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Soil microbial biomass carbon under different land uses in Tehri Garhwal district of Uttarakhand(India)

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Abstract

The soil microbial biomass carbon(SMBC) is a source of nutrients and changes in the MBC can be used to predict the effects of ecosystem perturbations. This is why microbial indicators have been used as reliable tools to characterize soil quality with respect to land use and soil management. Soil Samples were collected from 0 to 30 cm depth with the help of hand spade from various points under different land uses in Narendranagar division of Tehri Grahwal district of Garhwal(India). These soil samples were used for estimation of microbial biomass carbon. Results of the study revealed that microbial biomass carbon under different land uses shows large variation in MBC from 25 microgram per gram to 200 microgram per gram.This difference occurs because of different land use systems prevailing in the area. Forest land have relatively higher MBC than human affected forest land because of absence of ploughing and fertilizer use. Soil Ph value also varied from 6.4 to 7.7 in the area under study.

Keywords: Microbial biomass carbon, Micro-organism, Land uses.

Introduction

Soil is a complex system wherein physico-chemical and biochemical factors are held in dynamic equilibrium (Arunachalam et al., 1999). It is the medium from which plant root systems acquire water and nutrients and is host to an array of macro and microorganisms. Soil contains a great diversity of organisms, the vast majority of which are microbes. In terrestrial ecosystems the greatest diversity of organisms are in the soil (Wardle, 2002). A single gram of soil is estimated to contain several thousand different species of bacteria alone (Torsvik et al., 1996). Nowadays, particular attention is given to soil functionality, largely related to microorganisms and their activity. The soil microbial biomass is involved in the decomposition of organic materials and, thus, the cycling of nutrients in soils. It is also frequently used as an early indicator of changes in soil chemical and physical properties resulting from soil management and environmental stresses in agricultural ecosystems (Brookes 1995; Jordan et al. 1995; Trasar-Cepeda et al. 1998). Although the soil microbial biomass C constitutes only 13% of total soil C, they are the most labile C pools in soils (Jenkinson and Ladd 1981). Therefore, nutrient availability and productivity of agroecosystems mainly depend on the size and activity of the microbial biomass (Friedel et al. 1996).

The Microbial biomass carbon of the entire soil microbial population is treated as an entity. It is a source of nutrients and changes in the MBC can be used to predict the effects of ecosystem perturbations. This is why microbial indicators have been used as reliable tools to characterize soil quality with respect to land use and soil management (Turco et al., 1994;). Also, soil biological properties should be used as a soil erodibility indicator (Kızılkaya et al., 2004). Recent interest in agroecology has been focused on studying soil and fertilizer management in agricultural systems to improve soil quality and minimize possible deleterious effects on the environment (e.g., soil erosion and eutrophication of natural ecosystems). Because crop residues are primary sources of organic matter, crop management and fertilizer regime can exert a significant influence on soil quality (Campbell et al. 1991). Compared with systems involving crop rotations, soils under monocultural systems, in general, contain significantly lower concentrations and qualities of soil organic matter, less soil structural stability, and reduced amounts of microbial biomass and activities. The positive effect of crop rotations on physical, chemical, and biological soil properties are related to higher C inputs and diversity of plant residues returned to soils (Havlin et al. 1990; Varvel 1994; Friedel et al. 1996; Robinson et al. 1996). Soil MBC is a soil microbiological property of great agronomic value because it shows organic compounds and various inorganic nutrient forms (mineral N, PO42-, SO42- etc)

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are available to plants. Variations in MBC, apart from indicating changes in the quantity and quality of a soil's carbon, are also good indicators of the biological status of soils (Pascual et al., 1998). The MBC, containing only 1 to 3% of total soil organic C is an important component of soil organic matter. The MBC depends on many factors including texture, organic matter content, soil nutrient status, soil depth, environmental conditions such as temperature and humidity, pollutants (heavy metals, exhaust emissions etc) and agricultural practices such as fertilizer and pesticide treatments (Baath, 1989; Kızılkaya, 1998; 4; Aşkın and Kızılkaya, 2004). Classic statistics assumes that variation is randomly distributed within sampling units. Geostatistics are useful in predicting the spatial distribution of soil properties in the field with a limited number of samples (Bonmati et al., 1991; Chien et al., 1997). Semivariograms and autocorrelograms are typically used to study of the spatial structure of soil properties. Spatial variability is critical to our understanding of soil quality status and the development of methods for soil quality and healthy assessment (Aşkın et al., 2004). However, there are few published studies on the spatial patterns of MBC in soils.

Material method

Soil Samples were collected from 0 to 30 cm depth with the help of hand spade. This soil was mixed thoroughly and gravels were removed. Then the sample were kept in a polythene bag labelled and tightly closed. Twelve soil samples from the forest Land, 4 from grassland and 36 from different agricultural lands were collected for the analysis.

Forest soils were collected from different forest covers such as Sal(*Shorea robusta*) and *Quercus sp.*, mixed forest near Muni ki reti , mixed forest near Shiv puri, *Pongamia pinnata* and pine forest near Agarkhal. The samples were named as TF and TR near Kalthari and Bakriyana region respectively. *Imperata cylindrica* is the main grass however *Sachharum, Lantana camara and Ziziphus sp.* were also noticed. Soil samples were collected from twelve different sites of agricultural fields of Tehri.

Soil Microbial Biomass Carbon

Microbial biomass carbon(MBC) in soil samples was estimated following chloroform fumigation extraction procedure as described by Jenkinson and Powlson (1976) and modified by Vance *et al* (1987). Field-moist soil samples containing about 25 g soil on oven dry basis was fumigated with ethanol-free-chloroform for 24h in a vacuum desiccators. Following evacuation and fumigant removal, the soil samples were extracted with 0.5M K_2SO_4 (1:4 soil: solution ratio) by shaking for 30 min on an oscillating shaker. The soil suspension was filtered through Whatman No. 42 filter paper. Non-fumigated soil samples were also extracted with 0.5M K_2SO_4. The readily oxidisable carbon in the extracts of the fumigated and non-fumigated soil samples was estimated by dichromate digestion method and expressed on an oven dry weight basis (105^{o} C for 24hours). Biomass carbon in soil was calculated from the relationship $Bc = Fc/Kc$, where Fc is the difference between extractable carbon from fumigated soil and non-fumigated soil. Kc is conversion factor, which is 0.45 (*Vance et al.*, 1987).

Results and Discussion

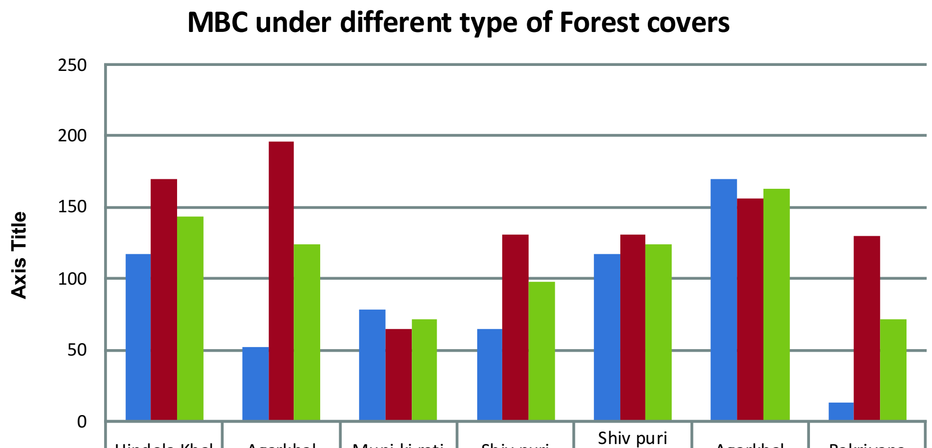
The microbial biomass not only contains a labile pool of nutrients but also drives the cycling of organic matter and nutrients in soil (Jenkinson and Ladd 1981). McGill et al. (1986) proposed that seasonal changes in soil microbial biomass are directly involved in the turnover of organic matter and the cycling of nutrients in soil, thereby affecting their availability.The microbial communities in forest soils, rich in organic matter, may differ considerably from those found in grassland and in arable soils with lower organic matter content (Frostegard and Baath, 1996). In forest ecosystems, trees may cause soil resource heterogeneity and spatial patterns in soil properties that correspond to the positions of trees (Kleb and Wilson, 1997). For example, microbial biomass and activity in a mixed forest were spatially dependent at distances up to 8 m, and birch and spruce trees differed in their infuence on soil biological properties (Saetre, 1999). Thus, it can be expected that fatty acids other than those spatially structured in arable soils will be spatially structured in forest soils, and that the variation in the microbial communities will be spatially structured at a larger spatial scale in forest soils, corresponding to the position of trees in the forest.

According to present study of microbial biomass carbon of Tehri district under different landuses are concluded in following table 1,Figure 1. This shows large variations in MBC from even 25 microgram per gram to 200 microgram per gram.This difference arises because of different land use systems viz., area showing forest land are flaunting with larger bars than agricultural one but some of agricultural fields also show big bars that means they have good amount of microbial biomass carbon and less affected by harmful agricultural practices.

T1 and T2 in the figure represent two samples that is first and second .Since they show great variation in MBC level, average is calculated and represented as green bar .Some bars that represent high level of MBC

Table 1. MBC of soil samples by fumigation extraction method

S.No.	Sample name	pH	Microbial Biomass Carbon (MBC in μ gm)
1.	Hindola Khal Forest	6.450±0.212	143.480±36.897
2.	Soni Nadrendar Nagar	7.167±0.321	82.610±41.931
3.	Agarkhal Quercus	5.750±0.354	123.910±101.456
4.	Duadhar Mustard	7.433±0.208	73.917±29.405
5.	Muni Ki Reti Mixed Forest	6.650±0.071	71.705±9.270
6.	Kalthari Grassland	6.950±0.495	149.995±9.228
7.	Cilar Mustard	7.333±0.208	56.520±7.526
8.	Shivpuri Rajma	7.333±0.289	39.130±15.063
9.	Shivpuri Mixed Forest	6.900±0.141	97.795±46.068
10.	Gular Mustard	7.333±0.289	39.130±15.063
11.	Badal Shivpuri Mustard	7.533±0.153	50.013±9.942
12.	Narendar Nagar Mustard	7.700±0.173	73.933±27.174
13.	Badal Shivupri Masoor	7.367±0.252	100.013±32.825
14.	Daur Gahri Mustard	7.533±0.153	47.830±7.534
15.	Muni Ki Reti Medicinal Plant	6.833±0.208	36.957±9.959
16.	Shivpuri Pongamia Pinnata	7.550±0.212	123.905±9.242
17.	Agarkhal Pine Forest	6.600v±0.141	163.055±9.242
18.	Bakriyana Grassland	6.800±0.283	130.380±0.071
19.	Bakriyana Mustard	7.733±0.153	45.627±17.307
20.	Kalthari Garlic	7.400±0.100	91.313±13.055



	Hindola Khal Forest	Agarkhal quercus spp	Muni ki reti mixed forest	Shiv puri Mixed forest	Shiv puri Pongamia pinnata	Agarkhal pine forest	Bakriyana grassland
T1	117.39	52.17	78.26	65.22	117.37	169.59	13.43
T2	169.57	195.65	65.15	130.37	130.44	156.52	130.33
AVERAGE	143.48	123.91	71.705	97.795	123.905	163.055	71.88

Figure 1. MBC in forest land by fumigation extraction method

are named as A and Q which represent Hindola Khal Forest and Agarkhal pine forest. According to previous experiments it is found that conifer forests produce more easily digestible litter containing good quantity of lignin and hence show good variation in microbial activity.

Figure 3 shows the average microbial biomass carbon in various agricultural fields of Tehri district of Uttrakhand and as above discussion shows that forest soil have more microbial biomass carbon since they are not human interfered as much as agricultural land. Similarly here showing some bar with great length which show more MBC such as TM and TT which correspond to Daur Garhi Mustard and Kalthari agricultural field respectively. from this data we can infer many points like some fields are need of proper management to retain their fertility for a longer time.

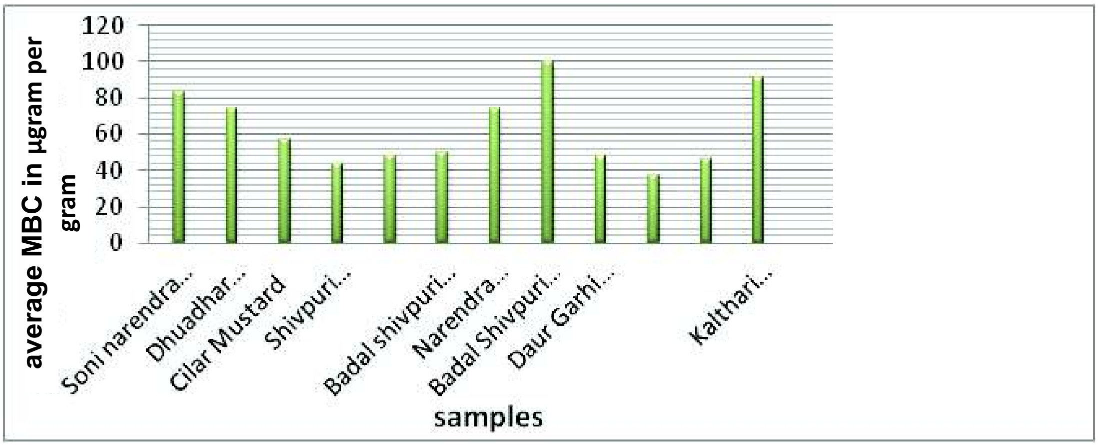


Figure 2. MBC in forest land by fumigation extraction method

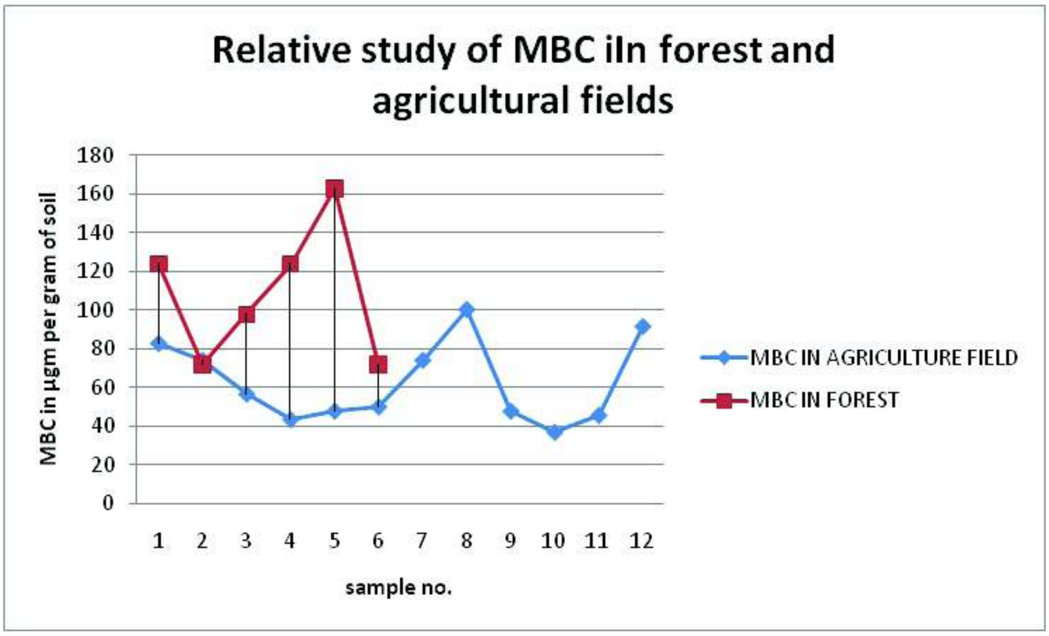


Figure 3. Average MBC in various agricultural fields and forests.

Microbes are very important part to make soil lively and productive. According to this Figure we can conclude that relatively forest land have much MBC than human affected forest land because of no ploughing, no fertilizer use that reduces the normal activity of microbes present in soil and some time reduction is so large that agricultural fields are not able to produce quality and quantity of crop estimated. The microbes which break down complex organic carbon to simple inorganic carbon so that it can be available to plant as their nutrients. Microbes secrete enzyme that provide structure to the soil and in absence of required amount of microbe soil become dust and lose it productivity gradually. So it is necessary to take account of microbial biomass while implementing any agricultural practices.

Nowadays, particular attention is given to soil functionality, largely related to microorganisms and their activity. The soil microbial biomass is involved in the decomposition of organic materials and, thus, the cycling of nutrients in soils. The microbial biomass not only contains a labile pool of nutrients but also drives the cycling of organic matter and nutrients in soil (Jenkinson and Ladd 1981). In Agrakhal Quercus.spp. forest have the highest microbial biomass carbon.this may be due to higher leaf litter and high amount of organic matter and high microbial activity. Average microbial biomass carbon in various agricultural field of Tehri district of Uttrakhand as above discussion shows that forest soil have more microbial biomass carbon since they are not human interfered as much as agricultural land. Microbial biomass and activity in a mixed forest were spatially dependent at distances up to 8 m, and birch and spruce trees differed in their infuence on soil biological properties (Saetre, 1999).

So it is necessary to take account of microbial biomass while implementing any agricultural practices. In conclusion, felling has altered the vegetation and physico-chemical characteristics of the soil that confounded by the microbial population and biomass. A high release of CO^2 is sometimes explained with a high microbial activity and is interpreted as a positive property. Overall, stem harvesting through selective logging and soil degradation by clear-felling have exposed the soil to direct insulation and reduced litter and fine root input, thereby reducing the soil fertility level. This indicates the dynamic nature of C circulation on the land and the microbial populations and biomass are important for nutrient conservation, regeneration and management. . Further research needs to be conducted in order to measure the diversity of the microbial community in monitored sites by using molecular techniques. Results would contribute to the present study concerning the flow of carbon and energy through the microbial biomass in various soil types and ways of soil use.

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