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Dynamics of soil organic carbon and soil texture in Marine National Park, Gujarat

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Abstract- The soil carbon stock can surely be taken as one of the important parameter in deciding strategies for management of different soils falling under different physiographic region of the country. In this paper, a soil database of topsoil estimates of soil organic carbon and soil organic carbon stock for Marine National Park, Gujarat is highlighted. Along with soil organic carbon stock, its correlation with the texture of the soil is also established.

Index Terms- Soil organic carbon (SOC), Carbon Sequestration (CS), top soil, global change, bulk density, Soil texture.

I. Introduction

Soil is one of the three major natural resources. Soil is made up of three main components- minerals that come from rocks below or nearby, organic matter (SOM) and the living organisms that reside in the soil. SOM is formed by the biological, chemical and physical decay of organic materials that enter the soil system from sources above ground (e.g. leaf fall, crop residues, animal wastes and remains) or below ground (e.g. roots, soil biota). The elemental composition of SOM varies, with values in the order of 50 per cent carbon (Broadbent 1953), 40 per cent oxygen and 3 per cent nitrogen, as well as smaller amounts of micronutrients. Thus, SOC is the main constituent of Soil organic matter. (Schuur et al., 2001) found that the top soil (0-20 cm) total C of the different ages of the rehabilitated forest was significantly different from those of the subsoil (20-40 cm and 40-60 cm). This was due to the positive correlation of C and SOM. This suggests that the SOM is a source of C as C is stored in the soil profiles in the form of SOM (Brady and Weli, 2002).

Carbon is usually derived from weathering of the material/geology, the decomposition of plant and animal matter, or by addition through anthropogenic activities (Schumacher B.A., 2002). The soil organic C (SOC) plays an important role in the global C cycle. It is generally assumed that soils are the largest C sinks in terrestrial ecosystems. The carbon stock of soil equals 1500 Pg in the topmost 1 m soil layer (Eswaran, et al.,1993; Jobbágy and Jackson, 2000), and approximately 506 Pg (32 percent) of this is in the tropics (Eswaran, et al., 1993) and 160 Pg in Africa (Henry,et al., 2009). Sombroek et al., (1993) were able to estimate organic carbon stocks by FAO soil group and the soil carbon stock of the world. The first available estimate for forest carbon stocks (biomass and soil) for the year 1986, were in the range of 8.58 to 09.57Gt C (Ravindranath *et al.*, 1997, Haripriya, 2003; Chhabra and Dadhwal, 2004). The current estimate of Indian forest phytomass C pool are in the range of 2000-4400 T g C (Lal and Singh, 2000; Chhabra et al., 2003). Globally, soil C pools contain approximately 1550 Gt of organic C in the top 1m (from a total of approximately 2500 Gt C), and SOC sequestration the annual release from fossil fuel combustion (Lal, 2004; Houghton, 2005). The rate of soil organic carbon sequestration adoption of recommended technologies depends on soil texture and structure, rainfall, temperature, farming system and soil management. Organic matter binds to minerals, particularly clay particles, and a process that further protects carbon (Von Lützow et al., 2006). Key site-specific parameters influencing soil carbon dynamics are soil texture and foliar lignin content (schimel et al., 1994,) their results showed that soil carbon is related linearly to soil texture, increasing as clay content increases, that soil carbon stores and turnover time are related to mean annual temperature by negative exponential functions, and that heterotrophic respiration originates from recent detritus (~50%), microbial turnover (~30%), and soil organic matter (~20%) with modest variations between forest and grassland ecosystems. Soil texture is simply the relative proportion of sand, silt and clay in a given soil sampleing and thus is useful and important in identifying properties of soil characteristics such as water holding capacity, soil drainage and soil fertility. Feller, C., & Beare, M. H. (1997) came up with Physical control of soil organic matter dynamics in the tropics wherein they showed the role that soil physical properties (mineralogy, texture, and structure) play in regulating the accumulation and loss of SOM in tropical soils. They also showed the relationships between total SOM and soil physical properties like effects of climate and mineralogy on latitudinal gradients in SOM, interactions between texture and mineralogy as determinants of SOM storage. This will show its distribution among fractions and characterise its biochemical composition, bioavailability and turnover time.

II. Material and Methodology

Study area : India is lined with a 7500 km long coastline. Among the Indian maritime state, Gujarat state has the longest coastline extending to 1600 km. Marine national park is second largest covering more than 33% area amongst four national parks present in State of Gujarat.

This national park 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 of which we have explored Narara and Sikka for sampling purpose.

Random sampling of soil collection is done using GPS. The GPS points are decided randomly knowing the different eco-zone in the park and are decided according to the area of National Park which should be at least 25% of the area of National Park Published by FAO-Data. The soil samples are collected from on site at 3 different depths: 0-10cm, 10-20cm, and 20-30 cm in the month of February 2012. For the estimation of Total Soil Organic Carbon from soil, wet digestion titrimetric method (Walkley and Black, 1934), was adopted. The correction factor of 1.33 was applied as mentioned in Krishnan G. 2009). For Soil Texture analysis, spread soil on a newspaper to dry. Remove all rocks, trash, roots, etc. Crush lumps and clods and then followed the methodology in (Gupta P.K., 2006).

Calculation for the experiments is as follows: The formula for estimation of Organic carbon (OC) used was as follows:

$$\% \text{ easily oxidizable OC} = \frac{(B-S) \times M \text{ of } Fe^{2+} \times 12}{100 \times 4000} \times \text{Sample gram of soil}$$

12/4000 = 0.003 is the miliequivalent weight of soil, B blank burette reading, S sample burette reading, M of Fe^{2+} is Molarity of Fe^{2+} = 0.5 N and Sample gm of soil taken was 0.5 gm

Obtained amount of OC is multiplied by Conversion factor of 1.32 to get the actual amount of underestimated SOC (Krishnan G., 2009).

The SOC density (SOCD) for each interval was then calculated using the following equation:

$$SOCD = SOC \times BD \times h$$

Where SOCD = Soil Organic Carbon Density (t/ha)
SOC = Soil Organic Carbon Concentration
BD = Bulk Density (gm/cm^3) and
h = soil depth for the interval (e.g. 0-10 cm, 10-20 cm and 20-30 cm)

The SOCD of 0-10 cm, 10-20 cm, and 20-30 cm were calculated and analyzed in this study. Using above values, SOC stock (SOCS) was also measured using the following formula.

$$SOCS = SOCD \times AREA / 10^{10}$$

The bulk density was estimated for every sample. Bulk Density calculations adopted from (Cress well and Hamilton, 2002). Accordingly the total amount of SOC 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})

Soil texture was obtained by methodology as followed from Gupta P.K. (2006). Relationships between SOC concentration in the near surface layer and at depth were determined by regression analysis. Correlation of SOC with different parameters like BD, EC and pH were also analyzed.

III. Results and Discussion

The results and graph of (1.) Available Total Oraganic Carbon and (2.) Soil texture of Marine National Park describes about both parametres briefly. The SOC level of all the samples in this study ranged from 0.04-2.39 in percentage. The mean organic carbon was 0.47 (± 0.055) percent. The maximum mean was present in samples analyzed at the depth of 0-10 as 0.48(±0.10) percent, followed by 0.47(±0.094) percent. Therefore depth wise, the highest SOC 1.19% being present in layer 1 i.e., 0-10cm and lowest in 0.04% in layer 3 i.e., 20-30cm. The Narara sites showed OC values obtained in the range of 0.08-0.59 % whereas Samples from Sikka showed values varying from 0.44-1.19%. That means OC values were low in samples taken from Narara as compared to samples collected from Sikka. The following graph shows the available total organic carbon in Marine national park at Narara and Sikka site. As seen for SOC results, SOCD values obtained also showed uniformity site-wise. The SOCD values were minimum of 0.40 gm/cm^2 found in the samples collected from depth 10-20cm and maximum of 13.40 gm/cm^2 in the upper layer 0-10cm. The statistical mean obtained for all three layers 5.32(± 1.15), 5.15(±1.07), and 4.69(±1.01) respectively for the depth of 0-10, 10-20 and 20-30cm.

SOC shows moderately weak negative correlation with soil pH (R= -0.623) and EC shows moderately positive correlation with soil OC as R=0.608. BD shows weak correlation with SOC. Normally it shows decreasing trend in the amount of organic carbon but few exception of site 5,6, 7 and the decreasing upper layer in high tide and low tide.

Average % of clay obtained is 1.03 followed by average % of silt as 39.2 and finally average % of sand obtained is 58.7. In Marine National Park the average % of clay is (P= 1) i.e. positively correlated with amount of total Organic Carbon followed by average % of silt which is (P = -0.762) significantly negatively correlated whereas the average % of sand is (P = 0.751) sparsely positively correlated with the amount of total available Organic Carbon of Marine National Park.

A pH range of approx. 6-7.5 promotes the most ready availability of plant nutrients. Highly alkaline pH values shows low decomposition rates increasing turn over times of nutrient. Though Marine National park show high amount of number of microbial species present (Bhatt et al., 2015) but, the pH in Marine National Park is alkaline in nature hence it signifies low decomposition rates as compared to Gir and Vansda National Parks.

IV. Conclusion

The determination of total organic carbon is an essential part of any site characterization or ecological assessment since its presence or absence can markedly influence how chemicals will react in the soil or sediment. Sites in Narara showed little less available organic carbon as compared to sites in Sikka. Presence of Mangroves and algal blooms in Narara surely affects the kind of soil microflora present therein (Bhatt et al., 2015) and that inturn affects the amount of Soil microbial biomass carbon (Bhatt and Banmeru, 2014) affecting decomposition rates of SOC. The overall SOCS stock was found to be 24.56 Tg of Soil organic carbon in total area of 162 sqaure kilometers of the national park. We can surely conclude that the amount of SOC shows decreasing trend with the depth. pH in Marine National Park is alkaline in nature hence it signifies low decomposition rates. Climate affects SOC amount as it is a major determinant of the rate of decomposition and therefore the turnover time of C in soils. Soils with high clay content therefore tend to have higher SOC than soils with low clay content under similar land use and climate conditions.

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Figure 1 Graph showing Marine National Park covering second largest area amongst National parks of Gujarat.

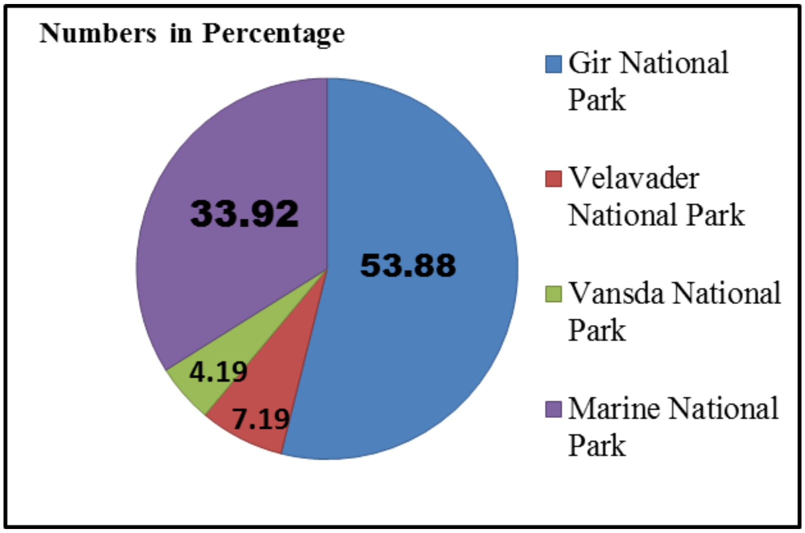


Figure 2 showing site of Marine national Park

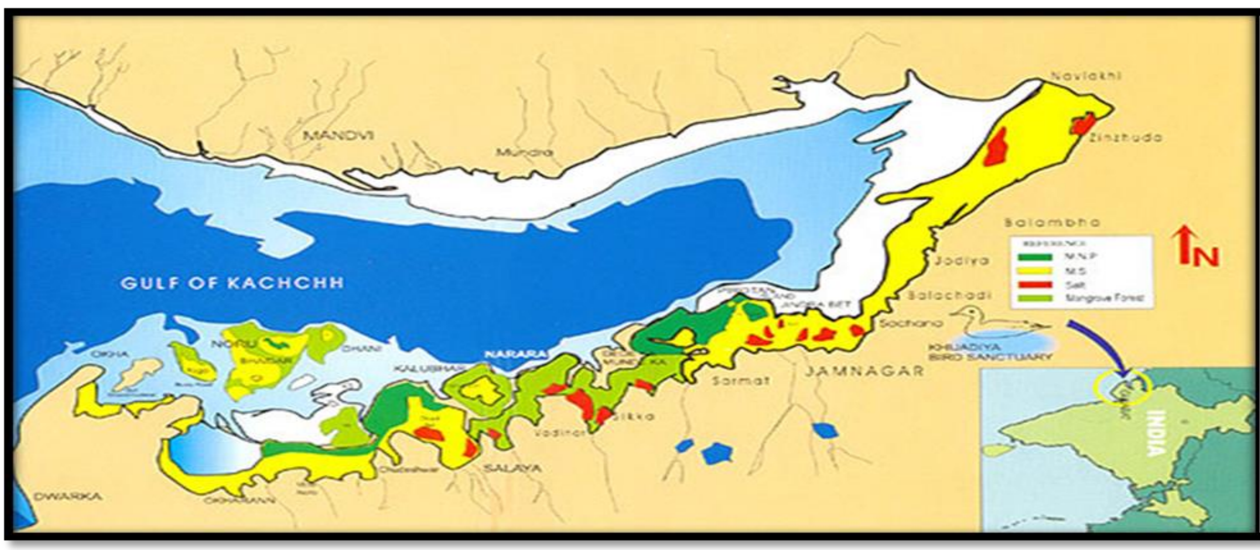
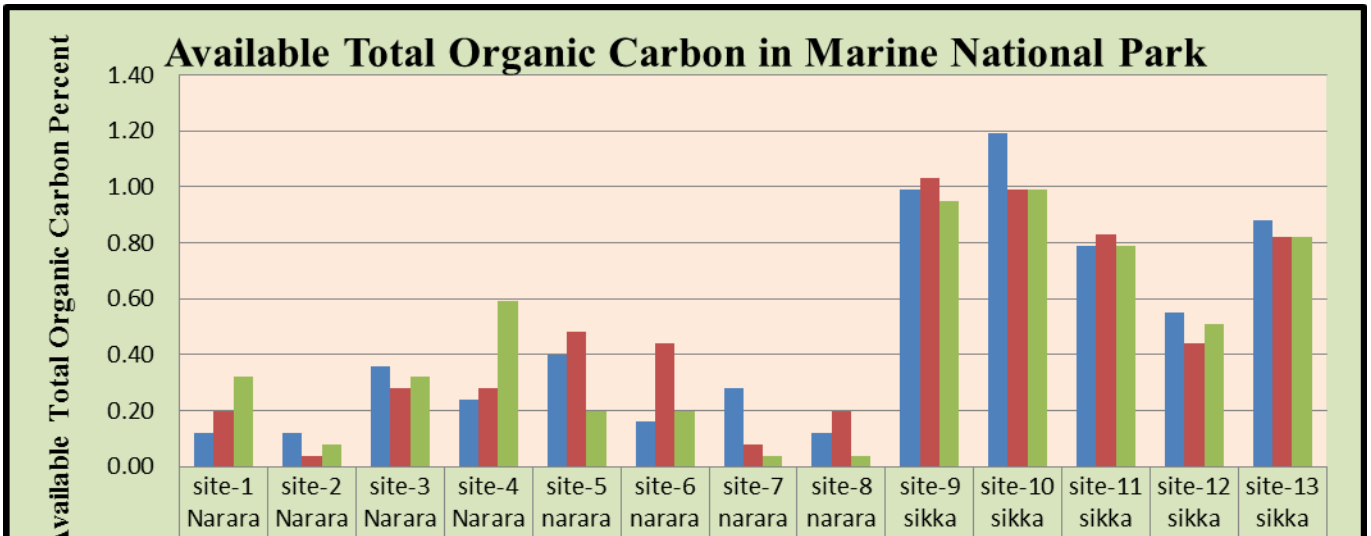
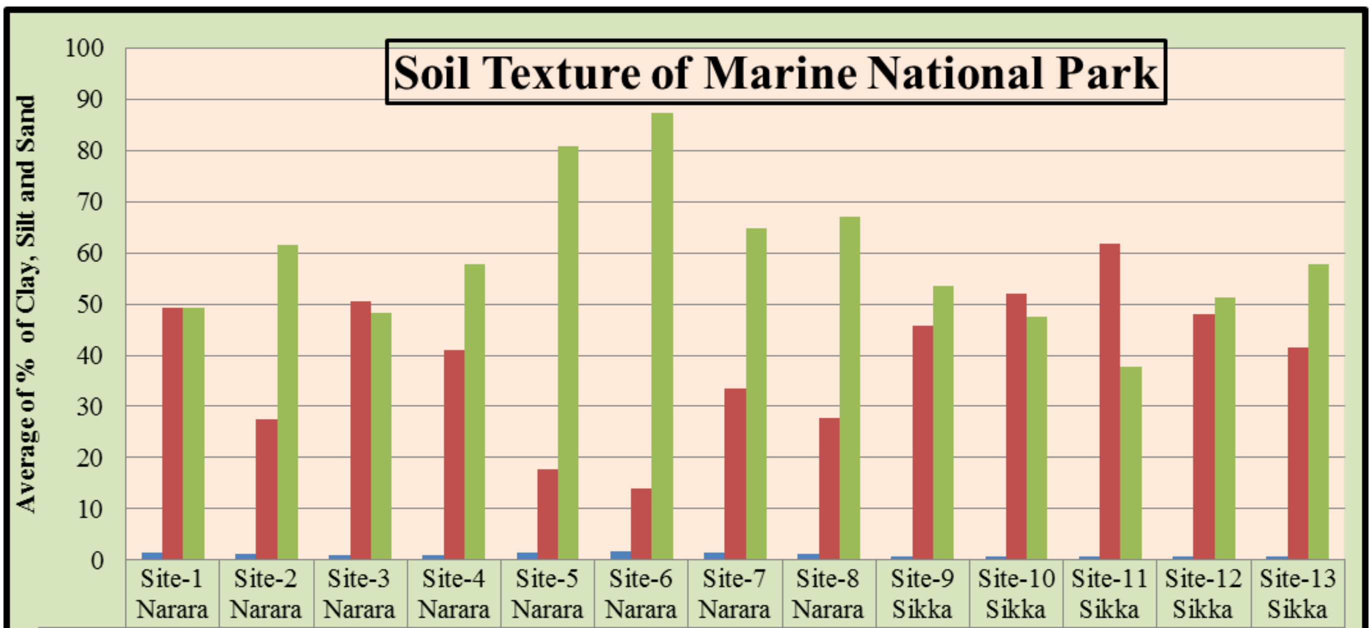


Figure 3 showing site wise available Organic carbon Percent at different Depths.



	site-1 Narara	site-2 Narara	site-3 Narara	site-4 Narara	site-5 narara	site-6 narara	site-7 narara	site-8 narara	site-9 sikka	site-10 sikka	site-11 sikka	site-12 sikka	site-13 sikka
0-10cm	0.12	0.12	0.36	0.24	0.40	0.16	0.28	0.12	0.99	1.19	0.79	0.55	0.88
10-20cm	0.20	0.04	0.28	0.28	0.48	0.44	0.08	0.20	1.03	0.99	0.83	0.44	0.82
20-30cm	0.32	0.08	0.32	0.59	0.20	0.20	0.04	0.04	0.95	0.99	0.79	0.51	0.82

Figure 4 sitewise average Percentage of Clay, Sand and silt.



	Site-1 Narara	Site-2 Narara	Site-3 Narara	Site-4 Narara	Site-5 Narara	Site-6 Narara	Site-7 Narara	Site-8 Narara	Site-9 Sikka	Site-10 Sikka	Site-11 Sikka	Site-12 Sikka	Site-13 Sikka
Clay	1.45	1.21	0.97	0.91	1.52	1.64	1.32	1.19	0.65	0.69	0.62	0.64	0.64
Silt	49.2	27.6	50.6	41.1	17.6	13.9	33.6	27.7	45.7	52.06	61.8	48.06	41.6
Sand	49.2	61.5	48.3	57.8	80.7	87.3	64.9	67.06	53.4	47.4	37.7	51.2	57.7