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Organic Carbon in Soil and Biomass of an *Alnus nepalensis* Forest in Kathmandu, Nepal

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Abstract This article reports the results of measuring organic carbon contents in biomass and soil of an *Alnus nepalensis* forest in Kathmandu. The aboveground and belowground biomass of *A. nepalensis* were 62.21 t/ha and 12.44 t/ha respectively in the forest. The aboveground and belowground carbon stock in the forest were 29.24 t/ha and 5.85 t/ha respectively. Average organic carbon stock in soil depths 0-10 cm and 10-20 cm were found 19.78 t/ha and 10.61 t/ha respectively. The mean organic soil carbon stock in 0-20 cm soil depth was found 15.20 t/ha and in living biomass was found 35.09 t/ha. The organic carbon stock in 0-10cm soil depth was found 1.86 times more than in soil depth of 10-20 cm. Carbon stored in living vegetation biomass is 2.31 times more than soil organic carbon in the forest upto 20cm soil depth. Soil bulk density in 0-10 cm and 10-20cm soil depths were found 0.69 g/cm^3 and 1.14 g/cm^3 respectively.

Keywords Carbon, Soil, Biomass, *Alnus nepalensis*

1. Introduction

The exchange of carbon between the atmosphere and terrestrial ecosystems (soil and vegetation) is critical to the patterns of carbon dioxide concentration in the atmosphere [1][2][3][4]. The carbon pool in a terrestrial ecosystem can be broadly categorized into biotic (vegetative carbon) and pedologic (soil carbon) components.

Forests are the largest carbon stock in terrestrial ecosystems[5][6][7][8][9] and estimated to be about 1150 Gg, of which 49% is in boreal forests, 37% in tropical forests and 14% in temperate forests[10]. Soils are viable sinks of atmospheric carbon (C) and may significantly contribute to mitigation of global climate change[11][12][13][14]. Soil organic carbon (SOC) stocks in forest soils fluctuate from 50 to more than 200 Mg/ha, depending upon the climate and soil conditions, the age and type of the tree stand, and management practices[15].

A study by FAO[16] showed that 496 million metric tons of organic carbon is stored in soils at forest and shrub land of Nepal. Bajracharya et al.[17] estimated soil organic carbon storage in Nepal's middle hills to be around 423.7 mt C. By depth, forest and shrub land have higher amount of soil organic carbon (2.0% and 2.3% respectively) than the cultivated soils in the top layer between 1 and 30 cm.

Vertical patterns of Soil Organic Carbon (SOC) can contribute as an input or as an independent validation for biogeochemical models and thus provide valuable information for examining the responses of terrestrial ecosystems to global change[18][19][20]. Thus, improved knowledge of distribution of SOC across different soil depth is essential to determine whether carbon in deep soil layers will react to global change and accelerate the increase in atmospheric carbon dioxide (CO_2) concentration [21]. In this context, this research was carried out to quantify levels of organic carbon in soil at two depths and biomass of an *Alnus nepalensis* Forest in Kathmandu, Nepal.

2. Materials and Methods

The study was conducted in Rajat Uddhyan Community Forest, located in Mulpani-6, in Kathmandu District of Nepal. It is about 3 km away from Chabahil Chowk. The forest is a community managed forest with 1.5 hectares area. Alnus nepalensis is dominant species with more than 90 percent coverage. The *A. nepalensis* in the forest are only of pole sizes.

Vegetation Measurement

The area of forest was 1.5 hectares, so all the poles of *A. nepalensis* were measured for diameter and height. Diameter at breast height (Dbh) was measured using diameter tape. The distance between the *A. nepalensis* pole and measurer was measured using Linear Tape. Ground slope, and top and bottom angle to the pole of *A. nepalensis* was measured using Clinometer. The information thus taken was used to

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calculate the height of the measured pole of *A. nepalensis*.

Soil Measurement

Ten pits of 40cm depth were dug for soil sample collection in the study area. For the purpose of estimating bulk density, three individual soil samples of approximately 200 cm^3, one each from two depths (0-10 cm, and 10-20 cm) were collected with the help of a standardized 200 cm^3 metal soil sampling corers. Similarly for the purpose of analysing organic carbon, three individual soil samples of approximately 100 gram, one each from two depths (0-10 cm, and 10-20 cm) were collected.

Soil samples were placed in sample bags, labelled and transported to the laboratory for further analysis.

The overall field measurement methods were guided by ANSAB[22].

Vegetation Data Analysis

The following biomass model was used to estimate aboveground pole biomass as per guidelines given in[23] on the basis of climate and forest stand type.

$AGPB = 0.0509 * \rho D^2 H$

Where,

AGPB = above ground biomass of pole (kg),

D = Diameter at Breast Height (cm),

ρ = Wood Specfic Gravity (g/cm^3)

H = Height of tree (m).

After taking the sum of all the individual weights (in kg) and dividing it by the forest area, the biomass stock density was attained in kg m^{-2}. This value was converted to t ha^{-1} by multiplying it by 10. The biomass stock density was converted to carbon stock density after multiplication with the IPCC[24] default carbon fraction of 0.47. Belowground pole biomass was estimated as 20% of aboveground pole biomass using MacDicken[25] root-to-shoot ratio value of 1:5.

Soil Data Analysis

Soil bulk density was determined using the soil core samples[26]. The soil organic carbon (SOC) concentration was determined by dry combustion of oven-dry soil samples[27].

Bulk Density of Soil = (Oven dry weight of soil in gram) / (Volume of the soil in cm^3)

Soil Organic Carbon (ton per hectare) = Organic carbon content% × soil bulk density ($gram/cm^3$) × soil layer depth (cm).

3. Results and Discussion

Biomass of *Alnus nepalensis*

The aboveground biomass and belowground biomass of *A. nepalensis* forest was found to be 62.21 t/ha and 12.44 t/ha respectively. Mean living biomass of *A. nepalensis* was found 74.65 t/ha in the forest (table 1).

Table 1. Biomass of *Alnus nepalensis*

Species	Aboveground biomass(t/ha)	Belowground biomass (t/ha)	Net biomass (t/ha)
Alnus nepalensis	62.21	12.44	74.65

Ranabhat et al.[28] found 91.92 t/ha living biomass in *A. nepalensis* forest in Kaski district of Nepal at altitude range of 1200-1300 m. This study found 74.65t/ha living biomass in *A. nepalensis* forest, the slight fluctuation can be referred to the absence of tree size of the species in the area and altitudinal variation.

Organic Carbon in Biomass of *Alnus nepalensis* Forest

The organic carbon content in aboveground and belowground biomass of *A. nepalensis* forest was 29.24 t/ha and 5.85 t/ha respectively. Mean organic carbon content in living biomass of *A. nepalensis* was found 35.09 t/ha in the forest (table 2).

Table 2. Vegetation carbon content of *Alnus nepalensis*

Species	Aboveground biomass carbon (t/ha)	Belowground biomass carbon (t/ha)	Net biomass carbon (t/ha)
Alnus nepalensis	29.24	5.85	35.09

Ranabhat et al.[28] found 39 t/ha organic carbon in living biomass of *A. nepalensis* forest in Kaski district of Nepal at altitude range 1200-1300 m. This study found 35.09 t/ha organic carbon in living biomass in *A. nepalensis* forest, the slight fluctuation can be referred to the absence of tree size of the species in the area and altitudinal variation.

Soil Bulk Density

Soil bulk densities in soil depths 0-10 cm and 10-20 cm were 0.69 g/cm^3 and 1.14 g/cm^3 respectively (table 3). The soil density was found increasing with depth.

Organic Carbon Content in Soil

Organic carbon content in soil depths 0-10 cm and 10-20cm in *A. nepalensis* forest were 2.91% and 0.99% respectively. The mean organic carbon content up to 20 cm soil depth was 1.95%. Mean organic carbon stock in soil depths 0-10cm and 10-20 cm were 19.78 t/ha and 10.61 t/ha respectively, which differs significantly at 0.5% level of significance in ANOVA test. The mean organic carbon stock upto 20cm soil depth was 15.20 t/ha (table 3).

Table 3. Organic carbon and density status of soils in Alnus nepalensis forest

Organic carbon and density status of soils in *A. nepalensis* forest			
Soil depths (cm)	Organic carbon (%)	Bulk density (gm/cm^3)	Organic carbon stock (t/ha)
0-10cm	2.91	0.69	19.78
10-20cm	0.99	1.14	10.61
Mean	1.95	0.91	15.19

The soil organic carbon was found decreasing with soil depth.

Ranabhat et al.[28] found 43.3 t/ha organic carbon in soil upto 20cm depth of *A. nepalensis* forest in Kaski district of Nepal at altitude range 1200-1300 m. The slight fluctuation can be referred to the absence of tree size of the species in the area, limited litter deposition, decomposition and altitudinal variation.

Total Carbon Stock Measurement

Total organic carbon content in aboveground and below ground biomass in *A. nepalensis* forest was 29.24 t/ha and 5.85 t/ha respectively. Soil organic carbon stock was found 15.19 t/ha in the forest. Total organic carbon stock in the *A. nepalensis* forest was found 50.28t/ha (table 4).

Ranabhat et al.[28] estimated the total carbon sequestration potential of *A. nepalensis* forest to be 186.05 t/ha. In that case, the soil organic carbon was estimated upto 1m soil depth. The variation of the total organic carbon stock in the forest can be attributed to the variation in the site conditions, vegetation maturity level, soil profile depth for carbon estimation and altitude,

Table 4. Carbon stock in *Alnus nepalensis* forest

Organic Carbon Stock (t/ha)				
Species	In above ground biomass	In belowground biomass	In soil	Total Carbon Stock
Alnus nepalensis	29.24	5.85	15.19	50.28

4. Conclusions

A comparison of the organic carbon stock values in soils of *A. nepalensis* forest show that the carbon stock tonnes per hectare decrease with soil depth upto 20cm from the ground level. The organic carbon content in living biomass of *A. nepalensis* was found around double than the total soil organic carbon content upto 20cm depth. Total organic carbon stock in the *A. nepalensis* forest was found 50.28 t/ha. Further studies on soil organic carbon in deep soil layers and *A. nepalensis* forest of varying age class are highly recommended for generalization of the findings.

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