (fig 3, 4). Also their % is higher under heterogeneous plantation under S7 treatment. Silt was the highest (57.2% in topsoil and 44.9% in subsoil) under forestland and. This finding revealed that soil particle size distributions significantly changes between sampling depths under forest land.

Table 1: Soil properties at 0-15cm and 15-20cm depth in forest land use under different stands

			Surface				Sub surface		
Treatments	**Stand**	**pH**	**Clay%**	**silt%**	**sand%**	**pH**	**Clay%**	**silt%**	**sand%**
S1	Jarul	5.32	2.03	58.07	28.00	7.09	14.03	46.03	24.03
S2	Kainjal	5.91	3.97	56.07	28.00	7.11	15.70	45.03	25.07
S3	Jarrul	5.47	2.03	52.07	30.00	6.05	11.60	44.03	26.13

S4	Kainjal	7.32	3.97	56.03	31.90	7.63	11.73	43.03	27.10
S5	Jarul	6.29	4.03	56.03	31.00	7.19	14.13	45.07	27.07
S6	Mixed species	7.07	4.07	60.03	32.07	7.41	14.57	53.07	28.07
S7	Mixed species	7.00	4.07	65.07	38.00	7.55	26.13	58.03	32.07
S8	Panisaj	6.65	9.63	58.03	30.07	7.28	10.57	44.07	26.03
S9	Panisaj	5.70	8.30	56.03	24.07	6.44	9.40	42.07	19.07
S10	Som	6.18	5.97	59.07	24.00	7.38	9.07	44.07	19.93
R1	Jarul	6.16	3.93	56.03	34.00	7.61	8.23	40.07	27.93
R2	Jarul	6.19	9.43	54.07	30.03	7.49	10.37	46.03	25.20
R3	Mixed species	6.35	8.50	58.07	33.97	7.49	9.93	44.03	31.03
R4	Mixed species	7.55	7.57	56.03	32.03	7.32	9.53	38.03	29.00
R5	Mixed species	7.52	5.90	58.03	35.07	7.65	8.07	42.07	32.10

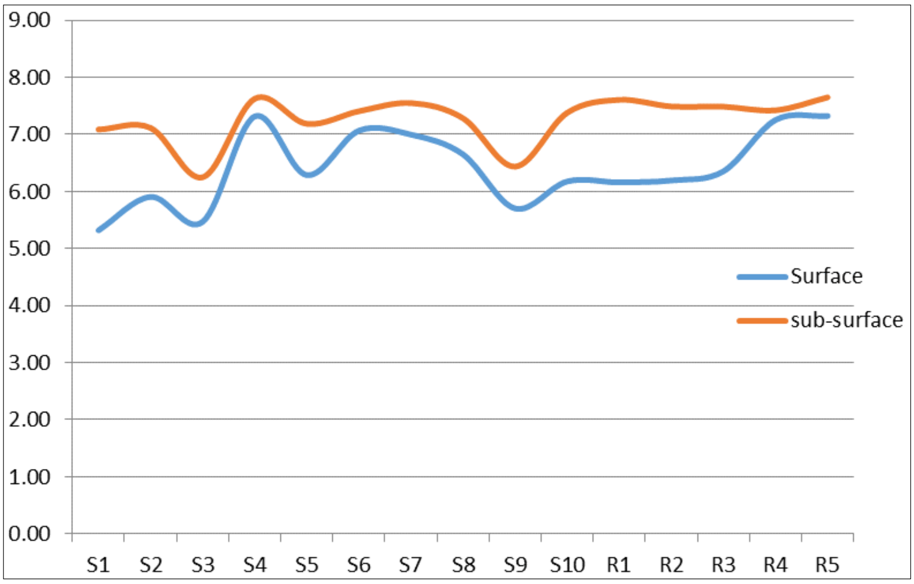

Fig 1: Variation of soil pH in different soil depth under homogeneous and heterogeneous forest stands

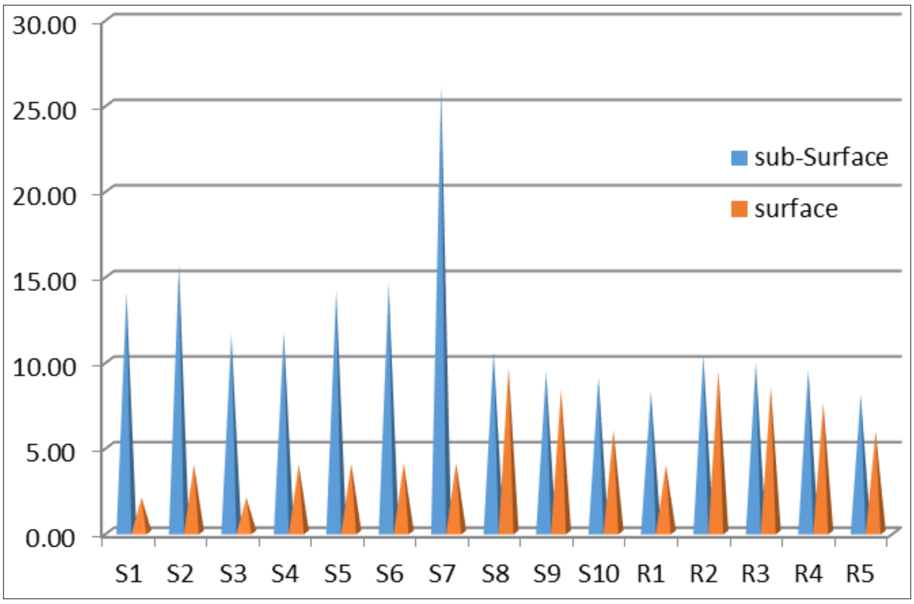

Fig2: Variation of clay% in different soil depth under homogeneous and heterogeneous forest stands

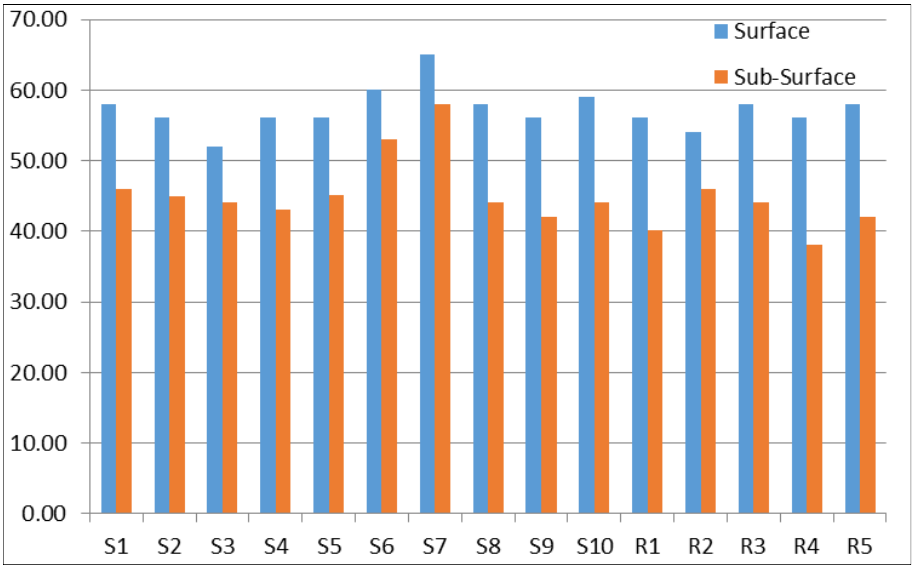

Fig 3: Variation of silt% in different soil depth under homogeneous and heterogeneous forest stands

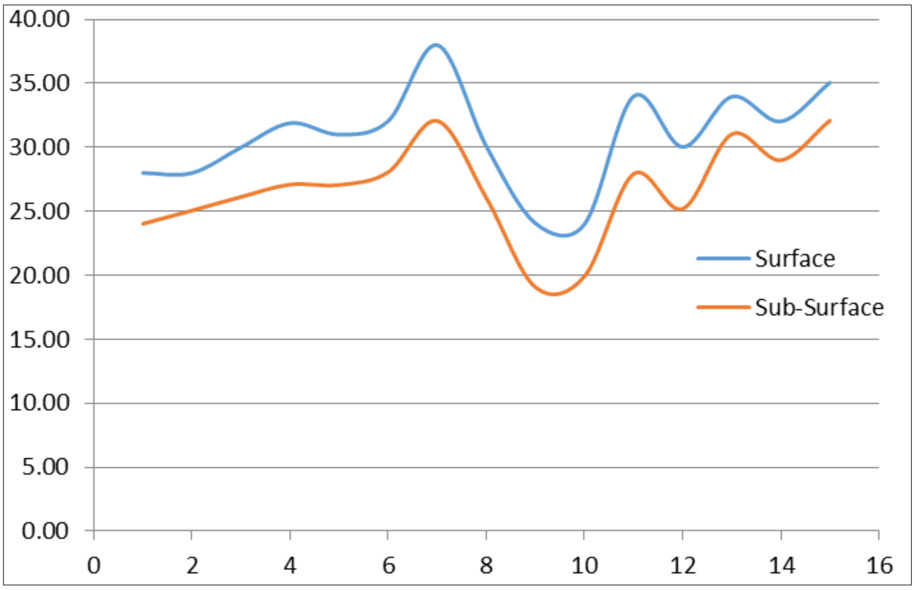

Fig 4: Variation of sand% in different soil depth under homogeneous and heterogeneous forest stands

Conclusion

The heterogeneous forest stand was showing optimum pH in forest land. The heterogeneous stand also showed higher % of sand, silt and clay as compared to homogeneous forest stand.

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