Original Research Article

SOIL PHYSICO-CHEMICAL PROPERTIES IN DIFFERENT FORESTS OF TEHRI & PAURI-GARHWAL HIMALAYAS, UTTARAKHAND, INDIA.

ABSTRACT

Garhwal Himalaya is ~~the~~ part of the Himalayan biodiversity hotspot and represents the westernHimalayan landscape of the Indian Himalayas. The present investigation aimedto analyse soil properties in different forest areas across different altitudes of the Garhwal Himalayas i.e., *Quercus leucotrichophora* Forest (>1900m), *Anogessious latifolia* Forest (1300m), Mixed Forest (900m) and Shrub Dominated Forest (600m). The soil's Physical and chemical properties were estimated using all standard procedures in the department laboratory. According to findings of this study high-altitude temperate *Quercus luecotrichophora* Forest has dominated in all soil properties and greater potential to store soil organic carbon stock and Nitrogen (29.64 ± 3.48 t ha^{-1}) (Nitrogen 254.22 ± 27.16 kg ha-1) than Sub – tropical *Anogeissus latifolia* Dominated Forest, Mixed Forest, Shrub Dominated Forest with values of 18.34 ± 2.90, 14.52 ± 2.27 and 10.74 ± 1.57 t ha^{-1}.

Keywords: Garhwal Himalaya, *Quercus luecotrichophora*, *Anogeissus latifolia*, Forests, Carbon sink, Climate change, Soil Physico-Chemical properties

1. INTRODUCTION

The Himalayas are the richest diverse and most fragile forest ecosystem, with tropical forests to alpine forests. Garhwal Himalayas are situated in the western part of the Central Himalayas witha wide altitudinal gradient range and rich biodiversity, making it interesting for

~~the~~research studies (Donald *et al.,* 1997), and have great potential to sequestrate carbon and mitigate climate change.

Vegetation plays an important role in soil formation. The vegetation enhances the aeration, hydraulic conductivity, water-holding capacity, soil structure, and infiltration rate (Iiorkar and Toley, 2001).

Forests play an important role in soil formation and also influence physicochemical characteristics. The forest soil influences the composition of the forest stand, ground cover, rate of tree growth, and other variables. Forest soil's physiochemical properties vary through time and place because of changes in terrain, climate, physical weathering processes, plant cover, microbiological activity, and a number of other biotic and abiotic factors. Soil gets colourthroughprocesses called lithochromatic and pseudo-achromatic processes. Soil colour is influenced by its mineral composition, organic matter, water content, and other factors. The soils with high calcium content are ~~in~~ white to grey colour and soils withhigh iron content are in red-brown to black coloured.

Plant tissues (aboveground and belowground detritus) are the main source of soil organic matter (SOM), influencingphysicochemical characteristics. Soil organic carbon depends on organic matter availability in the soil, and it is an important factor inindicating soil quality, and productivity. The plants greatly influence the soil's physical and chemical characteristics (Shameem *et al.,* 2011). Soil organic carbon (soc) sequestration is the ~~process of~~ transfer and storage of atmospheric carbon into the soil through ~~the~~ decomposition. Estimates of SOC stocks are required to assess the role of soil in the world carbon cycle (Yang *et al.,* 2007). Soil pH is the concentration of H^+ions used in the measurement. The soil pH of 5.5 – 7.0 is the optimal suitable range for most plant growth (Mc Claey*et al.,* 2017). The soil's water holding capacity (WHC) determines how much water is retained by soil particles. It is affected by soil structure and aggregate stability of the soil. Bulk density is defined as the soil mass per unit volume. It indicates the compactness of the soil and its structure. It affects root growth, proliferation, aeration, soil water regime, and biomass productivity (John *et al*.,

2001).The other soil physical properties like moisture content, texture, and soil porosity ~~is~~ influence ~~the~~ microbial activity, infiltration rate and gaseous exchange, nutrient uptake, overall plant growth, and Nutrient retention.

Soil nitrogen is available in the soil as ammoniacal, nitrate, and nitrite forms is taken up and utilized by the plants, influencing plant growth, promoting productivity, species diversity, and sustainability of forest ecosystems. It is estimated that more than 90% of the nitrogen reserves are in the soil organic pool through N mineralization. This nitrogen is a limiting factor for the productivity of forest ecosystems (Cheng *et al.,* 2016). The C:N ratio of soil refers to the proportion of carbon to nitrogen. In organic matter, carbon constantly predominates over nitrogen, the abbreviated C:N ratio is typically expressed as a single value (Flavel and Murphy, 2006). The increase in greenhouse gas emissions and climate change on earth have all eyes shifting towards mitigation activities, while forest terrestrial ecosystems are the major source of soil carbon poolsand nitrogen pools.

2. MATERIAL AND METHODS

2.1 Description of the study area

This study was carried out in the Silkakal (30°14'59.9064'' N 78° 46' 43.4676'' E), Badiyalgarh (30° 14' 20.1552'' N, 78° 48' 27.846'' E) (Tehri Garhwal) and Adwani (30° 4' 20.4924'' N, 78° 42' 58.626'' E) (Pauri Garhwal) regions of Garhwal Himalaya forest areas in districts of Tehri and Pauri of Uttarakhand, India. (**fig 1**). The present investigation includes four sites of different forest lands areas i.e., *Anogeissus latifolia* DominatedForest (ALDF: towards Silkakal), Mixed Forest Area (MF: towards Silkakal), Shrub Dominated Forest (SDF: towards Badiyalgarh) and *Quercus luecotrichophora* Forest (QLDF: Pauri, Adwani) across different altitudes ranges from **600** to **2000m asl.**The average annual rainfall is around 800 - 1500 mm and the average temperature rises to 35℃ in summers and falls to 15℃ in winters.

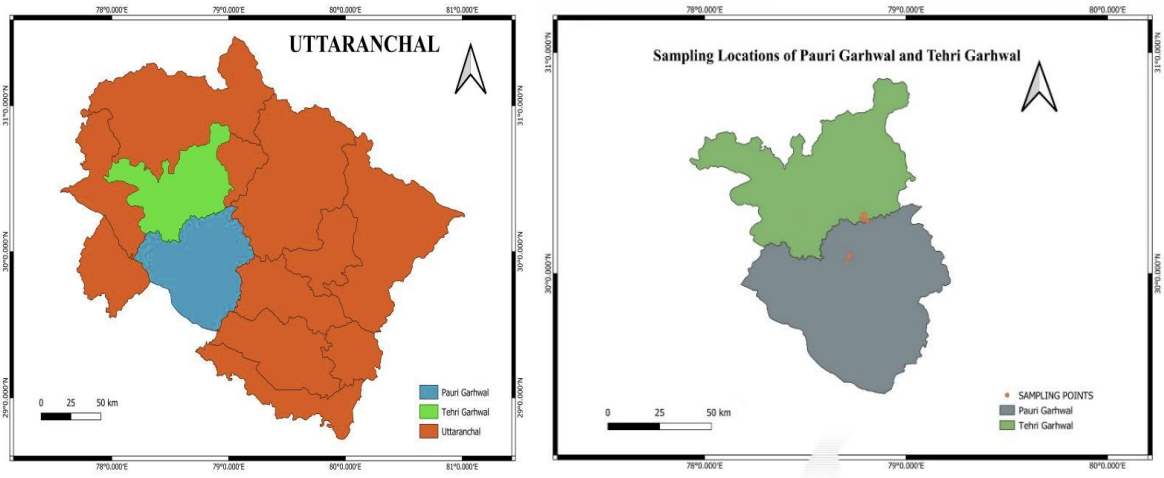

Fig.1: View of Indian state of Uttarakhand (Left) and Study area (Right)

2.2 Data Collection

The 9 Soil samples were collected from 3 sites randomly from each forest area with3 depths i.e., 0- 20cm, 20-40cm and 40-60cm. Thus, ~~A total of~~36 samples were collected from all four forest areas. The soil's physicochemical properties were analyzed using all standard procedures (**Table 1**) in the department laboratory and mean values were reported among all samples (**Table 3**, **Table 4 & Table 5**).

Table 1: Methodology used for the analysis of different soil parameters.

S No	Soil Parameter	Formula/ Method	Reference
1.	Moisture Content (%)	Fresh weight of soil (g) – dry weight of soil (g) ----------x100 Dry weight of soil (g)	Upreti, 2019
2.	Soil Texture and class	Weight of sieved soil proportion ---------- x 100 Total soil sample weight **Class:** Based on texture percentage values and assessed by using texture triangle method.	USDA, Groenendyk*et al*., 2015
3.	Soil bulk density (g/cm^3)	Dry soil weight (g)/ Soil volume (cm^3) Soil volume (cm^3) = 3.14 x radius^2 x ring height (h)	ISO, 2017
4.	Water holding capacity (%)	W2-W3-W4 ---------- x100 W3-W1	Upreti, 2019
5.	Soil pH	Determined using dynamic digital pH meter	Jackson, 1958

6.	Soil organic carbon (%)	10 (B-T) 0.003 x 100 ---------- x ---------- B weight of soil (g)	Walkley & Black, 1934
7.	SOC Stock (t ha^{-1})	Soil bulk density x Soil depth x SOC (%)	Pearson, 2007
8.	Soil Nitrogen (kg/ha^{-1})	14 x Tv x 0.02N x 2.24 x 10^6 ---------- Soil sample weight (gm) x 1000 Kg/ha x 0.4 = Kg/acre	Sáez-Plaza *et al.,*2013
9	Soil colour	Munsell colour chart	Munsell, 2010
10	Soil organic matter (SOM)	SOM% = Soil organic carbon (%) × 1.724.	Budiman *et al.,* 2020.
11	C:N ratio	The proportion of carbon to nitrogen	Flavel and Murphy, 2006

3. RESULTS AND DISCUSSION

3.1 Soil Physical Properties

3.1.1 Moisture Content (MC%)

In present study, soil MC% ranges from 1.52 ± 0.62 to 7.48 ± 2.15%. The highest MC was in Q. *leucotrichophora* dominated forest (7.48±2.15%) because of good WHC of soil and higher proportion of clay particles as well as dense forest cover and followed by forest areas of MF, ALDF and SDF with the values of 5.22 ± 0.77, 3.05 ± 0.42 and 1.52 ± 0.62 % respectively. Mahato*et al.,* 2013 reported MC of 14.39% in forest lands of the Garhwal Himalaya. Chauhan *et al.,* 2020 also reported the MC ranged from 9.01 to 16.09% in sub-tropical forest belt of the Garhwal Himalayas. These values of MC are higher than the present study

3.1.2 Water holding capacity (WHC%)

The WHC of present study ranged from 15.29 to 63.68% in different forest areas. Amongst the study sites, the highest WHC (48.63%) was found in QLDF due to good amount of clay particles and hold maximum water content in the soil which followed by ALDF, SDF and MF with the reported values of 33.71, 31.37 and 29.52% respectively, all forests types have shown moderate level of WHC. Chauhan *et al.,* 2020 also reported the values of WHC ranged from 24.84 to 55.23% in the similar *Anogeissus latifolia* forests of Garhwal

Himalayas, the present study estimates also falls within the same range. Mahato*et al.,* 2016, reported WHC value of 24.17% for the forest of Garhwal Himalaya and this value is lower than the present study.

3.1.3 Bulk Density (BD g cm^{-3})

Bulk density of the present study ranges from 0.73 ± 0.07 to 0.84 ± 0.24 (Among over all individual sample values range 0.41 to 1.06 g cm3) in different forest areas. The highest BD was found in Q. leucotrichophora dominated forest 0.84 g cm3 followed by SDF, ALDF and MF with the values of 0.79, 0.73 and 0.70 g cm3. Chauhan *et al.,* (2020) reported BD values from 0.90 to 1.06 g cm3. Bhat *et al.,* (2012) in temperate Himalayan forests reported BD ranged from 1.41 to 1.59 g cm-3. Bam and Surendra (2013) study BD of forest lands (1.0 g cm-3) and shrub lands (1.4 g cm-3). Mahato*et al.,* (2016) in the study of community managed forest reported BD of 1.29 g cm-3. All other works reported BD values were higher than the present study. It might be because of higher proportion of gravel particles which contributed more than 50% of the tested samples, where compactness of soil reduces due to presence of gravel**.**

3.1.4 Soil texture (%)

The particle of sand ranges from 51.67 (qldf) to 66.67% (mf). silt particle also ranges from 7.35 (sf) to 9.99% (aldf) and clay particle ranges from 23.58 (mf) to 39.07% (qldf). the highest proportion of soil particles was of sand followed by silt and clay in all the depths. the texture class was sandy clay loam and sandy clay. chauhan*et al.,* (2020) reported that the highest proportion reported of sand particle followed by silt and clay and texture class was sandy clay. mahato*et al.,* (2016) stated the highest proportion of sand particle followed by silt and clay. munesh*et al.* (2012) study on a. latifoila stands reported similar proportion of soil particles.

3.1.5 Texture class

A. latifolia dominated forest and mixed forest having texture classes of Sandy Clay Loam and Q. leucotrichophora dominated forest and shrub forest have Sandy Clay. The variation in texture class was not reported with the soil depths.

3.1.6 Soil Colour

Amongst the forest areas, various soil colour has been reported such as Pale Brown colour (A. latifolia dominated forest), Light Grey Colour (Mixed Forest), Yellowish Brown, Reddish Yellow & Pale Brown colour (Shrub Forest) and Brown to Yellowish Brown coloured (Q. leucotrichophora dominated forest) reported. Soil colour also used to predict the presence mineral properties of soil (**Table 2**).

Table.2 Study area forest soil colour and its mineral interpretation

Forest area	Depth (cm)	Soil colour	Mineral pigment (source USDA)
ALDF	0-20	pale brown	gypsum
	20-40	greyish brown	-
	40-60	brown	geiothite, brown
MF	0-20	light grey	quartz
	20-40	greyish brown	-
	40-60	light grey	quartz
SDF	0-20	Reddish yellow	hematite, lepidocrocite
	20-40	light yellowish brown	gypusm
	40-60	pale brown	gypsum
QLDF	0-20	brown	geothite, humus
	20-40	light yellowish brown	gypsum

3.2 Soil Physical Properties

3.2.1 Soil pH

Soil pH value ranges from 5.25 to 7.67 in the present study area. The highest (6.91) pH was found in ALDF followed by QLDF (6.69), MF (6.26) and SDF (6.02). The study revealed that the pH of all sites was Slightly Acidic. In depth wise, pH shown increasing trend with increasing depth. Chauhan et al. (2020) reported pH values ranged from 6.44 – 6.79. Mutanol*et al.,* (2016) estimated pH value of A. latifolia stands as 6.5. These values are similar to the present study. Mahato*et al.,* (2016) study on Community Forest of Garhwal

Himalaya reported pH value of 5.9. Rawat *et al.,* (2022) reported pH of 5.6. Shukla *et al.,* (2021) reported pH values from 4.86-5.16 for Mixed Forest stands & Single dominant forest (Sal, Teak), these values are quite lower of the present study.

3.2.1.1 Effect of soil pH on nutrient availability

Jackson *et al*., (2018) suggested the function of pH and the availability of vital plant nutrients (**Table 3**) are closely connected. The plants' ability to get these nutrients is correlated with varied pH conditions. With the exception of phosphorus, the macronutrients such as nitrogen, calcium, potassium, magnesium, and Sulphur are more easily obtainable in the pH range of 6.5-8. However, the micronutrients are available at a pH range of 5-7, which is slightly acidic. These are the ranges where nutrients are most readily supplied to plants in a sufficient amount. In present study, soil pH ranges from 5.25 to 7.67 i.e., slightly acidic soils which states that better availability of nutrients in soil for good plant growth in all present forest areas.

3.2.2 Soil Organic Matter (SOM%)

It was analyzed that SOM ranges from 4.79 to 0.27%. On mean the highest SOM was found in *Q. leucotrichophora* dominated forest was 2.99% followed by *A. latifolia* dominated forest, mixed forest and shrub dominated forest with the values of 2.14, 1.70 and 1.15% respectively.

3.2.3 Soil organic carbon (SOC %)

SOC % ranged from 0.67±0.32 to 1.73±0.16% (Among over all individual samples the values ranged from 0.16 to 4.08%) with the highest SOC found in QLDF (1.73 ± 0.16) followed by ALDF (1.24±0.16%), MF (0.99±0.08 %) and SDF (0.67±0.32 %). Chauhan *et al.*, (2020) reported SOC from 1.09–1.36%. Mahato*et al.,* (2016) study on Community Forest of Garhwal Himalaya reported SOC % of 1.28. Gupta and Rout (1989) study on Mixed-forest (A. latifolia &Lanneacoromandelica) reported SOC of 2.99%..

3.2.4 SOC Stock (t ha-1)

SOC stock ranges from 10.74 ± 1.57 to 29.64 ± 3.48 t ha-1 (Among over all individual sample values ranged from 2.81 to 46.70 t ha-1). The highest SOC stock was found in high altitude QLDF (29.64 ± 3.48 t ha-1) followed by ALDF, MF and SDF with values of 18.34 ± 2.90, 14.52 ± 2.27 and 10.74 ± 1.57 t ha-1. Munesh*et al.,* (2012) studied in A. latifolia forests and reported SOC stock of species Rhus parviflora (168.00 t ha−1) and Lantana camara (164.16 t ha−1). These values were higher compared to A. latifolia forest (161.28t ha−1). Shahid and Joshi *et al,*. (2018) studied that Carbon Stock Variation in Different Forest Types of Western Himalaya where carbon stock density varied between 129.81 and 136.00 Mg C ha−1. Mahato*et al.,* (2016) reported SOC stock 218.57 t ha-1 in Community Forest of Garhwal Himalaya. Sheikh *et al.,* (2011) reported 60.8-185.6 t ha-1 in Quercus of Garhwal Himalaya. The SOC stock values of all the studies were higher than the present study. Singh *et al.,* (2011) reported SOC stock of 64-72 t ha-1 in oak forest of Garhwal Himalaya. Shukla *et al.,* (2021) for mixed forest stands & Single dominant forest (Sal, Teak) estimated SOC stock of 75.9 -107.7 t ha-1. Chauhan et al. (2020) study on A. latifolia forest stands of Garhwal Himalayas reported stock of 14.94 -23.78 t ha-1 were similar to the present study.

3.2.5 Soil Nitrogen (kg ha-1)

Nitrogen ranges from 193.79±8.15 to 254.22 ± 27.16 (Among over all individual samples values ranged from 170.61 to 306.07 kg ha-1). The highest (254.22 ± 27.16 kg ha-1) nitrogen was found in QLDF followed by ALDF (205.47± 7.10 kg ha-1), MF (197.07 ± 1.50 kg ha-1) and SDF (193.79±8.15 kg ha-1). Chauhan *et al.,* (2020) study on A. latifolia forest reported soil nitrogen values from 291.64 - 323.01 kg ha-1. Rawat *et al.,* (2022) reported nitrogen of 217.38 kg ha-1 in Oak Forest. Mutanal*et al.,* (2016) study on A. latifolia forest reported nitrogen of 235.01 kg ha-1. All this studies, reported similar and close values to the present study. Shukla et al. 2021 study on Mixed Forest stands & Single dominant forest (Sal, Teak) estimated stored soil nitrogen values ranged from 210 -260 kg ha-1.

3.2.6 C:N ratio

The C:N ratio ranged from 5.54 to 11.65. The highest mean C:N ratio was found in Q. leucotrichophora dominated forest (11.65 ± 1.01) followed by A. latifolia dominated forest (8.93 ± 1.29), mixed forest (7.37 ± 0.48) and lowest shrub dominated forest (5.54 ± 0.83) respectively. Chauhan *et al.* (2020) study reported C/N ratio of < 10 within range of present study. Donald *et al*. (2011) estimated C/N ratio range of 11.6 – 45.3 in different tree species, the both N concentration and the C/N ratio was strongly related to tree species and C content. The Low C/N ratio was found in present study could be because of high soil nitrogen compared SOC. When the C:N ratio is between 1 and 15, N is quickly mineralized and released, making it available for plant uptake. The faster nitrogen is released into the soil of usage of crops with the lower the C:N ratios (Watson et al. 2002).

The Depth wise distribution of Soil Physico-chemical properties in the study area is demonstrated in the **Table.5.**

Table. 3 Mean values of soil physico- chemical properties

Physico-chemical properties of soil in different forest areas							
Parameter	**Forest area**				**Depth wise**		
	ALDF (1300m)	**MFA (900m)**	**SDF (600m)**	**QLDF (1900m)**	**0-20**	**20-40**	**40-60**
Moisture (%)	3.05 ± 0.42	5.22 ± 0.77	1.52 ± 0.62	7.48 ± 2.15	4.36± 1.14	4.9±1.51	3.67±0.78
WHC (%)	33.71 ± 4.20	29.52 ± 3.72	31.37 ± 6.58	48.63 ± 14.15	43.52 ± 3.60	33.51± 4.83	30.27± 4.46
Soil pH	6.91 ± 0.17	6.26 ± 0.07	6.02 ± 2.06	6.69 ± 2.29	6.23±0.16	6.48±0.18	6.73±0.21
SOC (%)	1.25 ± 0.16	0.99 ± 0.08	0.67 ± 0.32	1.73 ± 0.16	1.45±0.19	1.23±0.11	0.81±0.6
BD (g cm^3)	0.73 ± 0.07	0.704 ± 0.06	0.79 ± 0.18	0.84 ± 0.24	0.82±0.03	0.84±0.04	0.63±0.04
SOC Stock (t ha^{-1})	18.34 ± 2.90	14.52 ± 2.27	10.74 ± 1.57	29.64 ± 3.48	28.73± 5.20	49.29 ± 4.79	59.14 ± 1.94
Nitrogen (kg ha^{-1})	205.47 ± 7.10	197.07 ± 1.50	193.79 ± 8.15	254.22 ± 27.16	221.76 ±14	220.75± 25.40	199.26 ± 5.83
SOM (%)	2.14 ± 0.28	1.70 ± 0.14	1.15 ± 0.55	2.99 ± 0.42	2.31± 0.30	1.85±0.23	1.31± 0.21

C/N Ratio	8.93 ± 1.29	7.37 ± 0.48	5.54 ± 0.83	11.65 ± 1.01	12.95 ± 2.38	22.32 ± 2.60	29.67 ± 2.92

Table.4 Mean values of soil texture and texture classes

Particle	Forest areas			
	ALDF	MF	SDF	QLDF
Sand (%)	61.21 ± 1.27	66.67 ± 1.29	57.63 ± 2.37	51.67 ± 1.22
Silt (%)	9.99 ± 0.49	9.27 ± 1.00	7.35 ± 0.43	9.27 ± 1.03
Clay (%)	28.91 ± 1.15	23.58 ± 1.46	34.05 ± 2.52	39.07 ± 0.80
Texture class	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay	Sandy Clay
Gravel (%)	67.19 ± 0.99 (Sand, silt, clay= 32.81%)	69.46 ± 2.40 (Sand, silt, clay=30.54%)	66.92 ± 3.36 (Sand, silt, clay=33.08%)	52.13 ± 5.84 (Sand, silt, clay=47.87%)

Table.5 Depth wise distribution of soil Physico-chemical properties in the study area.

Forest area	Depth (cm)	SOC (%)	SOC stock (t ha^{-1})	Nitrogen (kg ha^{-1})	SOM (%)	BD (g cm^{-3})	Soil pH (1:2.5)	WHC (%)	Moisture (%)
ALDF (1300 m)	0-20	3.06	26.67	225.79	3.06	0.74	6.68	45.87	3.29
	20-40	2.17	19.81	210.73	2.17	0.84	6.92	31.04	3.09
	40-60	1.22	8.53	195.63	1.22	0.61	7.31	24.23	2.77
MF (900m)	0-20	2.16	39.56	199.66	2.16	0.88	6.08	43.6	6.11
	20-40	1.62	13.45	190.66	1.62	0.71	6.32	21.23	5.67
	40-60	1.34	8.05	200.7	1.34	0.52	6.38	23.23	3.88
SDF (650m)	0-20	1.41	12.68	195.68	1.41	0.75	5.8	32.32	1.14
	20-40	1.22	12.55	175.61	1.22	0.90	5.97	33.57	1.47
	40-60	0.84	6.37	210.07	0.84	0.75	6.3	28.22	1.94
QLDF (1900m)	0-20	2.62	36.44	265.92	2.62	0.94	6.37	52.29	6.88
	20-40	2.42	36.04	306.07	2.42	0.93	6.74	48.21	9.46
	40-60	2.03	16.44	190.66	2.03	0.65	6.93	45.38	6.12

Table.6 Comparative studies of earlier works

Vegetation type	**Moisture (%)**	**WHC (%)**	**BD(g cm^3)**	**Soil pH**	**SOC (%)**	**SOC Stock (t ha^{-1})**	**SOM (%)**	**Nitrogen (kg ha^{-1})**	**References**
***A. latifolia* dominated forest (**ALDF)	**3.05**	**33.71**	**0.73**	**6.91**	**1.24**	**18.34**	**2.14**	**205.47**	**Present study**
Mixed Forest (MF)	**5.22**	**29.52**	**0.70**	**6.26**	**0.99**	**14.52**	**1.70**	**197.07**	
Shrub dominated forest (SDF)	**1.52**	**31.37**	**0.79**	**6.02**	**0.67**	**10.74**	**1.15**	**193.79**	
***Q. leucotrichophora*Dominated forest (**QLDF)	**7.48**	**48.63**	**0.84**	**6.69**	**1.73**	**29.64**	**2.99**	**254.22**	
A. latifolia	-	30.90	-	-	-	161.28	-	-	Kumar et al. 2012
Shrubs forest (*Lantana camara&Rhus parviflora*)	-	-		-	-	168.00	-	-	Kumar et al. 2012
Mixed forest (*A. latifolia &Lanneacoromendalica*)		49.80	1.31	7.60	2.99	-	-	-	Gupta and Rout (1989)
A. latifolia forest	-	-	1.30	6.5	-	-	-	235.01	Mutanal et al. (2016)
Community Forest of Garhwal Himalaya	14.39	24.17	1.29	5.90	1.28	218.57	-	-	Mahato et al. (2016)
Quercus leucotrichophora forest	-	-	-	-	-	64-72	-	-	Singh et al. (2011)
Quercus leucotrichophora forest	-	-	-	-	-	60.8-185.6	-	-	Sheik et al. (2011)
Shrub land	-	-	-	6.38	2.06	-	-	-	Worku et al. (2014)
Quercus. L	-	-	-	5.6	1.95	-	-	217.38	Rawat et al.2022
Mixed forest stands & Single dominant forest (Sal, Teak)	27.01-1.03	-	-	4.86-5.16	-	75.9-107.7	-	0.21-0.26	Shukla et al. 2021

A. latifolia Forest	9.01-16.09	24.84-55.23	0.90-1.06	6.35-6.79	1.36	14.94 - 23.78	-	291.64 - 323.01	Chauhan et al. 2022
Forest land	-	-	1.00	-	-	98.01	-	-	Bam & Surendra et al. 2013
Barren land	-	-	1.2	-	-	83.6	-	-	
Agriculture land	-	-	1.4	-	-	36.6	-	-	
Shrub land	-	-	-	-	-	10.8%	-	55.9%	Wang & Kang et al. 2013
Mixed forest (*Quercus* & *Rhododendron*)	25.83	-	1.47	-	-	23.2 mg/ha	-	-	Bhat et al. 2012
Grass land	33.21	-	1.53	-	-	25.0	-	-	
Tropical forest	-	-	-	-	-	64.3	-	-	Gachhadaret al. 2022
Sub-tropical forest	--	-	-	-	-	84.4	-	-	
Mountain forest	-	-	-	-	-	95.3	-	-	
Chauras Campus (Garhwal University)	3.30 ±0.28	31.53±0.72%	1.38±0.4 g/cm^3	6.84±0.11	0.86±0.06%	302.62 t ha^{-1}		133.12±5.79	Prashanth *et al*., In Press

4. CONCLUSION

This study revealed that soil physico-chemical properties changes with different forest areas, altitude and also with soil depth. The Highest SOC and Nitrogen reported in high altitude QLDF forest area, followed by ALDF, MF, SDF. Same trend followed in almost all soil properties like MC, WHC, SOC%, SOM, Nitrogen, SOC stock), highest pH found in ALDF. Highest Bulk density was found in SDF followed by QLDF, ALDF, MF.

C/N ratio, Soil pH, Nitrogen and SOC stock was increased with increase in depth, While MC, WHC, SOM, SOC (%), BD, were found decreasing with soil depth.

This study concluded that among four different forest areas, the high-altitude temperate *Quercus luecotrichophora* Forest (QLDF) has greater potential to store soil organic carbon stock and Nitrogen than Sub – tropical *Anogeissus latifolia* Dominated Forest (ALDF), Mixed Forest (MF), Shrub Dominated Forest (SDF). In almost all other soil properties are dominated by *Quercus luecotrichophora* Forest followed by *Anogeissus latifolia* Dominated Forest, Mixed Forest, Shrub Dominated Forest. This study revealed the carbon sequestrating potential of four major Himalayan region forest types and their key role to combat the climate change.

CONSENT

I on behalf of all authors confirms that all authors are read the copy of this manuscript and all authors are approved for submission of this manuscript.

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DEFINITIONS, ACRONYMS, ABBREVIATIONS

Here is the Definitions section. This is an optional section.
Term: Definition for the term