Distribution of Selected Soil Properties under Different Land Use Patterns in Terai Region of West Bengal (India)

D Pal[1], PK Patra[1] and D Mukhopadhyay [2*]
[1]Department of Environmental Studies,Sikshsa-Bhavana, Visva Bharati, Santiniketan, West Bengal, India
[2]Department of Soil Science and Agricultural Chemistry, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India

Abstract
A study was conducted to characterize and find out the important physico-chemical properties and available nutrient status in soils with increasing depth under four different eco-systems (forest land, agricultural land, tea garden and fallow land) in *Terai* region of West Bengal. It was observed that the available N-P-K contents , exchangeable (Ca + Mg), pH, electrical conductivity (EC), oxidisable Organic Carbon (OC) and total C-H-N-S significantly varied with the depth (0-20 cm, 20-40 cm and 40-60 cm) of soils in most of the cases. The given physico-chemical properties were analyzed by the standard methods. The soils were acidic (4.77-6.24) in reaction and non-saline in character. The available N-P-K content and OC of soils of forest, agricultural and tea-garden were different from the uncultivated fallow land. The survey of the regions showed that the build-up of nutrients (N-P-K, Ca + Mg) varied with the changing ecosystems as reflected by the C/N, C/S and C/H ratios of the soils.

Keywords: Ecosystem, Land-use, Nutrients, Physico-chemical
Corresponding author:dibsm107@gmail.com

Introduction

The Terai region of West Bengal (India) is characterized by biomass production well supported complimentary climatic factors, particularly high rainfall for luxuriant vegetative growth and regeneration rate. Availability of abundant phyto-biomass, both above and below ground in the form of forests and other allied sources has made the region a unique place in India. Since vegetation or biomass is one of the most important sources to enrich soil with organic matter, a general belief is that the soil of Terai region is very high in carbon content. Land use/land cover change and type of land use practices have considerable influences on changing the soil properties. The conversion of natural forests to other forms (agricultural land, tea gardens) may have effect on changing the important nutrients (Ca, Mg, N, P, K, S) in soils and also the carbon stock of the region. Chandra *et al.* (2010) observed that the soils of the organically cultivated field (OCF) had higher moisture, total organic carbon, nitrogen, microbial biomass Carbon and Nitrogen, compared to fallow grassland at the neighboring plot. Sidhu *et al.* (2014) observed that the soil properties are being influenced by the management practices and change of cropping pattern in the Indo -Gangetic Plain (IGP). Studies were taken to assess the impact of conversion of native ecosystem into arable land on labile pool and also to find out the role of soil as sink for carbon under different management practices and land uses. Emission of carbon dioxide from soil is influenced by oxidation of soil organic matter, root and microbial respiration. Besides, reasonable amount of information on soil organic carbon status and carbon stock has not been generated for main land India. Based on this background, the present study was conducted to assess the variability in the physico-chemical properties of the soils under different ecosystems.

Materials and Methods

Experimental sites and Soil sampling

Considering the different climatic conditions and land use pattern under the Terai agro-ecosystems, the selection of the sites for collecting soils was done on the basis of different land use and land cover (e.g. agricultural, fallow, tea garden and forest land) situations. The annual average rainfall varied from 1200-3000 mm over the region with an average temperature of 25-30^0 C. A field survey was conducted in identified agricultural and fallow lands at Kharibari (Darjeeling District), Binnaguri, Kumargram (Jalpaiguri District) and Balarampur (Cooch Behar District) under the Northern Province of West Bengal (India). The soils were collected from tea gardens of Darjeeling and Jalpaiguri districts and soils from forest land cover were collected from Mahananda Sanctuary, Gorumara National Park, Chilapata Forest and Buxa Tiger Reserve Forest of West Bengal at four to five uniform spots from each of the land use/land cover site at 0-20 cm, 20-40 cm and 40-60 cm depths. The collected soil samples were processed to determine the important physico-chemical properties by the standard procedures of Jackson (1973). The total carbon (C), Hydrogen (H), nitrogen (N) and sulfur (S) contents of soils were determined in the CHNS analyzer and the C/N, C/H and C/S

were calculated for each of the land situation. Least significant difference (LSD) and correlation analysis were performed using SPSS software (version 6.0) to study the underlying relationships among different soil properties.

Results and Discussion

Characterization of soils under study

Forest ecosystems: The soils were collected from four sites (Gorumara, Mahananda, Buxa and Chilapata) of the region. In all the sampling sites, the soil was acidic in reaction (average pH 5.15). A general trend of increasing the pH with the depth of the soils was observed. The range of pH in soils varied from 4.77 to 5.62. The ECs of the collected soils showed the non-saline characteristics having an average of 0.05 dSm^{-1}. The (Ca + Mg) content in soils was low in this zone (average 3.48 meq/kg) which also indicated the acidic nature of the soil. The oxidisable organic carbon (average 1.59%) showed variation at different depths of soils. The available nitrogen (kg/ha) was relatively higher (238.34) in Gorumara forest and was lowest in Chilapata forest (194.43) at the surface soils (0-20 cm). Besides, significant variations of CEC with soil depths were observed at different sites of the forest ecosystems. The N-P-K content under different ecosystems (Figure 1) showed the native pools of N-P-K in soils. The available nitrogen (N) tends to decrease with the depth of the soil.

The lowest value of N (119.17 kg/ha) was at 40-60 cm depth of soils under the Chilapata forest (data not shown). The available phosphorus under the forest ecosystem varied at different locations. A general trend of decreasing the available P with the depth of soil (except at the Mahananda and Chilapata forest ecosystems) was observed. The average Bray-extractable P was 86.09 kg/ha. In the Chilapata forest ecosystem the exchangeable (Ca + Mg) should have a positive correlation with the available P in soil at different depths. A general trend of lowering of K content with the soil depths was observed under this ecosystem. The average K content was 108.70 kg /ha. The maximum K content was observed in the soils of the Gorumara and minimum at the Mahananda forest. The total (%) C-N-S decreased with the increasing depths of the soil having the average content (%) 2.07, 0.18 and 0.52 respectively. The C/N C/S and C/H in soils varied from 9.29-12.58, 2.75-9.66 and 2.95-12.32 respectively.

Agricultural land: The soil samples collected from Binnaguri, Kumargram and Kharibari were acidic, while the soils of Balarampur were towards neutral. The average pH was 6.24 for the soils of agricultural land and in general, there was a trend of increasing pH with the soil The ECs of the soil samples showed the non-saline character with an average value of 0.13 dSm^{-1}. The exchangeable (Ca + Mg) of the soils of Balarampur and Kumargram were relatively higher than the soils of Binnaguri and Kharibari. The variation may be due to the acidic reaction of the soils and indiscriminate application of liming materials in the field. The oxidisable organic carbon generally decreased with the depth of the soils, being the average of 0.93%. The available nitrogen in soils (0-20 cm depth) was in the order Binnaguri > Kharibari > Balarampur > Kumargram and the content tends to decrease with the increasing depth of the soil. A significant variation of the available P with the depth of the soil was observed. The mean P content of 30.99 kg/ha of the soils might be due to the fixation of the phosphate under the acidic condition of the soils. The mean exchangeable K was 150.92 kg/ha in the agricultural field. The exchangeable K in Kharibari soil was highest followed by Binnaguri, Kumargram and Balarampur soils. The exchangeable K decreased with the depth of the soils collected from Binnaguri and Kumargram. In most of the soils, the total C-H-N-S decreased in the sub-surface layers with an average distribution (%) of C-H-N-S as 1.17 – 0.29 – 0.14 – 0.43(data not shown) respectively.

Tea garden: The soils were collected from tea gardens of Moraghat, Ellenbari, Nimti and Kumargram areas. The soils were acidic with an average pH of 4.78 and ECs of 0.12 dSm^{-1}. The exchangeable (Ca + Mg) in soils of Kumargram was relatively higher than Moraghat, Ellenbari and Nimti soils. The variation may be due to the lowering of the soil pH and improper application of liming materials in the field(Roy and Mukhopadhyay, 2012). A general trend of decrease of the organic carbon with the depth of soils was observed. The available nitrogen, phosphorus and K also varied with the depth of the soils with an average value of 178.23, 82.34 and 199.86 kg/ha respectively. The total C-H-N-S also varied with the soil depth in this region. The average C/N of the tea garden soils was 9.33.

Fallow land: The soils were collected from the uncultivated fallow land of Binnaguri, Balarampur, Kumargram and Kharibari sites and were characterised with important soil properties. All the soils were acidic in reaction (average pH 5.74) and ECs as 0.19 dSm^{-1}.

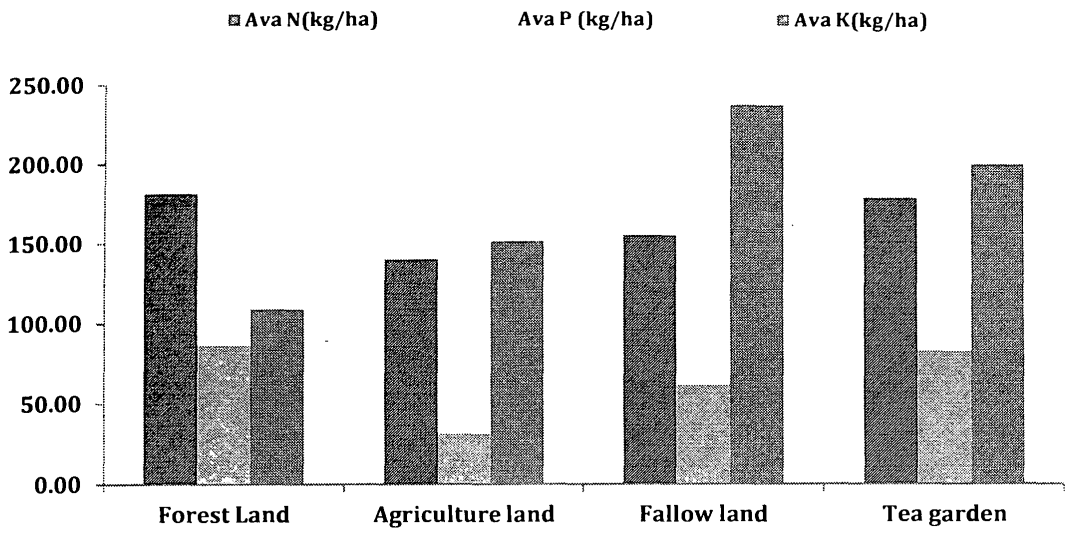

Figure 1: Status of N-P-K (kg/ha) in soils under different ecosystems

A general trend of increasing the (Ca + Mg) content was observed with the soil depth having an average of 5.61 meq/kg. This may be due to the sub-surface deposition of (Ca + Mg) with leaching water. The average organic carbon content in soil was 0.99% in this region, while the mean available N-P-K (kg ha^{-1}) were 154.19, 60.75 and 162.15 kg/ha respectively in soils. The total available C-H-N-S (%) in soils was 1.22, 0.24, 0.15 and 0.42 respectively. The variation of C/N with the soil depth was observed with an average of 7.44 in soils under the fallow land situation. The C/S and C/H in soils varied from 0.90-10.26 and 2.82-9.23 respectively.

Conclusion

It was observed that there were variations in the physico-chemical properties of soils under the different land use systems. The properties of the soils under the fallow land varied significantly with the other ecosystems (tea garden, agriculture and forest). The present study emphasizes the need for proper management of the soils to prevent soil erosion, reduction in soil fertility and land degradation of a region.

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