Variations in soil organic carbon and litter decomposition across different tropical vegetal covers

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The present study shows variations in soil organic carbon (SOC) and litter decomposition across different vegetal covers. Tropical vegetal covers occupied by teak, bamboo and mixed species were used for the study. SOC was analysed in the soils up to a depth of 1.25 m at different intervals. Physical fractionation was done in the collected soil samples. Respiration was measured in the soils of the three types in summer, monsoon and winter. Litter-bag experiment was carried out to understand the process of decomposition in the three types of litter at three different depths, viz. top, 25 cm and 50 cm. SOC values from the three different types of vegetal cover showed significant differences. The annual fall of leaf-litter was maximum in mixed vegetal cover followed by teak and bamboo. Litter-bag experiment showed that the litter got decomposed within a year on storage. Higher soil respiration in all the three vegetal covers supports faster rates of decomposition. The decomposition was faster in bags kept at the top layers of the soil compared to the ones in the deeper layers. There was an increase in SOC of samples from the litter-bag study, indicating that tropical soils can absorb additional carbon. Physical fractionation of SOC showed uniformity in the proportions of mobile and recalcitrant pools across soil profiles of the three vegetal covers. A proton NMR study carried out to understand the chemical nature of SOC revealed complete absence of carboxyl group, whose presence is generally reported in the SOC of temperate soils. The groups observed were alkyl, *O*-alkyl and aromatic. Fluctuations were seen in the proportion of alkyl groups. Uniformity seen in the chemical composition of SOC from the proton NMR study revealed that barring initial steps, decomposition of organic matter would follow more or less the same path in tropical soils, irrespective of differences in plant litter.

Keywords: Litter decomposition, physical fractionation, soil organic carbon, soil respiration, tropical vegetal cover.

FOREST soils are regarded as one of the major sinks of carbon. Different explanations are offered for the movement of carbon in these soils. Decomposition and movement of soil organic carbon (SOC) is explained as a mechanistic process[1–3], negative exponential model and first-order kinetics[4–6] with global constants for rates of decomposition[7]. Influences of variation in the proportion, composition and type of vegetal cover on carbon sink potential of soils have been looked into. An earlier study[8] mentioned that under the 'business as usual' scenario, the terrestrial biosphere acts as an overall carbon sink until about 2050, but turns into a source thereafter. Variations in the accumulation of carbon by young and old-growth forests have been reported[9–11]. Influences of land-use change on the dynamics of soil organic matter were reported[12–14]. Most of these changes are because of variation in plant cover. In spite of all these studies, conceptual clarity is still elusive for the role of vegetal cover and litter decomposition on the sink potential of soils. A better understanding of the tropical forest carbon dynamics is clearly needed to predict the future trajectory of carbon stocks under global change[15–18]. Improved monitoring and modelling of the tropical environment is required to better understand this trajectory[19]. Physical and chemical fractionation studies categorized SOC into a mobile and a recalcitrant pool[1,13,20]. The mobile pool is a dynamic one, whereas the recalcitrant pool is said to be stable for longer periods of time. Evaluation of the chemical nature of recalcitrant pools is gaining prominence[2,21,22]. Quantity and chemical quality of these pools is largely influenced by the type of plant litter and its pattern of decomposition. Currently little information is available for *in situ* litter decomposition in tropical soils. The stability and residence times of SOC present in the deeper layers when fresh organic matter (litter) is added is unclear. Chemical break-up of SOC present in the deeper layers of tropical soils is not available.

The probability of the soil turning into a source from a sink increases once its vegetal cover is altered. We presume that (i) as long as the land-use pattern remains unaltered, the soil remains a sink rather than a source to whatever small extent it may be and (ii) the potential of addition of soil carbon in the tropics is much higher than what it is understood to be. Another aspect that is said to be altering the sink status of soils is the stimulation of microbial mineralization by the supply of carbon derived

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from fresh plant to the sub-soil[23]. Keeping these aspects as a background, the present study was carried out to answer the following questions:

- Is the movement of carbon the same across different vegetal covers at different depths of soil? Is there variation in SOC?
- How does fresh organic carbon supply influence different pools of carbon in a soil profile?
- Are the proportions of labile and recalcitrant pools the same across soils of different vegetal covers? If so, is their chemical composition similar?

Materials and methods

Study area

The area chosen for the present study was the Shoolpaneswar Wildlife Sanctuary (SWS; lat. 21°29′–21°52′N and long. 73°29′–73°54′E), Narmada District, Gujarat, India, and spread over an area of 656 sq. km. According to the Holdridge life-zone system of classification, the vegetal cover falls under tropical dry forest. It receives an annual rainfall in the range 900–1200 mm. Rainfall is restricted to June–October. Other months are dry without precipitation. Minimum temperature recorded in winter is 8°C and maximum temperature recorded in summer is 42°C. Humidity levels are maximum during monsoon (June–October) and range from 15% to 30% (dry environment) for the rest of the year. Soils at the study sites are classified as Entisols[24]. They are light grey, greyish-brown and reddish-brown in colour. Alluvium deposits of clay–loam type are also seen with light brown to grey/black colour (Gujarat State Forest Department, unpublished data). Soils are slightly acidic with pH ranging from 6.60 to 6.96 and with small variations at different depths. Bulk density of the soils at different depths ranges from 1.14 g cm^{-3} at surface to 1.39 g cm^{-3} at 1.25 m.

Vegetation

Vegetal cover is dominated by *Tectona grandis* L. (teak) and *Dendrocalamus strictus* Nees. (bamboo). Both of these are spread across vast areas. Rest of the area is occupied by a variety of trees such as *Mangifera indica*, *Madhuca indica*, *Terminalia bellirica*, *Pongamia pinnata*, *Wrightia tinctoria*, *Morus alba* and *Bauhinia racemosa*. All the trees have broad leaves. Tribal settlements are also seen in the study area with restricted agricultural activity. Density of vegetation in the sanctuary is ~650 ha^{-1} teak trees, ~350 ha^{-1} bamboo clumps and ~650 ha^{-1} mixed trees. The average age of the trees is ~60 yrs (unpublished records). Most of the vegetation is deciduous in nature. Foliage of canopy gets replaced every year. Herbaceous cover or floor cover begins to develop in the monsoon season (June) and is complete by January or February. Three types of vegetal cover were chosen to understand their influence on soil carbon. One is predominantly occupied by teak, the second by Bamboo and the third by mixed trees.

Soil sampling and analysis

Soil samples were selected by composite sampling. Five points were identified for soil collection in each locality. Samples were taken as follows: seven samples at 2 cm interval up to a depth of 14 cm; three samples beyond 14 cm and up to 30 cm at 5 cm intervals; four samples beyond 30 cm and up to 90 cm at 15 cm intervals; one sample beyond 90 cm but below 100 cm, and one sample beyond 100 cm but below 1.25 m. Soil samples from all the layers of five different points were pooled and labelled as a composite sample. Three composite samples per vegetal cover with a distance of 10 km between any two were collected. Samples were brought to the laboratory in sealed bags, air-dried and processed for SOC estimation[25]. Prior to SOC estimation, coarse biomass was removed and the sample was passed through a 2 mm sieve. Sampling was done twice a year for two successive years, one prior to the monsoon (April) and the other after the monsoon (October), and SOC was estimated.

Physical fractionation

Physical fractionation of the soil samples was done following the method of Six *et al.*[26]. Briefly, the samples were screened for removal of roots and debris by passing through a 2 mm sieve. Air-dried samples (100 g) were submerged in water for 30 min and then subjected to wet-sieving. Samples were physically fractionated into two different pools, one > 250–2000 μm and the other < 250 μm by passing through 250 μm-size sieve and SOC was estimated for the fractions. Fractionated sample > 250–2000 μm was designated as the mobile pool (pool 1) and the < 250 μm size faction was designated as the recalcitrant pool (pool 2). These designations were made on the basis of variation in the rate of SOC decomposition present in these two particle sizes. Similar references have been made earlier[27–29].

Litter collection

Litter was collected at quarterly intervals for one year. At each time of sampling 1 m^2 quadrats were randomly laid on the forest floor. The litters that fell in those areas were picked up, oven-dried and their dry weights were measured. At each site five to eight quadrats were laid. Extreme values were discarded while pooling the data. It was ensured that there was no repetition of areas. About

85–90% of the litter consisted of leaves. The rest consisted of dried twigs. The measurement for each vegetal cover is the average of all these measurements.

Soil respiration

Soil respiration was measured in the field using an alkali absorption method[30] in three different seasons (summer, monsoon and winter). All the plant parts were cleared before the measurement. Briefly, five cylindrical plastic chambers (of 18 cm diameter and 20 cm height) were randomly placed in teak, bamboo and mixed vegetal cover sites. Each of them was inserted to a depth of 3 cm into the soil surface. CO_2 efflux was collected in small plastic chambers with 20 ml 1 M NaOH over a 24 h period. The amount of CO_2 absorbed was estimated by titrating with 1 M HCl using phenolphthalein as an indicator. Values presented are averages of the five samples taken at each site during each season.

Litter bag experiment

Litter decomposition was monitored using the litter-bag experiment. Litter bags having perforations of different sizes on two sides were used. Litter bags consisted of a 0.5 mm mesh at the bottom and 1 mm mesh at the top. Three bags were kept for each type of leaf-litter at each depth. A total of 135 litter bags were used for this experiment. Each litter bag was filled with 50 g of air-dried litter (only leaves) collected from the floors of teak, bamboo and mixed vegetation. These bags were placed at 2–5 cm, 22–25 cm and 47–50 cm depth with minimum possible disturbance. To understand the microorganism specificity towards litter, samples of bamboo and teak were interchanged between the two vegetal covers and kept at the same depth at different points. Litter bags were exhumed carefully at the three intervals of 90, 220 and 320 days, and the samples were carefully transported to the laboratory. Litter left in the bags was carefully picked up taking due care to see that it was not mixed with the soil and weighed after air-drying. Soil samples also were taken every time from the vicinity of the litter bags to observe variations in SOC content. SOC was estimated in all these samples.

NMR study

Air-dried soil samples at the two different depths of 0–2 and 12–14 cm of teak and bamboo were screened for any remnants of root/leaf material by passing through a 2 mm sieve. Known amounts (40–60 g) of soil were weighed and SOC was extracted by magnetically stirring the soil samples continuously for 1 h in a mixture of methanol and chloroform (50 : 50). The samples were allowed to settle and subsequently filtered through Whatman filter paper. Methanol : chloroform extract was evaporated to dryness under liquid nitrogen. Then 3–5 mg of this dried sample was solubilized in a deuterated solvent. Solubilized samples were subjected to NMR analysis using a Bruker 400 MHz Proton (^1H) NMR spectrophotometer (Bruker Instruments Inc., Karlsruhe, Germany). Spectra were classified into the chemical-shift regions: 0.5–2 ppm alkyl group; 3–5 ppm *O*-alkyl; 7–8 ppm aromatic and 10–12 ppm carboxyl group[31].

Statistical analysis

All the data generated were pooled and averages were calculated. ANOVA (two-way) was carried out on the SOC data, litter-fall values, litter-bag experiment data and soil respiration values.

Results

Soil organic carbon

SOC values from the three different vegetal cover types showed significant differences (Table 1). Differences across soil depths and between types of vegetal cover were found to be significant ($P < 0.01$). SOC content was high in the top layers and decreased with increasing depth. The decrease was gradual. At deeper layers (60–75 cm onwards), SOC content was more in teak than that in bamboo and mixed vegetation.

Litter fall

Values of litter fall were different and were relatively higher (Figure 1). Litter-fall data (Figure 1) showed signi-

Table 1. Soil organic carbon (SOC) content (g kg^{-1}) from three different vegetal covers at different depths (mean ± SE)

Depth (cm)	Teak	Bamboo	Mixed cover
0–2	33.7 ± 0.15	30.8 ± 0.13	30.8 ± 0.23
2–4	31.4 ± 1.13	30.8 ± 0.11	30.4 ± 0.39
4–6	28.1 ± 0.14	29.8 ± 0.09	28.3 ± 0.16
6–8	26.2 ± 0.13	28.5 ± 0.12	28.3 ± 0.13
8–10	25.4 ± 0.12	27.1 ± 0.11	26.7 ± 0.12
10–12	25.3 ± 0.12	24.6 ± 0.10	22.9 ± 0.12
12–14	23.5 ± 0.11	24.4 ± 0.09	19.8 ± 0.11
15–20	22.2 ± 0.13	24.5 ± 0.08	18.8 ± 0.08
20–25	21.6 ± 0.13	23.8 ± 0.07	18.4 ± 0.10
25–30	18.9 ± 0.14	23.3 ± 0.06	14.0 ± 0.09
30–45	16.0 ± 0.12	21.2 ± 0.11	13.8 ± 0.08
45–60	15.1 ± 0.08	15.4 ± 0.13	9.7 ± 0.08
60–75	12.2 ± 0.08	8.0 ± 0.14	8.9 ± 0.06
75–90	10.1 ± 0.09	7.1 ± 0.08	7.9 ± 0.06
90–100	9.3 ± 0.07	6.8 ± 0.07	6.5 ± 0.04
100–125	8.1 ± 0.08	6.6 ± 0.107	6.5 ± 0.05

Table 2. Mass remaining and loss (%) of three types of litter in three different site covers at three different depths (cm), after 90, 220 and 320 days ($n = 3$)

		Days								
		90			220			320		
Vegetal cover	Litter	Top (cm)	25 (cm)	50 (cm)	Top (cm)	25 (cm)	50 (cm)	Top (cm)	25 (cm)	50 (cm)
Teak	Remained	20	86	90	16	70	66	3	1	2
	Decomposed	80	14	10	84	30	34	97	99	98
Bamboo	Remained	76	76	60	64	54	60	28	43	56
	Decomposed	24	24	40	36	46	40	72	57	44
Mixed	Remained	14	60	92	14	24	30	12	6	4
	Decomposed	86	40	08	86	76	70	88	94	96
Bamboo litter in teak site	Remained	90	92	96	80	68	88	24	32	28
	Decomposed	10	08	04	20	32	12	76	68	72
Teak litter in bamboo site	Remained	88	90	88	84	76	70	62	32	34
	Decomposed	12	10	12	16	24	30	38	68	66

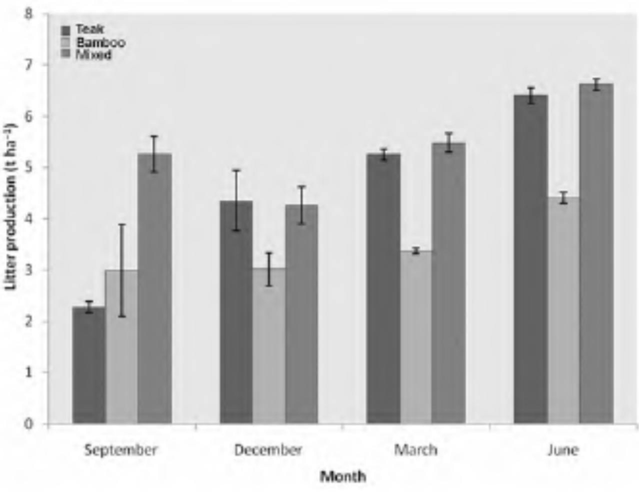

Figure 1. Litter production (t ha^{-1}) in three different stands with standard error bars ($n = 5$).

ficant ($P < 0.01$) differences between the types of vegetal cover and different periods of litter collection. There was a gradual increase in the litter-fall values of teak and bamboo. The increase was much higher in teak. Spikes in the litter-fall values of teak and bamboo clearly revealed the deciduous nature of both the species. Mixed cover showed a different pattern as it had several evergreen species as well. Annual leaf-litter addition was maximum in mixed species followed by that in teak and bamboo.

Litter decomposition

Litter-bag experiments showed near completion in the decomposition of litter kept within a year (Table 2). There was a difference in the decomposition of litter kept at different depths. Influence of plant trait variation could be seen in the rate of decomposition. The decomposition was faster in teak and mixed cover than in bamboo. Differences in the decomposition of litter for different types of leaf material at different depths in the soil were found to be significant ($P < 0.01$). The one kept at the top of the soil got decomposed to a maximum extent in the first 90 days, whereas the proportion was less at the other two depths (Table 2). At the end of 320 days decomposition was maximum at all the depths (Table 2). At the site where litter bags were exchanged between vegetal covers (teak litter bag in bamboo cover and vice versa), initially (at 90 days) the decrease was less, but as time progressed the proportion of decomposed material was almost similar (at 320 days) to the previous experiment (Table 2).

SOC pools

Proportions of pool size (pools 1 and 2) in the composite samples from the three vegetal covers remained almost the same (5–20% for pool 1 and 95–80% for pool 2) at different depths (Table 3). Variation in vegetal cover showed minimal impact. Increase in SOC content of soils from the litter-bag experiment was mostly in the range 7–27% (Figure 2). Physical fractionation of soils collected from the litter-bag experiment showed a small increase in pools 1 and 2. Increase was in the range 10–20% and 5–10% for pools 1 and 2 respectively. Relative increase was more in the lower layers compared to the top layers.

Soil respiration

Soil respiration values (Figure 3) of the three vegetal covers were relatively higher. ANOVA values were significant ($P < 0.05$). Both teak and bamboo showed similar patterns in their values, high during monsoon and low in

Table 3. SOC content (g kg^{-1}) in pool 1 (>250–2000 μm) and pool 2 (<250 μm) of three different vegetal covers soils with different depths (mean ± SE)

	Teak		Bamboo		Mixed cover	
Depth (cm)	Pool 1	Pool 2	Pool 1	Pool 2	Pool 1	Pool 2
0–2	4.1 ± 0.14	29.43 ± 0.21	5.65 ± 0.09	24.52 ± 0.12	5.49 ± 0.16	17.56 ± 0.06
2–4	1.2 ± 0.17	27.51 ± 0.15	3.01 ± 0.06	26.88 ± 0.13	2.05 ± 0.12	25.09 ± 0.08
4–6	0.7 ± 0.05	25.80 ± 0.17	1.83 ± 0.07	26.84 ± 0.16	1.48 ± 0.08	21.20 ± 0.07
6–8	2.80 ± 0.04	20.88 ± 0.15	5.22 ± 0.06	21.32 ± 0.05	2.64 ± 0.14	21.06 ± 0.04
8–10	0.70 ± 0.09	22.67 ± 0.08	1.97 ± 0.06	27.99 ± 0.06	1.52 ± 0.05	19.29 ± 0.08
10–12	1.00 ± 0.06	22.38 ± 0.6	1.59 ± 0.07	21.33 ± 0.09	1.44 ± 0.05	20.65 ± 0.05
12–14	2.05 ± 0.02	21.30 ± 0.05	4.63 ± 0.5	18.76 ± 0.06	2.78 ± 0.14	16.75 ± 0.12
20–25	4.02 ± 0.01	16.96 ± 0.05	3.68 ± 0.06	16.16 ± 0.12	1.36 ± 0.05	14.94 ± 0.16
30–45	1.92 ± 0.15	11.26 ± 0.05	3.90 ± 0.04	13.59 ± 0.13	3.82 ± 0.14	7.10 ± 0.18
60–75	1.88 ± 0.19	8.05 ± 0.06	0.75 ± 0.16	5.09 ± 0.17	1.66 ± 0.14	5.13 ± 0.13
100–125	0.74 ± 0.06	7.73 ± 0.08	1.19 ± 0.05	3.42 ± 0.15	0.44 ± 0.14	3.69 ± 0.04

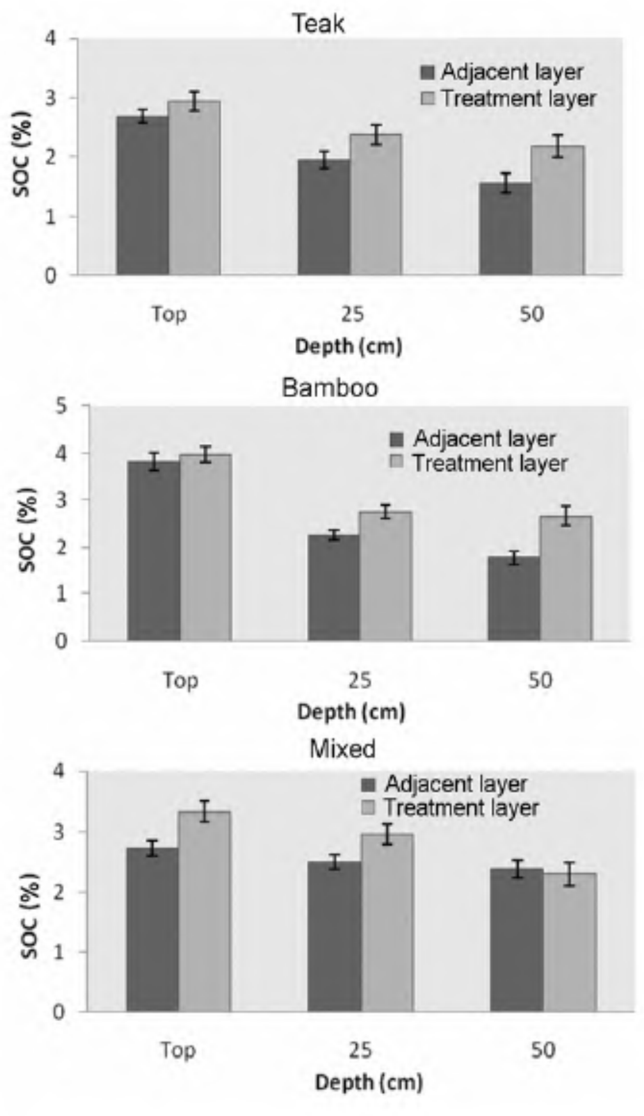

Figure 2. Soil organic carbon (SOC; %) in the soil (treatment layer) of litter-bag study and adjacent layer of three different stands, depth with standard error bar (n = 3). Increase in SOC content in the treatment layer is significant at $P < 0.05$ level.

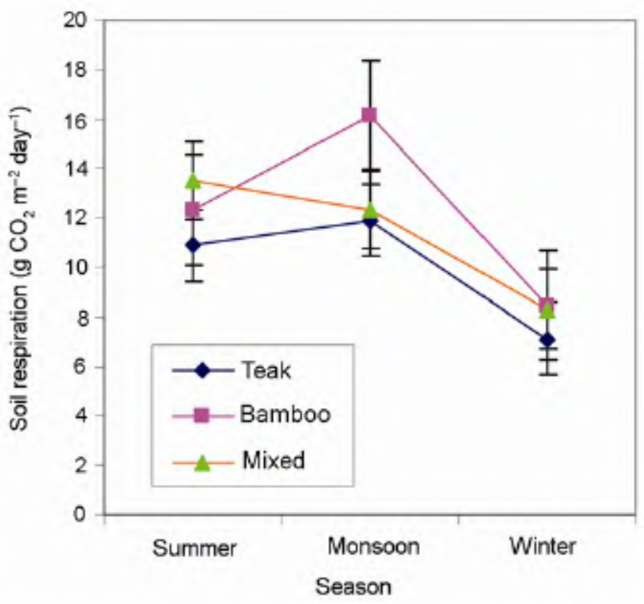

Figure 3. Soil respiration (g CO_2 m^{-2} day^{-1}) from three different vegetal cover with standard error bars (n = 5).

winter. Bamboo showed higher respiration during monsoon. In mixed vegetal cover soil respiration was maximum in summer.

Chemical break-up of SOC

Proton NMR analysis of the soils at two different depths (0–2 and 12–14 cm) and two pools showed the presence of three groups (alkyl, *O*-alkyl and aromatic). Carboxyl group was missing completely in the samples. Variation in the proportion of different groups was minimal across vegetal cover and depth. The proportion of *O*-alkyl and aromatic groups remained almost the same (Figures 4–6). Fluctuations were seen in the proportion of alkyl groups.

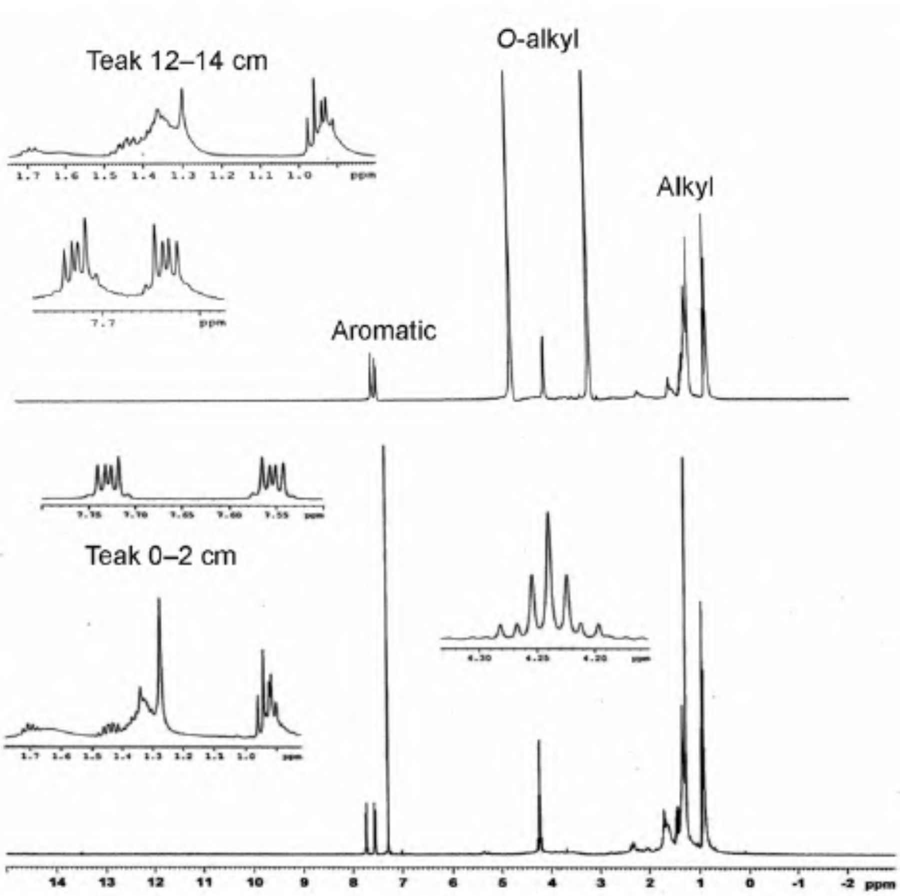

Figure 4. Proton (^{1}H) NMR spectra of teak soil extracts at 0–2 and 12–14 cm depths. The spectra show the three types of group (alkyl, *O*-alkyl and aromatic). Of these, the proportion aromatic group is almost the same. Fluctuations are noticed in *O*-alkyl and alkyl groups.

The proportions of these three groups in pools 1 and 2 also remained the same (Figure 6).

Discussion

SOC and litter fall

The rise in SOC values is negligible in comparison with the quantity of litter added annually (Figure 1), indicating that most of the litter that falls gets decomposed. This also shows that SOC present in the top layers of the soil does not come from fresh litter alone. It is from the cumulative accumulation of undecomposed/partially decomposed leftover litter of previous years. In timescale these previous years can very well be decades. Our understanding is that SOC gets 'soaked' into the lower layers. Addition coming from the decomposition of fresh litter (especially of leaves) is less. At all the experimental points leaf-litter gets decomposed within a year, whereas pieces of stem/branch remain for a longer time. An earlier study[32] reported that the turnover time of litter in tropical forests is less than one year. Our results are in conformity with this. Correlation is not seen between the quantity of litter and amount of SOC present in the top layers, indicating that the pattern of decomposition of litter is different for the three types of vegetal cover. There is a significant difference in the downward movement of SOC in the three types of vegetal cover. This confirms that SOC in the tropical soils depends on the type of vegetal cover. The SOC value itself is seen to be much higher than the values mentioned earlier[9,13,33]. Growth rates in the forests of this study area (~4 mm yr^{-1} in the mean DBH) are higher than those reported[34] for the Amazon forest area, according to the records of the Gujarat State Forest Department (unpublished data). This higher growth rate is likely to be good for SOC. Similar accumulation of SOC was reported for the growth of old forests[9]. A non-equilibrium conceptual framework for soil carbon dynamics was proposed. We conclude that soils similar to our study area (of tropical regions) are likely to function as a sink for carbon; they are yet to reach a steady state.

SOC quantity in the top layers (up to 25 cm) is much higher and showed less difference with the contents of subsequent layers. At lower depths SOC content was

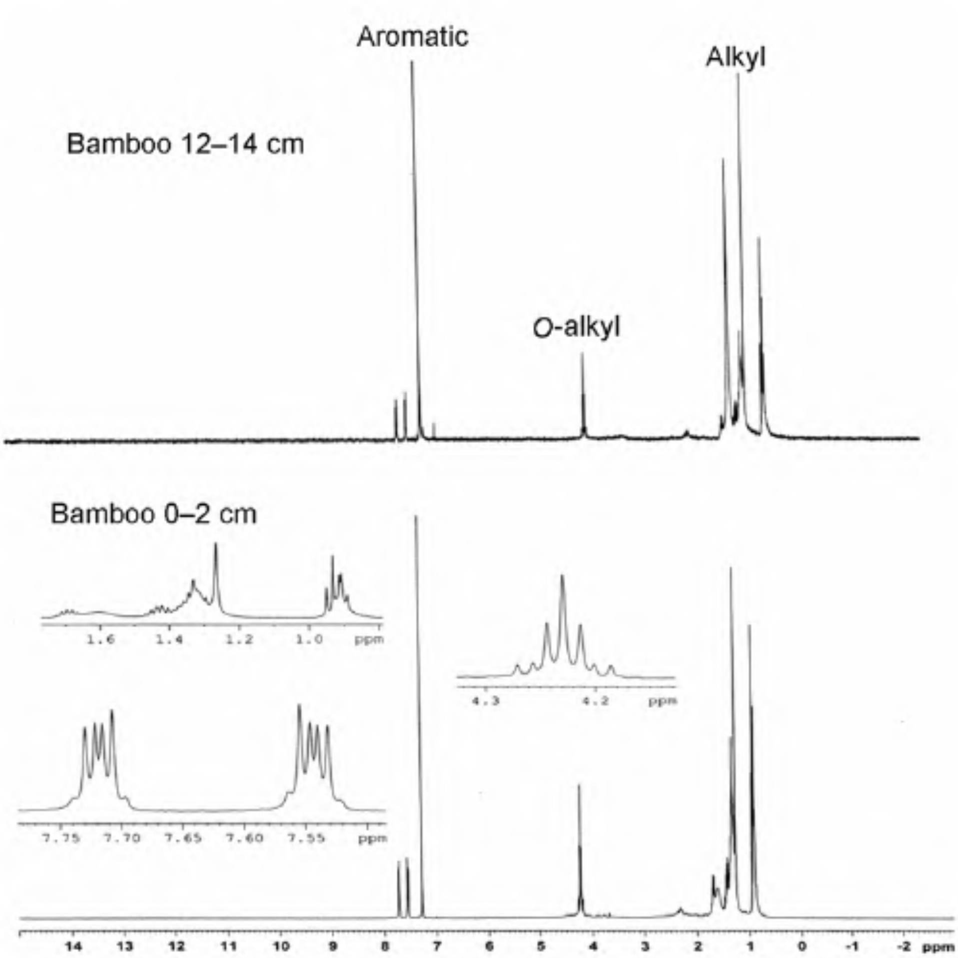

Figure 5. Proton (^1H) NMR spectra of bamboo soil extracts at 0–2 and 12–14 cm depths. The spectra show the three types of group (alkyl, *O*-alkyl and aromatic). Of these, the proportion *O*-alkyl and aromatic groups is almost the same. Fluctuations are noticed in the alkyl groups.

relatively less and differences between adjacent layers were much higher (Figure 2). Differences in the quantities and movement of SOC seen across the soils of the study area indicate that their sink potential is high. To validate this observation we conducted the litter-bag experiment. The rate of decomposition and subsequent change/s seen in SOC of these soils indicated that additional inputs (though the quantity in the bags was small) can be easily taken in (Table 2).

Litter decomposition

There is a difference in the decomposition of litter kept at different depths. Decomposition was faster at the top layers than at deeper layers. Quantity of litter decomposed is much higher than those reported[35–37]. This may be specific to the tropics as the soils largely show more biological activity. Uniformity was seen in the decomposition of teak and mixed species in spite of greater diversity at the site of the mixed species. This uniformity shows that richness of the diversity of species has not altered the overall process of litter decomposition. This is contrary to the results reported earlier[35]. The results of the litter bag experiment show that decomposition is influenced more by the time of stay of litter in the soil and not specifically by species diversity. Uniformity was seen in the decomposition of the three types of litter by the end of 320 days at all depths, irrespective of initial differences. This shows that microbial activity in the deeper layers is stimulated slowly by fresh litter/organic carbon supply. Quantity of litter decomposed in the litter bags of teak and bamboo kept at the exchanged sites (teak litter bags in the soils covered by bamboo and vice versa) was almost similar to the decomposition values coming from the matching sites. This confirms that the microbial population is more general by being responsive to compounds present in foliage for decomposition and not specific to plant/tree species. Increase in SOC of soils from the litter-bag experiment show that tropical soils do have-

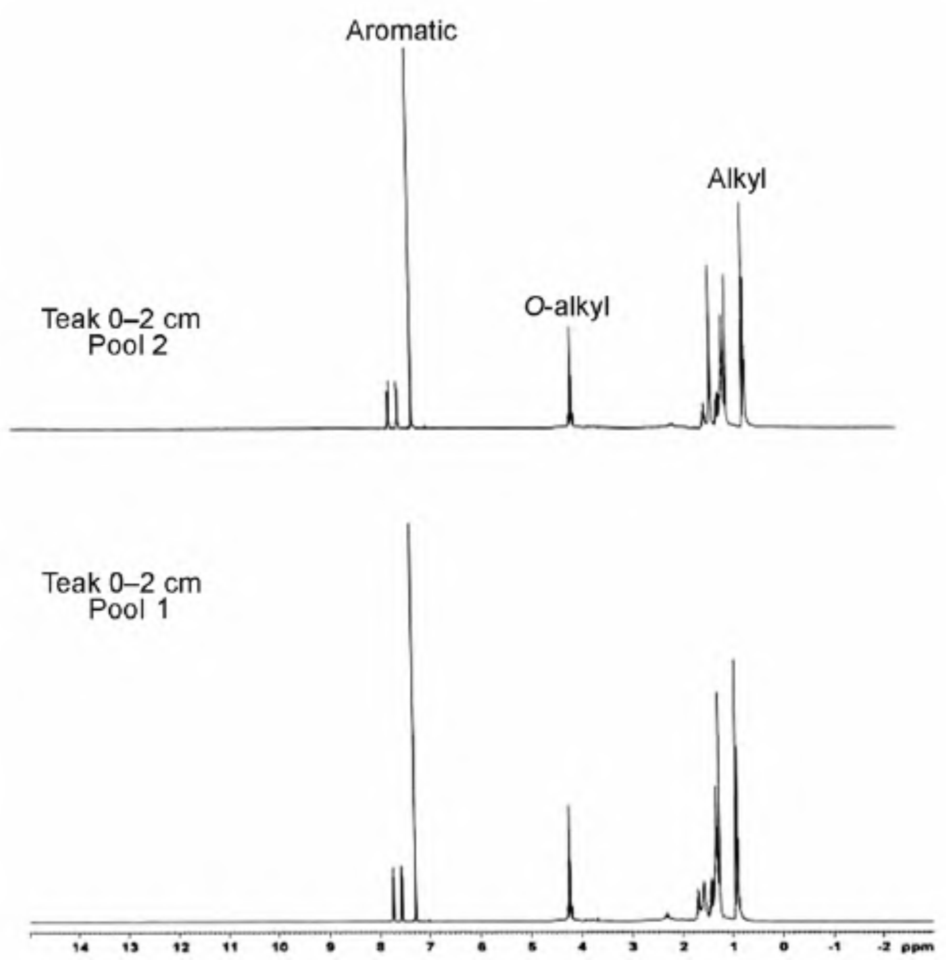

Figure 6. Proton (^{1}H) NMR spectra of pools 1 and 2 (physical fractions of teak) at 0–2 cm depth. The spectra show the three types of group (alkyl, *O*-alkyl and aromatic). Of these, the proportion *O*-alkyl and aromatic groups is almost the same. Fluctuations are noticed in the alkyl groups.

additional absorptive capacity for organic carbon (OC). The limitation is only with the input and not with their sink potential. Changes in SOC content at deeper levels (25 and 50 cm) revealed another dimension in decomposition activity. The newer inputs are relatively less than the base levels of SOC content of previous years present in these layers. The proportion of decomposition was maximum for fresh inputs in the litter bag compared to the small variations seen in the already existing SOC. This shows that microbes process SOC according to the law of diminishing returns. Availability of fresh SOC (in the bags) activates microbes, and processing/ decomposing of fresh litter becomes faster. Once SOC reaches or becomes 'stationary' with compounds equivalent to the type present in these soil layers, the microbial activity becomes low as the microbes do not get any further energy by the breakdown. This is contrary to the views of others[23,38] who reported that supply of fresh plant-derived carbon to the sub-soil stimulates microbial mineralization of old carbon.

Soil respiration

Soil respiration values (Figure 3) of the three vegetal covers were higher than the published values for the tropical soils[39,40]. This supports the conclusion that rates of decomposition observed in these soils are higher. Higher respiration values during monsoon and less in winter may be related to variation in soil moisture content. Bamboo showed higher respiration during monsoon as the leaves of bamboo hold relatively less moisture and increase in moisture content during monsoon enhanced the rate of decomposition.

SOC pools

Proportion of OC in the two physical pool sizes (pools 1 and 2) remained almost the same across different soils. Uniformity in pool proportion across the profile shows that all differences expected amongst vegetal covers are to be seen mostly at the beginning of the process of decomposition. Once these initial stages are crossed, subsequent alterations are the same in these soils. This observation reaffirms that variations in vegetal cover will have an impact on the initial stages of decomposition only. A chemically diverse litter mixture would contain a more even representation of labile and recalcitrant compounds[1]. In this study a similar observation was not seen. Proportion of recalcitrant pool was higher. Plant diversity did not influence this SOC fractionation into pools 1 and 2. Proportion of pool 2 was much higher in our experiment compared to those reported[2,41].

Chemical break-up of SOC

Uniformity in the proportion of SOC in both pools 1 and 2 across different vegetal covers led us to check for any variation in their chemical constituents through proton NMR analysis. Among the four groups (alkyl, *O*-alkyl, aromatic and carboxyl) reported in the literature[2,23,41,42], the carboxyl group was completely missing in the samples. This is due to the tropical origin of the samples, whereas most of the published reports indicating the presence of carboxyl group are from the temperate regions. Variation in the proportion of different groups was minimal across vegetal covers and depths. The proportion of *O*-alkyl and aromatic groups remained almost the same (Figures 4–6). Fluctuations were seen in the proportion of alkyl groups. Proportions of these three groups in pools 1 and 2 also remained the same. These results clearly show that at least in the tropical soils, the process of decomposition for different types of plant material eventually leads to uniformity in chemical composition. Subsequent changes become negligible. Our proton NMR results support an earlier view[20] that the soil biotic community is able to disintegrate any organic matter of natural origin till it reaches uniform molecular recalcitrance.

Conclusion

We conclude that variation in vegetal cover alters the quantity of SOC in the soils. As long as a forest shows some growth, it will be acting as a sink rather than a source. The litter-bag experiment showed the ability of tropical soils to take up extra carbon. Results show a different understanding for the mechanics of movement of SOC in the tropics. SOC present in the top 5–10 cm of the soil moves almost passively. The proportions of pools 1 and 2 remained the same across the profile. There was a decrease in SOC at deeper layers, but the proportion of the recalcitrant pool remained almost the same. Uniformity seen in chemical composition of SOC coming from proton NMR study reveals that apart from the initial stages, decomposition of organic matter follows more or less the same path in the tropical soils, irrespective of the differences in plant litter. Our study opens up a new understanding of the processes in SOC movement across the tropics.

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