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Soil organic carbon (SOC) in selected sacred groves from Bhor region of western ghats, Maharashtra

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ABSTRACT : Western ghats of Maharashtra represents several sacred groves. Sacred groves are ideal ecosystems of a particular geographical area and represents unique floristic and faunal composition. Sacred groves are often studied from floristic and faunal view point. Present attempt is based on soil organic carbon estimation from four selected sacred groves situated in Bhor region of Pune district. These are – Somjaichi Rai, Maulidevichi Rai, Nivaganjaichi Rai, and Umberjaichi Rai. Rai is a local term used for sacred grove. Soil organic carbon in each sacred grove varied depending on decomposition of leaf litter as well as amount of biomass. In Somjaichi Rai the amount of soil organic carbon was 66.25 tonnes/ha while in Maulidevichi Rai it was 65.88 tonnes/ha; whereas in Nivganjaichi Rai it was 138.67 tonnes/ha and in Umberjaichi Rai it was 101.12 tonnes /ha.

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Key Words :
Soil organic carbon, Sacred groves, Western ghats, Bhor region

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Sacred groves are one of the traditional methods of wildlife conservation based on religious ground. The size ranges from small group of trees to one acre to 10-15 acres. In India, a large number of sacred groves have been reported from Andhra Pradesh, Karnataka, Maharashtra, Madhya Pradesh, Uttar Pradesh, Gujrat, Tamil Nadu, West-Bengal, and Orissa (Kunhikannan and Singh, 2005). Western ghats of Maharashtra represents more than 400 sacred groves and high tree species diversity (Kulkarni *et al.*, 2015). Highest number (> 109) has been reported from Pune district alone. The Sacred groves from Pune district were surveyed for various aspects. Detailed floristic account of sacred groves in Panshet and Varasgaon dam site was recorded by Vartak and Gadgil (1981); Kulkarni and Kumbhojkar (1999) and Tetali and Gunale (1990). Dhup rahat sacred grove was studied by Kulkarni and Nipunage (2009). Kulkarni and Shindikar (2005) reported plant diversity in Shirkai sacred grove. Quantitative plant diversity of monotypic sacred groves from Pune district carried out by Kulkarni *et al.* (2013). Sacred groves from Bhor region reported by Kulkarni *et al.* (2010) and Hangarge and Kulkarni (2012) pointed out role of forest conservation. In recent years carbon sequestration of tree resources has been carried out by Hangarge *et al.* (2012) from Somjaichi Rai (Sacred grove) at Nandghur village, Bhor taluka of Pune district. Kulkarni and Kulkarni (2013) have worked on Kalamvihira sacred groves from Jawhar taluka of Palghar district. Apart from sacred groves, Shinde and Mahajan (2015); Hamed *et al.* (2011) and Choudhari *et al.* (2014) have envisaged the role of urban parks, gardens and urban forests in carbon sequestration very well. Phansalkar and Kulkarni (2014) have made ecological survey of Anjawale sacred grove from Junnar taluka of Pune district and Nipunage *et al.* (2009) have made ecological survey of Malshejghat sacred groves.

Sacred groves in Maharashtra state are located in heavy rainfall area in Western ghats and low rainfall or rain shadow areas in eastern parts. Climatic conditions are varied and naturally affect the regeneration of plant species. Nipunage and Kulkarni (2011) studied natural regeneration of plant species in 19 sacred groves from Ambegaon taluka of Pune districts. Sacred groves in Western ghats of Maharashtra have very thick vegetation with large number of big trees and it provides ecosystem services to the local people, environmentalists, botanists, teachers and students, healers, etc. (Josh *et al.*, 2015).

Trees in sacred groves serve a variety of ecosystem functions including biodiversity conservations, removal of atmospheric pollutants, oxygen generation, microclimate regulation, stabilization of soil, ground water recharge, prevention of soil erosion and carbon sequestration (Lal, 2004). The present study has been carried out on estimation of soil organic carbon from selected sacred groves of Bhor taluka, dist-Pune, India. This data will be a new dimension for conservation point of view and revitalize their traditional ecosystem. The soil organic carbon deposited through the decaying of bio-resources in sacred groves has been studied in detail. Present paper deals with SOC in four selected sacred groves from Bhor region of Western ghats.

EXPERIMENTAL METHODOLOGY

Study area :

Bhor taluka is located in hilly and remote Western ghat region covering an area about 892.0 sq.km. The Bhor town is located 55 km south of Pune city and between 18º.45' N latitude and 73º -15' E longitude. Elevation of Bhor from mean Sea level is 591.43 meters. The chief rivers in the taluka are Nira, Velvendi, Gunjawani and Shivganga which flow from west to east. Three major dams have been constructed namely Bhatghar, Nira-devghar and Gunjawani for irrigation purpose. It has 185 villages and total population is 171719 as per 2001 census. Out of this scheduled cast and scheduled tribe population is 10,917 (7576 + 3341). During the field work, soil samples were collected from 15 and 30 cm from four sacred groves (Table A) namely i) Somjaichi Rai at village Nandghur; ii) Nivganjaichi Rai at village Nivgan; iii) Moulidevichi Rai at village Varvand; and iv) Umberjaichi Rai at village Parhar.

Table A : Sacred groves under investigation

Name of sacred grove	Village name	Total area (ha)
Somjaichi Rai	Nandghur	50000
Nivganjaichi Rai	Nivgan	10000
Moulidevichi Rai	Varvand	20000
Umberjaichi Rai	Parhar	04375

Soil :

Black cotton soil :

Derived from Deccan trap which contains high proportion of aluminum and carbonate of calcium with variable amount of potash, nitrogen and phosphorus are found in black soil. It occurs in eastern part of Bhor, Nasarapur, Khedshivapur, Sarola and Bhongavali

.

Alluvial soil :

(Pale yellow to dark brown) deposited along the banks of different rivers.

Red soil :

It is found in the western part.

Brown soil :

It is common in Hirdoshi, Umbarde, Bope and Rayreshwar areas.

Estimation of soil organic carbon (SOC) :

Stocks of organic carbon in soil vary with land use systems. The share of soil organic carbon in the total carbon stock may vary from 50 per cent to 84 per cent in forests to 97 per cent in grasslands (Bolin and Sukumar, 2000). The concentration of organic carbon in soil is highest in the topsoil. Soil carbon dynamics is normally restricted to the top 15-45 cm, which is the zone of maximum microbial activity. Soil organic carbon is normally estimated to a depth of 0-30 cm since most of it is present in the top layers and root activity is also concentrated in this horizon.

The soil samples were analysed by Walkely (1947), Walkely and Black (1934) method as the most accepted method for SOC evaluation. Wet digestion or titrimetric determination method, which is also cost effective procedure is the most common method used in the field that involved a rapid titration procedure to estimate the organic carbon content of soil (Kalara and Maynard, 1991). Organic matter was oxidized with a mixture of $K_2Cr_2O_7$ and H_2SO_4. Unused $K_2Cr_2O_7$ was back-titrated with ferrous ammonium sulphate (FAS). Organic carbon in the soil is oxidized to CO_2. The percentage of soil organic carbon was calculated using following formula:

% of organic carbon in the soil = [(X-Y)/2*0.003*100]/S

where,

S= Weight of the sample in gram.

X= Volume of FAS used in blank in grams.

Y= Volume of FAS used to oxidize SOC in grams.

N= Normality of FAS.

(X-Y)/2= Volume of 1 N $K_2Cr_2O_7$ used for the oxidation of carbon

1 ml of 1 N $K_2Cr_2O_7$ = 0.003g SOC.

Measurement of bulk density parameters :

Soil bulk density was defined as the oven-dry weight of soil per unit of its bulk volume. Bulk density is considered to have relatively low spatial variability (the co-efficient of variation is less than 10%) but values were required for converting soil organic matter content to tonnes of soil organic carbon per unit area (tC/ha) (Baruh and Barthakur, 1997). Soil bulk density was determined by samples which were taken by driving a metal corer into the soil at the desired depths of 15 to 30 cm. The samples were then oven dried and weighed.

Bulk density (g/cc) = (W_2-W_1)/V

where;

W_1= (empty container),

W_2= (Soil+container) and

V = volume of container.

Field sampling involves two common statistical concepts, namely accuracy and precision (IPCC, 2003 and Pearson *et al.*, 2005). Accuracy is a measure of how close the sample measurements are to actual values. Precision is a measure of how well a value is defined. In the case of carbon inventory, precision shows how closely the results from different sampling points or plots are grouped.

Accuracy and precision reflect how well the measurements estimate the true value of tree variables such as diameter, height and area covered by a stand of tree. An unbiased estimate will depend on repeated measurements being similar (Precise) and averaging close to the true value (Pearson *et al.*, 2005).

EXPERIMENTAL FINDINGS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under the following heads :

Somjaichi Rai (sacred grove) at the Nandghur village :

Total 48 soil samples had been collected from 7500 m^2 sampled area. The samples were analysed and the amounts of SOC at 15 and 30 cm depths were recorded in Table 1.

As per Table 1 soil organic carbon at 30 cm depth is more than that of 15 cm depth. The average amounts of soil organic carbon recorded from sample plots at 15 cm and 30 cm were 1.73 tonnes and 4.14 tonnes, respectively. The maximum soil organic carbon at 15 cm and 30 cm depths was recorded for Q1 *i.e.* 1.875 and 4.39 tonnes, respectively. The minimum soil organic carbon was found in Q10 *i.e.* 1.56 tonnes at 15 cm and 3.89 tonnes at 30 cm depth. The total soil organic carbon at 15 cm depth was found as 20.762 tonnes/7500 m^2 *i.e.* in 12 sampled plots. The total soil organic carbon at 30 cm depth was found as 49.69 tonnes/7500 m^2 *i.e* in 12 sampled plots. The soil organic carbon (SOC) at 30 cm depth covers the total carbon from 0-30 cm layer of soil. Therefore, this amount of carbon was considered as the total SOC in 12 samples. After extrapolation, the SOC in Nandghur Sacred grove was 66.25 tonnes/ha (50000m^2) had been recorded as 331.26 tones.

Maulidevichi rai (sacred grove) at the Varvand village :

Total SOC in 5 sample plots = 20.59/3125m^2

Total SOC in 32 plots after extrapolation = 131.77 tonnes/20000m^2

Nivganjaichi rai (sacred grove) at the Nivgan village:

Total SOC in 3 sampled plots = 26 tonnes /1875 m^2

Total SOC in 16 plots after extrapolation = 139.2 tonnes/10000 m^2

Umberjaichi rai (sacred grove) at the Parhar village:

Total SOC in 2 sample plots = 2.64 tonnes/1250 m^2

Total SOC in 7 plots after extrapolation = 44.24 tonnes/4375 m^2

Table 1: Soil organic carbon (SOC) in selected sacred groves (tonnes)

Name of sacred grove	Somjaichi Rai		Moulidevichi Rai		Nivganjaichi Rai		Umberjaichi Rai	
Depth samples	15cm	30cm	15cm	30cm	15cm	30cm	15cm	30cm
Q1	1.875	4.39	1.52	4.19	2.5	8.7	1.85	5.79
Q2	1.775	4.11	1.30	3.74	2.8	8.9	2.00	6.85
Q3	1.807	4.32	1.56	4.35	2.4	8.5	--	--
Q4	1.860	4.35	1.37	4.09	--	--	--	--
Q5	1.660	4.16	1.45	4.22	--	--	--	--
Q6	1.715	4.08	--	--	--	--	--	--
Q7	1.610	3.92	--	--	--	--	--	--
Q8	1.545	3.95	--	--	--	--	--	--
Q9	1.675	4.09	--	--	--	--	--	--
Q10	1.560	3.89	--	--	--	--	--	--
Q11	1.835	4.14	--	--	--	--	--	--
Q12	1.845	4.29	--	--	--	--	--	--
Average	1.73	4.14	1.44	4.118	2.567	8.7	1.925	6.32
Extrapolated	331.26		131.77		139.20		044.24	
Tons/ha	66.25		65.88		138.67		101.12	
Total area (m^2)	50000		20000		10000		04375	

Conclusion :

Sacred groves are thick forest patches and leaf litter decomposes in the ecosystems that result into increase in soil organic carbon at 30 cm depth as compare to 15 cm depth. Present soil organic carbon in four sacred groves varies due to climatic conditions and soil depth. In Somjaichi Rai in 12 plots SOC was 49.69 tonnes/7500 m^2 while in Maulidevichi rai SOC in 5 sample plots was 20.59/3125m^2. SOC in 3 sampled plots of Nivganjaichi rai was 26 tonnes /1875 m^2 Umberjaichi rai SOC in 2 sample plots was 12.64 tonnes/1250 m^2. The sampling plot number varied due to size of sacred groves.

SOC levels result from the interactions of several ecosystem processes of which photosynthesis, respiration and decomposition are key factors. Photosynthesis is the fixation of atmospheric CO_2 into plant biomass. SOC input rates are primarily determined by the root biomass of a plant, but also include litter deposited from plant shoots. Soil C results both directly from growth and death of plant roots, as well as indirectly from the transfer of carbon-enriched compounds from roots to soil microbes. Many plants form symbiotic associations between their roots and specialized fungi in the soil known as mycorrhizae; the roots provide the fungi energy in the form of carbon while the fungi provide the plant with often-limiting nutrients such as phosphorus. Decomposition of biomass by soil microbes results in carbon loss as CO_2 from the soil due to microbial respiration, while a small proportion of the original carbon is retained in the soil through the formation of humus, a product that often gives carbon-rich soils their characteristic dark colour. These various forms of SOC differ in their recalcitrance, or resistance to decomposition. Humus is highly recalcitrant and this resistance to decomposition leads to a long residence time in soil. Plant debris is less recalcitrant, resulting in a much shorter residence time in soil. Other ecosystem processes that can lead to carbon loss include soil erosion and leaching of dissolved carbon into groundwater. When carbon inputs and outputs are in balance with one another, there is no net change in SOC levels (Ontl and Schulte, 2012).

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