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Original Research Article

Estimates of soil microbial biomass carbon of forest soil types of Gujarat, India

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Keywords

Soil Microbial Biomass Carbon (SMBC), Carbon Sequestration (CS)

A B S T R A C T

Through carbon sequestration in soils, regional study of estimates of soil microbial biomass carbon stock always helps in identifying strategy to mitigate greenhouse gas emissions. In order to highlight the intricate interrelationships and controlling mechanisms between the output and input of nutrients and energy in the soil, quantification of the microbial biomass is required. In this paper, a soil database of topsoil estimates of soil microbial biomass carbon for four National Parks of Gujarat is highlighted. The highest SMBC stock was obtained in Gir National Park followed by Marine National Park then in Velavadar National Park and least was obtained in Vansda National Park.

Introduction

Carbon (C) sequestration in soils has been considered as a potential measure for mitigating global climate change (Schlesinger, 1999; IPCC, 2005; Smith *et al.*, 2007) as well as for sustaining productivity, ecosystem functioning, and sustainability of the global earth system (Lal, 2004; Sachs, 2004). The microbial biomass is the primary component and is also the primary agent of the soil ecosystem responsible for litter decomposition, nutrient cycling, and energy flow (Sparling, 1983). It mainly consists of bacteria and fungi, which decompose crop residues and organic matter in soil. This process releases nutrients, such as nitrogen (N), into the soil that are available for plant uptake. Soil carbon (soil organic carbon, soil inorganic carbon, soil microbial biomass carbon) plays a key role in the carbon cycle and thus is important in global climate models (Batjes, 1996).

About half the microbial biomass is located in the surface 10 cm of a soil profile and most of the nutrient release also occurs here. Generally, up to 5% of the total organic carbon and N in soil is contained in the microbial biomass at any one time. The microbial biomass accounts for only 1- 3 % of soil organic C but it is the eye of the needle through which all material that enters the soil must pass (Jenkinson, 1977), where microorganisms convert the materials to generate energy and also produces new cellular metabolites to support their maintenance and growth. In the C-limited soil system available C in organic materials entering the soil is the driving force behind these processes but other essential nutrient elements (particularly N, P and K) are also involved. The extent of this turnover is controlled by the size and activity of the microbial biomass under suitable environmental conditions. Valuable information on biomass growth, turnover time, death rates, and the efficiency of C use can be derived from reliable biomass C data. The soil microbial biomass carbon comprises 2–5% of total organic carbon in soil and is an important component of soil organic matter (Jenkinson and Ladd, 1981). Thus, the Microbial biomass carbon and the Soil organic carbon (C/SOC), ratios are useful measures to monitor soil organic matter and both provide a more sensitive index than SOC measured alone (Sparling, 1992). In order to elucidate the intricate interrelationships and controlling mechanisms of the input/output fluxes of nutrients and energy in the soil ecosystem a reliable quantification of the microbial biomass is required. The global storage of soil microbial biomass C estimated to be 16.7 Pg C in the 0–30 cm soil profiles and 23.2 Pg C in the 0–100 cm soil profiles (Xu *et al.*, 2013). The microbial biomass itself may represent a labile pool of C and nutrient elements.

Climate change leads to destruction of flora as well as fauna leading to change in microbial diversity. In comparison, changes in temperature and precipitation have less effect on microbes and their activities than extreme weather events. It is well established that both drought and freezing can have substantial direct effects on microbial physiology and the composition of the active microbial community, with important consequences for ecosystem-level carbon and nutrient flows (Bardgett *et al.*, 2008)

Seasonal fluctuations in different carbon availability indices and microbial properties were not related to soil temperature. This is consistent with findings of Raubuch and Joergensen, 2002 but contrary to several earlier reports describing seasonal variations in soil C as a function mainly of soil temperature (Tate *et al.*, 1993; Zak *et al.*, 1993; Carnol and Ineson, 1999). Soil temperature and amount of soil microbial biomass carbon are inversely proportional to each other (Piao *et al.*, 2000).

Materials and Methods

Study Area

Chose the study area as four National Parks of Gujarat Area considered for all four National Park was from the National FAO data and also confirmed on following web link: http://gujenvfor.gswan.gov.in/ wildlife/ wildlife-national-parks-sanctuaries.html where the random sampling was done using GPS.

1)
2) **The Gir National Park** (Sasan Gir) is a dry deciduous forest covering area of 258.71 sq.km. in Gujarat, India established in 1965. The latitude and longitude of Gir National Park is 21.11609° N 70.7923° E respectively. It is the sole home of the Asiatic Lions (Figure 1).

3)
4) **Velavadar National Park** Established in 1976 in the Bhavnagar District of Gujarat state in India. Typically Grassland, semi-arid

bio-geographical zone and is spread over an area of 34.08 sq.km. The latitude and longitude of the park falls under 22.0333° N, 72.0500° E respectively (Figure 2).

Marine National Park It is the protected area on the southern coast of the Gulf of Kachchh in the Jamnagar District of Gujarat state, India. It is Mangrove forest occupying area of 162.89 sq.km. The latitude and longitude of the park is 22.4667° N, 69.6167° E respectively. There are 42 islands on the Jamnagar coast in the Marine National Park and the best known ones are Pirotan, Narara, Sikka and kalubhar (Figure 3).

Vansda National Park Situated in the Navsari District of Gujarat state, India, covering the area of 23.09 sq.km. and with thick woodlands of moist deciduous forest of Dang in southern part of Gujarat State. The latitude and longitude of 20.7333° N, 73.4667° E respectively (Figure 4).

Sample collection and Methodology

The Soil Samples were collected from four National Parks mentioned above. The random soil sampling was done from the surface at the depth of 0-30 cm using GPS. Sampling Tool used was Hand auger. Samples were put in Plastic bags and immediately refrigerated in Laboratory. Estimation of SMBC using fumigation-extraction method (Aery, 2010) was adopted.

Calculation

The methodology of calculation is also adopted from Manual of environmental Analysis (Aery, 2010) which is as follows:

$$\text{Biomass C } (\mu g.g^{-1}) = (S-B) \times N \times 0.003 \times \frac{100+\theta}{X} \times \frac{1000}{V} \times 1000$$

Where,

S= sample titration, mL

B=blank titration, mL

N=normality of ferrous ammonium sulphate solution

X= weight of soil in grams

V= aliquot used for soil digest measured in mL

θ= weight of water per 30 g fresh soil.

Microbial biomass C = ($C_{fumigated} - C_{control}$)

The bulk density was calculated for each site. Bulk Density calculations adopted from (Cress well and Hamilton, 2002). Accordingly the total amount of SMBC available in the entire National Park was calculated using the mean of all the sites and the average bulk density.

Bulk Density (p) = Bulk density (g/cm^3) = Dry soil weight (g) / Soil volume (cm^{-3})

Site Wise calculations were done for individual samples for estimating SMBCD and SMBCS in all four National Parks. SMBCD = SMBC × Bulk density and SMBCS = SMBCD × AREA

Analysis of Results was done using Microsoft Excel in the computation and accordingly, using the above formula park wise SMBCD and SMBCS calculation was done.

The amount of site-wise SMBC obtained in four National Parks is shown with graphs which also show the comparison between sites in respective parks (Table 1 and Figure 11).

Gir National Park

The total amount of available Soil Microbial Biomass Carbon was found 590.3 Kgs in Gir National Park. The site 16 showed highest amount of SMBC, which indicates that the soil of this site contains favourable conditions for microbial biomass growth and site 19 showed least amount of SMBC indicating less numbers of microbial organisms so soil of that site has less favourable contents for growth of microbial biomass (Figure 6).

Velavadar National Park

The total amount of available Soil Microbial Biomass Carbon was found 67.9 Kgs in Velavadar National Park. The site 1 showed highest numbers of SMBC, which indicates that the soil of this site contains favourable conditions for microbial biomass growth and site 3 showed least amount of SMBC (Figure 7).

Marine National Park

The total amount of available Soil Microbial Biomass Carbon was found 226.6Kgs in Marine National Park. Maximum numbers of SMBC was found in site 6 whereas Site 3 showed the least amount of SMBC (Figure 8).

Vansda National Park

The total amount of available Soil Microbial Biomass Carbon was found 36.16 Kgs in Vansda National Park. Number of SMBC found in Vansda National Park showed that the soil of site 1 only has appropriate conditions for SMBC to be present compare to other sites (Figure 9).

Gir National Park is dry deciduous forest. Since area of the park is 258.71 sq.km and also being the largest of four National Parks and collection of the Samples was done in winter, the stock obtained is highest as 590.3 kg of amount of SMBCS in the park. 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 (Yadav Richi, 2012).

Marine National Park is scrub forest dominated by mangroves, covering area of 162.89 sq. km. showed higher amount of SMBCS as 226.6 kg which is more than expected but since the samples were collected in winter, the growth of algae was maximum which may be the reason for higher amount of SMBCS. Velavadar National Park is tropical dry deciduous grassland and since grassland does not contribute much to macro biomass and area is also not substantial being 34.08 sq.km. Therefore, amount of SMBCS is 67.91kg seems to be appropriate.

Finally, Vansda National Park is moist deciduous forest and area 23.09sq. km., the process of decomposition are high but the area of Vansda National Park is too less compared to other National Parks. Therefore amount of SMBC is 36.16kg. In a disturbed ecosystem, soil carbon pool is away from its steady state and the magnitude from the steady state accordingly indicates the disturbance intensity (Gong, 2004). Thus, SMBC in Vansda was less than expected due to disturbance in the said area.

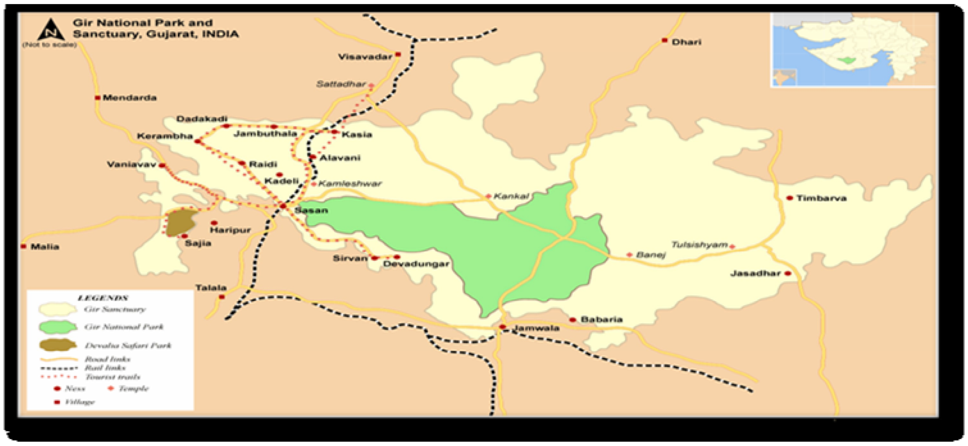

Figure.1 Map showing highlighted Gir National Park

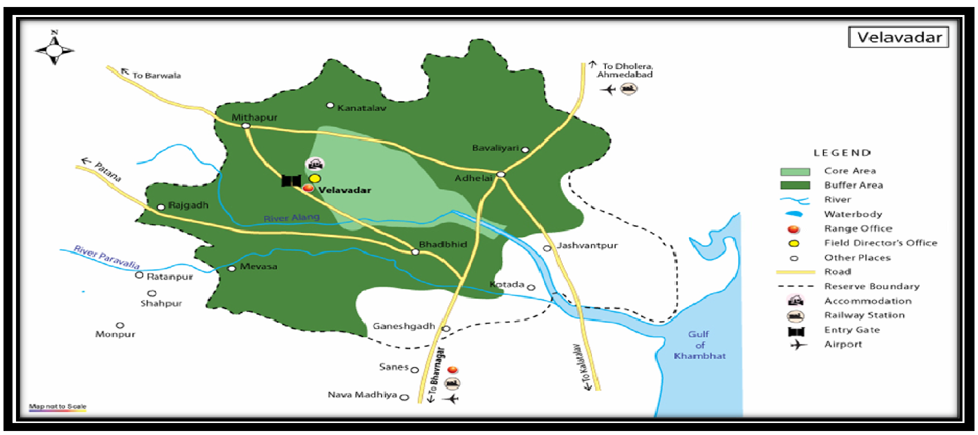

Figure.2 Map showing highlighted Velvadar National Park

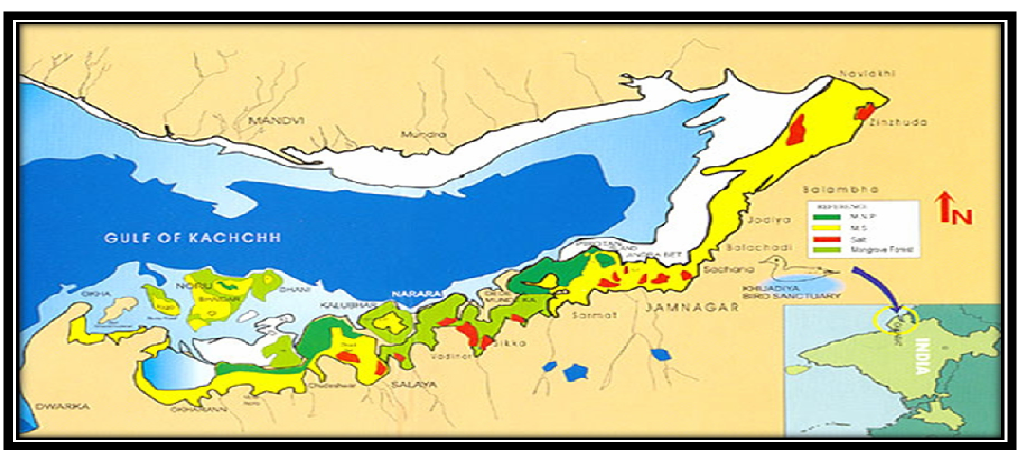

Figure.3 Map showing highlighted Marine National Park

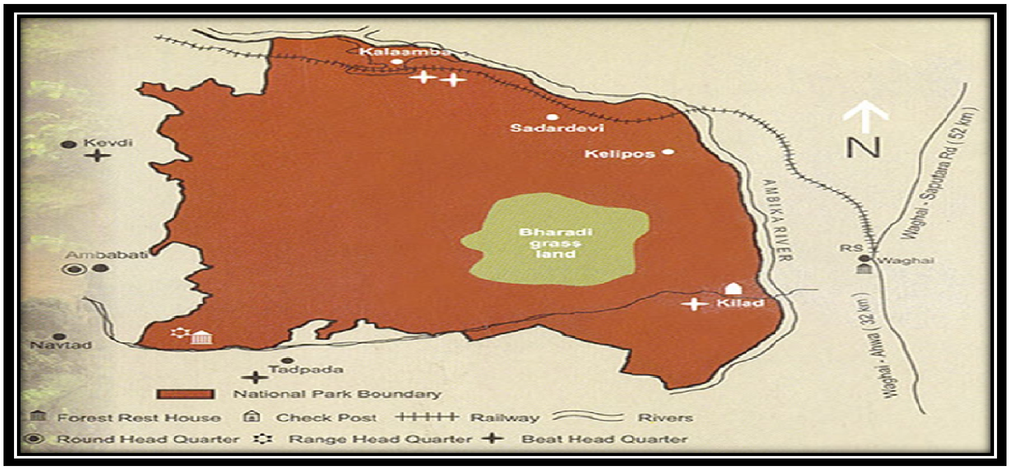

Figure.4 Map showing highlighted Vansda National Park

Figure.5 Vacuum desiccators showing control and treatment; Using 2-3 drops of 1,10 phenanthroline as indicator, and the colour changes from bluish-green to reddish-brown

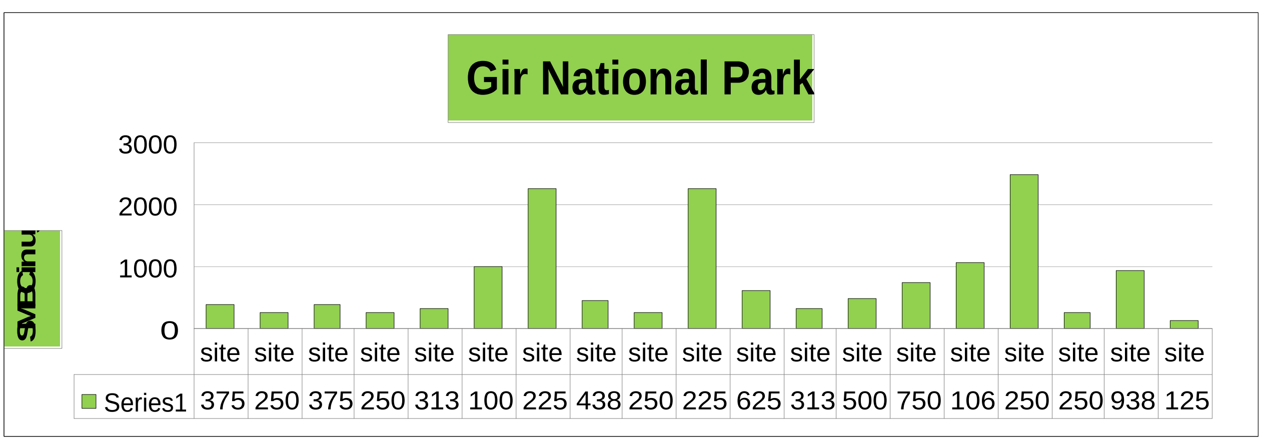

Figure.6 Site wise numbers of SMBC present in Gir National Park

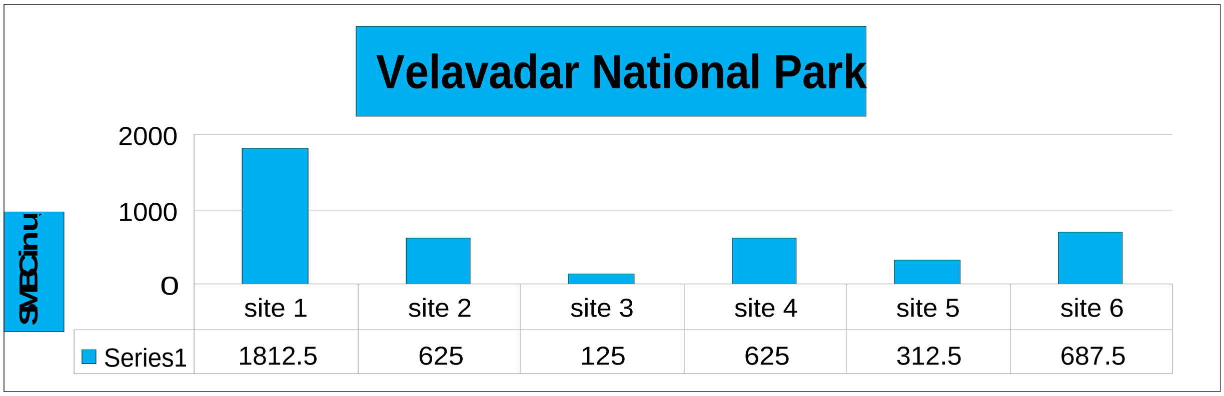

Figure.7 Site wise numbers of SMBC present in Velavadar National Park

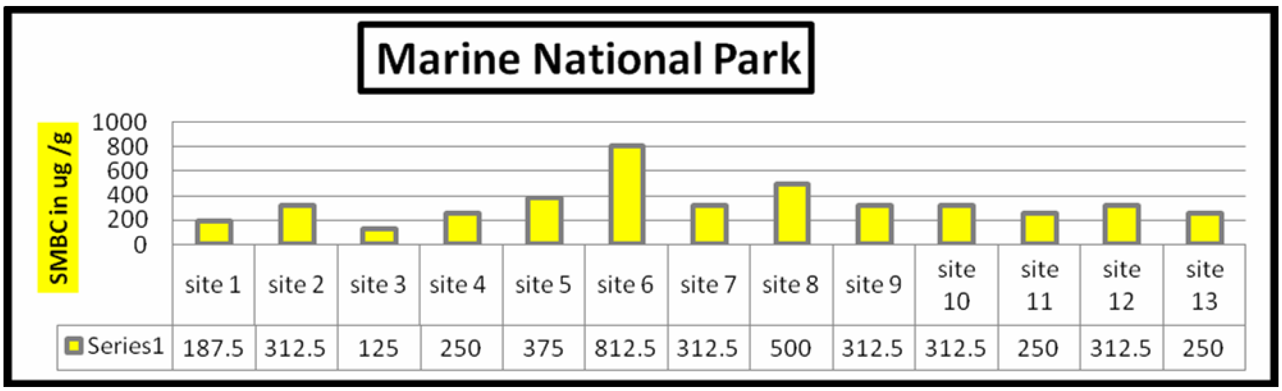

Figure.8 Site wise numbers of SMBC present in Marine National Park

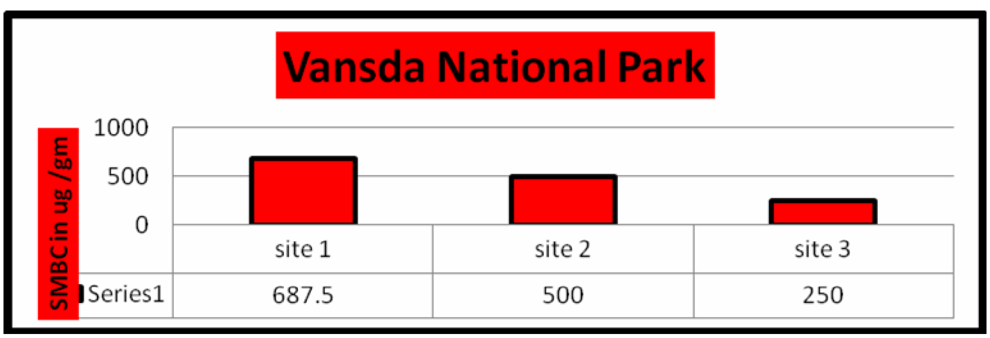

Figure.9 Site wise numbers of SMBC present in Vansda National Park

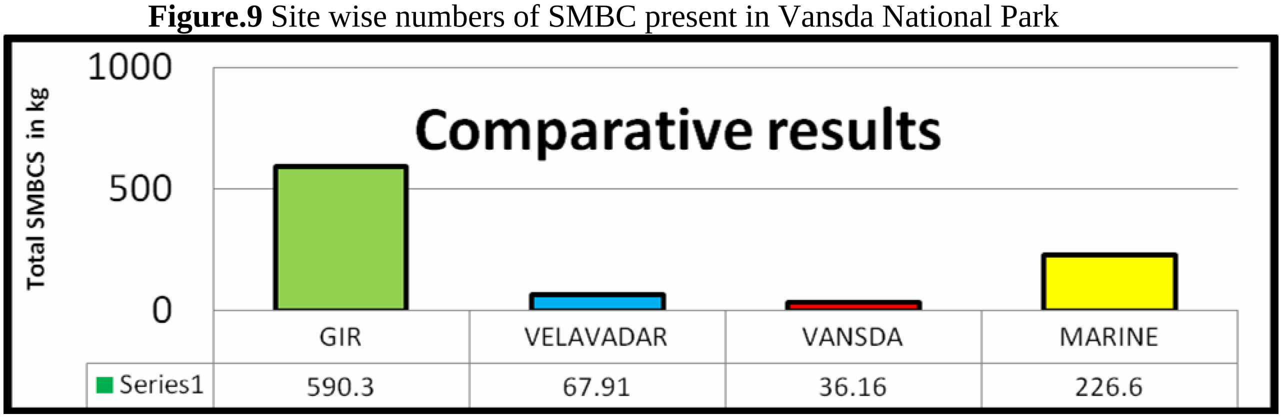

Figure.10 Comparative SMBC of Gir, Velavadar, Vansda and Marine National Parks

Table.1 Comparative SMBC Stock Results in kgs

Parameter(Units)	Gir	Velavadar	Marine	Vansda
SMBC(ug/gm)	779.61(±724.44)	697.92(+536.93)	479.17(+163.32)	331.73(+179.21)
SMBCD(ug/cm^3)	16340.62	663.02	498.33	424.61
SMBCS(kgs.)	590.3	67.91	36.16	226.6
BD (gm/cm^3)	0.96	0.956	1.04	1.28

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