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Soil carbon pools of bamboo forests of Mizoram, India

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Abstract

Soil carbon is an important aspect of soil fertility and represents a major reservoir of terrestrial carbon pool globally. The amount of soil carbon was estimated in bamboo forests of five administrative districts which account for more than 80% of the bamboo growing areas of Mizoram. The soil carbon pool of the study area ranged from 51.914 Mg ha^{-1} to 84.2352 Mg ha^{-1}. Maximum soil carbon pool, 84.2352 Mg ha^{-1} was recorded in Mamit district and minimum in Serchhip district (51.914 Mg ha^{-1}). The major differences in soil carbon pool in different districts of Mizoram may be attributed to the local habitat quality and climatic conditions.

Key words: Bamboo forest; soil carbon pool; Mizoram.

Introduction

Among terrestrial ecosystems, forests play the most significant role in the global carbon (C) cycling by sequestering ~ 60 - 80% of the global terrestrial C pool, of which bulk (~70%) of C is stored in the soil,[1,2] and remaining in vegetation. Forest soils have been reported to accumulate considerably higher C than other land uses such as savannas and agro-ecosystems and thus a small alteration in soil may lead to a considerable change in atmospheric CO_2 concentration.[3,4] Geographically, tropical forests are among the dominant forest ecosystems constituting about half of the world's forest area and storing 46% of the world's living terrestrial C pool and 11% of the world's soil C pool.[5] Because of huge potential to sequester and store large quantities of C, these forests are considered as the major resource for climate change mitigation.[6] In Indian tropical regions, the occurrence of extensive landscape transformations from natural forests to degraded landforms is accompanied by changes in soil structure and quality[7] due to opening up of crown cover, decreased soil organic matter content and reduced efficiency of nutrient cycling.[8-10]

North-eastern part of India is characterized by shifting cultivation practice where the piece of forest land is slashed and burned after drying and then cultivated for various crops for 1-2 years followed by a fallow period. Earlier fallow period was sufficiently prolonged (20-30 years) to sequester huge C in the system, however, as result of increasing population fallow period has

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been considerably decreased (<5 years) and thus leading fragile ecosystem characterized by less C stock in the vegetation and soil. Various species of bamboos are widely distributed in northeastern part of the country. Bamboos are occurring in pure patches and mixed with natural forests. The species of bamboo also grows well on degraded lands or fallow lands. Due to high growth rate the species has considerable ability to sequester C in soil and vegetation. Different forest management systems and activities such as crop rotation, harvesting practices, site preparation, fertilization etc. interfere more or less strongly with soil organic carbon.[9,10]

Ecological benefits of bamboo are numerous. It has been reported that bamboo conserves soil moisture and mitigates the adverse drought effect on flora and fauna.[11] The soils under different bamboo species show wide variation in chemical characteristics and assume greater significance on account of the shallow root system of the species. Bamboo's fast growth is one of its many attributes which make it a useful resource for mankind. It is also commonly seen as an indication of a high ability to capture and sequester atmospheric carbon and consequently mitigate climate change, in a similar way that trees do.[13]

In Mizoram the total bamboo cover is about 7091.66 sq. Km, which is about 33% of the total geographical land of the state.[14] Bamboo is distributed thoroughly between 400 m and 1520 m above mean sea level. Out of the 150 bamboo species in India, more than 58 species occur in the North-East India, of which 22 species have been recorded in Mizoram.[15,16] A recently concluded survey reported that 35 species of bamboo have been found in Mizoram including indigenous as well as introduced species[17] in which two newly discovered endemic species *Bambusa mizorameana* (Naithani) and *Bambusa dampaeana* (Naithani) were recorded. This study was conducted to estimate the soil organic carbon in bamboo stands of five districts of Mizoram.

Materials and Method

Five administrative districts namely Aizawl, Lunglei, Mamit, Kolasib and Serchhip districts of Mizoram, un-arguably the major bamboo growing districts in the states were selected for the study. The area under Bamboo and growing stocks are given in Table 1.

The study area comprises of 12,944.17 km^2 which is 61.4% of the total geographical area of the state; 78.72% of the total bamboo growing area of the state, which is 5583.16 km^2 and this accounted for 78.27% of the total bamboo growing stock in the state.

Since the input of organic matter is largely from the aboveground litters, soil organic matters tend to concentrate in the upper soil horizon.[18] The carbon held in the upper profile is often the most chemically decomposable and the most directly exposed to natural and anthropogenic disturbances.[19] Therefore, in this study, soil samples were collected to a depth of 30 cm.

Soil samples were randomly collected, for analysis of soil organic carbon content, from the bamboo stands of each five districts. After removing of forest litters, a pit was dug and soil

Table 1. Major bamboo growing districts in Mizoram.

Districts	Geographical Area (km^2)	Bamboo Area (km^2)	Total No. of Culms	Total Growing stocks ('000 tonnes)
Aizawl	2576.31	927.69	1020.94	4003.517
Kolasib	1382.51	661.8	714.1	2800.293
Lunglei	4538	1956.59	1557.85	6108.97
Mamit	3025.75	1598	1061.89	4164.116
Serchhip	1421.6	439.08	438.66	1720.158

(Source: MIRSAC, 2008)

Equation for SOC (IPCC, 2003)

$$SOC = \sum_{horizon=1}^{horizon=n} SOC_{horizon} = \sum_{horizon=1}^{horizon=n} ([SOC] \bullet BulkDensity \bullet Depth \bullet (1 - frag) \bullet 10)_{horizon}$$

Where, SOC = representative soil organic carbon content for the forest type and soil of interest, tonnes C ha^{-1}
$SOC_{horizon}$ = Soil organic carbon content for a constituent soil horizon, tonnes C ha^{-1}
[SOC] = concentration of soil organic carbon in a given soil mass obtained from lab analyses, g C (kg soil)$^{-1}$
Bulk Density = soil mass per sample volume, tonnes soil m^{-3} (equivalent to Mg m^{-3})
Depth = horizon depth or thickness of soil layer, m
frag = % volume of coarse fragments/100, dimensionless

samples were collected from three horizons, at a depth of 0–10 cm, 10–20 cm and 20–30 cm. The collected samples were packed in an air tight plastic bag and transferred to the laboratory for further examination. The samples were air-dried, ground and sieved through 100mm sieve. Euro EA Elemental Analyzer (CHN-OS) was used for determining the carbon content of the samples at the Central Instrumentation Laboratory, Mizoram University.

Results and Discussions

The soil Carbon pool of bamboo areas of different districts is presented in Table 2. Among the five districts, maximum C pool (84.2352 Mg ha^{-1}) was estimated from Mamit district followed by Kolasib district having a value of 65.81 Mg ha^{-1} whereas the minimum C pool was estimated from Serchhip district (51.914 Mg ha^{-1})

In terms of horizon, C pool was estimated to be maximum at the 0–10 cm horizon in each district. Among which, the Kolasib district has the maximum C pool in the 0–10 cm horizon. Minimum carbon pool was estimated from 20–30 cm horizon in each district. The district wise C pool, soil carbon content and bulk densities are given in Fig. 1.

Even though the soil carbon concentration is high in the Serchhip district (1.713%); higher than Aizawl (1.49%) and Lunglei (1.34%), the total soil carbon pool is the lowest. This may be attributed to the lower bulk density of soil in the Serchhip district and higher in Aizawl and Lunglei district. There is a high soil carbon pool variation in the *Dendrocalamus longispathus* forest of Mamit and Kolasib districts, that is, 84.2352 Mg ha^{-1} and 65.82507 Mg ha^{-1} respectively. Significant difference in the bulk density of soil is observed from these two bamboo forests. Low carbon concentration in the bamboo forest of Lunglei may be attributed to the age factor of the bamboo forest and the management systems. The sampled plots of bamboo forest in Lunglei districts were prone to disturbances due to harvesting and other human activities.

Bulk density is an important factor affecting the soil carbon pool of an area. The bulk density of soil reflects the soil's ability to function for structural support, water and solute movement, and soil aeration. High bulk density of soil may reduce root growth, and poor movement of air and water through the soil. Apart from natural phenomenon like temperature and precipitation, major factor influencing the bulk density of soil is the management system of the soil. Improving of soil structures decreases soil compaction, even though it might be temporary. It was observed the coefficient of determination, R^2 between Bulk density and Carbon content for the sampled area was 0.869, which is highly significant (Fig. 2). Decrease in soil compaction is required for having a higher concentration of carbon in the soil.

Moisture and temperature play a major role in the global carbon cycle. The stocks of organic matter in soils result from the balance between inputs and outputs of carbon within the below-

Table 2. Soil carbon pool (up to 30 cm depth) of Bamboo forest of different districts of Mizoram.

Sl. No.	Site	Horizon cm	Bulk Density g cm^{-3}	Depth cm	C%	C pool Mg ha^{-1}
1	Aizawl	0 – 10	1.34	10	1.81	24.254
		10 – 20	1.34	10	1.453	19.4702
		20 – 30	1.34	10	1.213333	16.25867
		0 – 30	1.34	30	1.492111	59.98287
2	Lunglei	0 – 10	1.3	10	1.59	20.67
		10 – 20	1.3	10	1.3	16.9
		20 – 30	1.3	10	1.159	15.067
		0 – 30	1.3	30	1.349667	52.637
3	Serchhip	0 – 10	1.01	10	2.47	24.947
		10 – 20	1.01	10	1.42	14.342
		20 – 30	1.01	10	1.25	12.625
		0 – 30	1.01	30	1.713333	51.914
4	Kolasib	0 – 10	1.04	10	2.89	30.056
		10 – 20	1.04	10	1.840333	19.13947
		20 – 30	1.04	10	1.599	16.6296
		0 – 30	1.04	30	2.109778	65.82507
5	Mamit	0 – 10	1.12	10	2.507	28.0784
		10 – 20	1.12	10	1.91	21.392
		20 – 30	1.12	10	1.763	19.7456
		0 – 30	1.12	30	2.507	84.2352

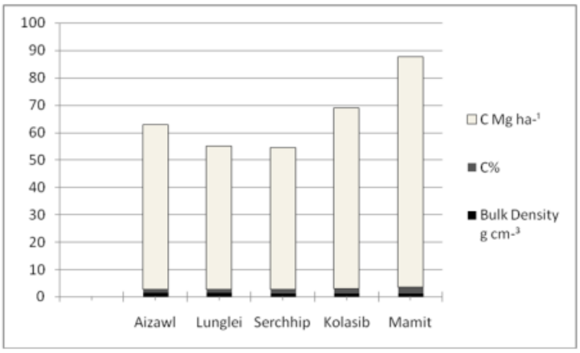

Figure 1. Bulk density, soil carbon concentration and Soil carbon pool.

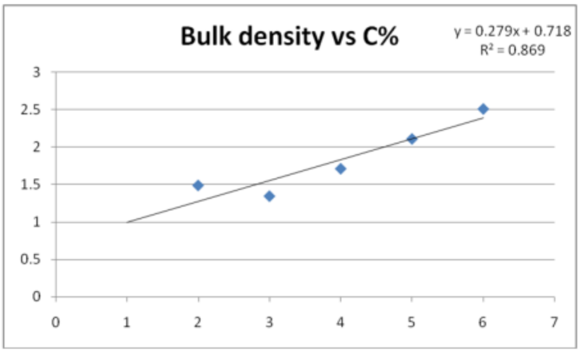

Figure 2. Coefficient of determination between bulk density and carbon concentration of soil.

ground environment.[20] The production of soil carbon is almost entirely from root respiration and microbial decomposition of organic matters. These processes are temperature-dependent as found in all chemical and biochemical reactions. Root respiration and microbial decomposition are also subjected to water limitation.

Understanding the role of bamboo in Carbon sequestration is important under the global background of advocating low carbon economy. The difference in soil carbon pool in different districts of Mizoram may be attributed to the local habitat quality, climatic conditions and the bamboo management practices.

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