

## Soil organic carbon and soil microbial biomass as affected by restoration measures after 26 years of restoration in mined areas of Doon Valley

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### ABSTRACT

Soil organic carbon is simultaneously a source and sinks for nutrients and plays a vital role in soil fertility maintenance. Soil microbial biomass can be a useful indicator of soil quality and could possibly serve as assessment criteria of successful rehabilitation of ecologically disturbed areas. To assess the impact of restoration on organic carbon and microbial biomass carbon of soil a study has been conducted at rock phosphate mined area, lies in between longitude 77° 38' to 78° 20' E and latitude 29° 35' to 30° 30' N of Doon Valley. Climate of Maldeota has well demarcated summer, rainy and winter seasons. The soil texture of Maldeota varies from sandy loam to loamy sand. The natural vegetation of the site is represented by tropical dry mixed deciduous forest type. The area was restored way back in 1982. The study site was 26 year old restored mined area having plantation of *Acacia catechu* and *Dalbergia sissoo* while adjacent Natural forest area contains dominant tree species of *Cassia fistula*, *Bauhinia vareigata* and *Flacourtia cataphracta* respectively. Results indicated the recovery of soil quality after restoration as the microbial biomass in the restored area was found to be greater as compared to the natural forest.

**Key words:** Soil organic carbon, Soil microbial biomass, mined area, restoration.

### 1. Introduction

Ecological restoration of mine disturbed areas should be dogmatic (Soni et al., 1994). The principle behind the restoration is that these areas must require the properties at least to the level of which existed before mining commenced. The reclamation process is thus the holistically and the best scientific involvement for not only reconstruction of degraded ecosystem but attaining it with speed, cost benefit and reliability. Natural recovery is thus a fairly the far slow process while the restoration is the process of assisting the ecosystem recovery with acceleration. To achieve this level of ecosystem recovery and development, it is necessary to understand the factors limiting succession at each point of its progress. Ecological restoration is defined by the Society for Ecological Restoration (2002) as 'The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed'. Microorganisms play an important role in the functioning of any soil ecosystem as they are actively involved in litter breakdown, cycling of nutrients, formation of stable microaggregates, and structural development. In many restoration projects, the main focus has been on the establishment of native plant species and creation of plant communities that closely resemble those of undisturbed native vegetation (Zedler, 2001).

Ecological impacts of restoration procedures on soils can directly affect plant community composition or system-level functions such as nutrient cycling. Monitoring periodical

changes not only in vegetation but also in soils portrays the overall success of the restoration process more accurately. Soil microbiological properties such as microbial biomass may be used as early and sensitive indicators of soil quality (Bending et al., 2004), for comparisons of soils under different managements (Kieft, 1994) and that high levels of microbial activity are fundamental in maintaining soil quality (Garcia et al., 2002). Soil microbial biomass is a potential source of plant nutrients, and a higher level of soil microbial biomass is an indicator of soil fertility. The microbial biomass of soil is defined as the part of the organic matter in the soil that constitutes living smaller microorganisms.

Microbial biomass may provide the information about the restoration progress of the degraded areas. The level of soil microbial biomass is an important factor in determining the soil health. The soil microbial biomass carbon is an important component of soil organic matter and comprises 1–3% of total organic carbon in soil (Jenkinson and Ladd, 1981), but it has a rapid turnover rate and represents a labile reservoir of nutrients (Marumoto, 1984). Due to its dynamic character, microbial biomass responds to management practices (cultivation, residue management, amendments, and fertiliser application) and other environmental variables and its effects are often measurable (Batra et al., 1997). The soil microflora and the vegetation of an ecosystem are closely interrelated. Plants influence soil biotic processes by delivering organic compounds, whereas soil microbes have a positive impact on plant growth by the decomposition and mineralization of plant material.

## 2. Materials and Method

### 2.1 Study Site

Maldeota, the study area where field observations were undertaken is located in Doon valley. Geographically Doon valley is situated in Northern part of Uttarakhand between longitude 77° 38' to 78° 20' E and latitude 29° 35' to 30° 30' N stretching in NW-NE direction following the main Himalayan range. It is about 18 km towards NE of Dehradun between 750 to 1050 m above mean sea level. Climate of Maldeota has well demarcated summer, rainy and winter seasons. The soil texture of Maldeota varies from sandy loam to loamy sand. Sal forests are the climax type of forests in Dun valley. As per Champion and Seth's classification (1968) natural vegetation of the experimental site is represented by tropical dry mixed deciduous forest type (5B/C2). Predominant species of the natural area are *Mallotus philippensis*, *Flacourtia cataphracta*, *Cassia fistula* and *Acacia catechu* and *Dalbergia sissoo* in riverine ecosystem. Undergrowth mainly consists of *Murraya koenigii*, *Adhatoda zeylanica*, *Lantana camara* and *Eupatorium glandulosum*.

Rock phosphate commonly known as Mussoorie Phos was being mined through open cast as well as underground mining methods. The waste product or overburden generated during mining contained major portions of shale, chert and limestone. The area was restored way back in 1982 using native plant species like *Acacia catechu*, *Wendlandia exerta*, *Dalbergia sissoo* etc. The adjacent Natural forest was taken as a reference site to the restored area.

### 2.2 Soil Sampling

Soil samples were collected from 26 year old restored site and from adjacent natural forest. A composite soil sample was prepared by mixing soil samples taken from each site. Replicates were taken from the composite sample to avoid the spatial heterogeneity among the soil microbes. Microbial biomass carbon (MBC) was estimated by using modified liquid chloroform fumigation incubation technique (Vance et al., 1987) and Soil organic carbon was

determined by Walkley and Black method (Walkley, 1947). The statistical analysis of data was done using Statistical Package for Social Sciences (SPSS) 17.0.

### 3. Results

The data from Table 3.1 infers that soil microbial biomass ( $\mu\text{g g}^{-1}$ ) was found to be maximum in restored site ( $249.61 \pm 73.91$ ) than in natural forest ( $205.27 \pm 92.17$ ) which is an indicator of good soil quality. The analysis of variance was found to be highly significant between sites and soil organic carbon and between sites and soil organic matter ( $p < 0.001$ ). However, it was found significant between sites and microbial biomass ( $p < 0.01$ ).

From Table 3.2, it can be observed clearly that there was highly positive correlation between organic carbon and organic matter at  $P < 0.01$ . Also, organic carbon had a non-significant but positive relationship with MBC. However, sites and organic carbon were significantly negatively correlated. Organic matter was negatively correlated with sites at  $P < 0.01$ .

The higher microbial biomass carbon recorded in restored site can be attribute due to higher organic matter and moisture content as organic matter can hold more moisture. Further insects and microbes digest this organic matter resulting in more microbial activity and this activity release nutrients and substances that glue together individual mineral soil particles. These aggregated particles enhance soil structure by increasing pore space, which, in turn, increases air and water availability.

Soil organic matter is the most important indicator of soil quality and productivity and consists of a complex and varied mixture of organic substances. A positive correlation was found between soil organic matter and soil organic carbon. Soil organic carbon is important for all three aspects of soil fertility, namely chemical, physical and biological fertility.

**Table 1:** Soil organic carbon, organic matter and microbial biomass carbon of restored area and natural forest area

Sites	Organic Carbon (%)	MBC ( $\mu\text{g g}^{-1}$ )	Organic Matter (%)
Restored Site	$1.91 \pm 0.15$	$249.61 \pm 73.91$	$3.29 \pm 0.26$
Natural Forest	$0.80 \pm 0.09$	$205.27 \pm 92.17$	$1.37 \pm 0.15$
Significance	***	**	***
CD	6.45	1006.65	11.11

\*\*\*Significant at  $P < 0.001$  Values are mean of five replicates.  $\pm$  standard deviation

\*\*Significant at  $P < 0.01$

**Table 2:** Pearson's Correlation Matrix between Soil properties of restored mined area and natural forest area

	Sites	%Organic Carbon	MBC ( $\mu\text{g g}^{-1}$ )	% Organic Matter
Sites	1			
%Organic Carbon	$-0.913^{**}$	1		
MBC ( $\mu\text{g g}^{-1}$ )	$-0.132$	$0.155$	1	
% Organic Matter	$-0.913^{**}$	$1.000^{**}$	$0.155$	1

\*\* Correlation is significant at the 0.01 level (2-tailed)

### 4. Conclusion

Microbial biomass has also increased in the restored site over the period of time if we correlate it with the organic carbon as earlier studies (Soni et al., 1992) indicated that organic carbon content has increased up to 60% in restored site after 26 years of restoration. The higher organic carbon and resulting component of microbial biomass in restored site than natural forest may be due to high species richness and diversity in former case than later (Soni et al., 2008). Furthermore the restoration measures adopted in the area were based on the ecological principles and it was totally depend on adaptability of site conditions. . An effective plantation rehabilitation measure can provide the satisfactory estimate of soil microbial biomass, in this context finding of Chodak et al. (2009), supports the findings that the reclamation measures boost the microbial properties as well as it promote the rapid development of metabolic abilities characteristic of natural forest soil microbial communities. The plantation enhanced the nutrient status of the degraded mine spoil land (Dutta et al., 2002). Some studies of reclaimed soils of mined lands indicate that microbial community may take 20 years or longer to recover (Sawada, 1999). Fu et al. (2010) also demonstrated in their study that through well managed vegetation restoration measures improvements in soil organic carbon stocks could be made.

Results of study done by Wang et al. (2011) also demonstrated the positive effects of vegetation restoration measures on soil organic carbon stocks at multiple scales. An Shao-shan et al. (2010) concluded in their study that revegetation of eroded soils accelerates soil remediation and rehabilitation. In present study also, it was observed during these several years of restoration soil organic carbon and microbial biomass was increased in the restored site. It is a good indicator of healthy environment for soil and vegetation to come up in that area. Results indicated that restored site is having higher microbial biomass and soil organic carbon value than Natural forest area which is an indicator of good soil quality and recovery. Thus, we can conclude that over the time period, the soil was trying to come back to its original state as observed indicating the fertility status of the soil.

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