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Carbon Sequestration Potential of the Soil of Jambughoda Wildlife Sanctuary, Gujarat

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Abstract- Gujarat is a western state of India which enjoys a tropical climate. The major concentration of forests is found all along the eastern border of the state and the hilly portion of Saurashtra. The Jambughoda Wildlife Sanctuary lies towards the eastern part of the state between the parallels of latitude 22-22'N and 22-28'N and the meridians of longitude 73-38'E and 73-44' E. The Sanctuary is spread over the Jambughoda and Halol Talukas of Panchmahals district and the Sankheda taluka of Vadodara district. The Sanctuary is spread over 130.38 Sq.Km. of undulating land with moist deciduous forest. This work deals with the analysis of soil samples collected from different areas of Jambughoda wildlife sanctuary. Stratified Random Sampling was employed to collect soil samples from surface as well as 10, 20 and 30 cm depths. The collected samples were analysed for macronutrients, micronutrients, organic carbon and organic matter. The amount of carbon sequestered was also calculated in kg/ha. Significant variations were seen in organic carbon content among samples collected from different places as well as from different depths. The average pH content of the soil samples was also measured.

I. Introduction

Carbon sequestration

Carbon management in forests will probably be the single most important agenda of the first half of the 21st century in India in the context of the greenhouse effect and mitigation of global climate change. (Ramchandran *et al*., 2007) According to the Intergovernmental Penal on Climate Change (IPCC), there has been an unprecedented warming trend during the 20th century. Carbon sequestration is a method for managing the amount of carbon dioxide ($C0_2$) that is released into the atmosphere by burning carbon-based fuels—predominantly carbon-rich petroleum fuels. In principle, carbon sequestration refers to storage of carbon that would otherwise be released into the atmosphere. The global biosphere absorbs roughly 2 billion tonnes of carbon annually, an amount equal to roughly one third of all global carbon emissions from human activity. Soil carbon sequestration is the process of transferring carbon dioxide from the atmosphere into the soil through crop residues and other organic solids, and in a form that is not immediately remitted (Umadevi & Thiyagarajan,2007). Most analyses till date of options for mitigating the risk of global climate change have focused on reducing emissions of carbon dioxide and other greenhouse gases (GHGs). Much less attention has been given to the potential for storing (or "sequestering") significant amounts of carbon in forests and other ecosystems as an alternative means of offsetting the effect of future emissions on GHG concentrations in the atmosphere.

Soil is one of the three major natural resources, alongside air and water. It is one of the marvelous products of nature and without which there would be no life. Soil is made up of three main components – minerals that come from rocks below or nearby, organic matter which is the remains of plants and animals that use the soil, and the living organisms that reside in the soil. The proportion of each of these is important in determining the type of soil that is present. But other factors such as climate, vegetation, time, the surrounding terrain, and even human activities (eg. farming, grazing, gardening etc.), are also important in influencing how soil is formed and the types of soil that occur in a particular landscape. The soil stores about 1500 Pg of carbon in its upper horizons worldwide (0-100 cm) (Sombroek *et al*., 1993; Batjes, 1996; Batjes,1998;) which is more than the amount of carbon that can be found in vegetation or in the atmosphere (FAO, 2001). Soils have a finite capacity to sequester organic carbon (OC) that is determined by soil texture and aggregation. Soil organic carbon levels increase with silt + clay content and the maximum level is achieved when soils are most highly aggregated, i.e. when they are not tilled. Tillage breaks aggregates and exposes soil organic carbon to biological decomposition. Loss of soil organic carbon is proportional to the intensity of tillage.

II. How is Carbon Sequestered in Soils?

Through the process of photosynthesis, plants assimilate carbon and return some of it to the atmosphere through respiration. The carbon that remains as plant tissue is then consumed by animals or added to the soil as litter when plants die and decompose. The primary way that carbon is stored in the soil is as ***soil organic matter (SOM).*** SOM is a complex mixture of carbon compounds, consisting of decomposing plant and animal tissue, microbes (protozoa, nematodes, fungi, and bacteria), and carbon associated with soil minerals. Carbon can remain stored in soils for millennia, or be quickly released back into the atmosphere. Climatic conditions, natural vegetation, soil texture, and drainage all affect the amount and length of time carbon is stored.

III. REVIEW OF LITERATURE

According to **Ramchandran *et al*., (2007)** Carbon management in forests will probably be the single most important agenda of the first half of the 21st century in India in the context of the greenhouse effect and mitigation of global climate change.

Soil carbon sequestration is the process of transferring carbon dioxide from the atmosphere into the soil through crop residues and other organic solids, and in a form that is not immediately remitted **(Umadevi and Thiyagarajan, 2007).**

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According to **Haripriya, (2001)** Forest ecosystem includes three carbon pools: live biomass, dead biomass and mineral soils. The live biomass carbon represents all living tree and plant biomass. The dead biomass pool consists of carbon in detritus, forest floor, standing dead trees and coarse woody debris. The mineral soil pool consists of soil organic matter in the top 30 cm. The deeper soils also have appreciable carbon stocks but they are generally much less impacted by different disturbances than the topsoil layers.

According to **Sombroek et al., (1993); Batjes, (1996); Batjes, (1998)** the soil stores about 1500 Pg of carbon in its upper horizons worldwide (0-100 cm) which is more than the amount of carbon that can be found in vegetation or in the atmosphere. (**FAO,2001)**.

According to **Bhattacharya *et al.*, (2008)** the method of Walkley and Black has been an acceptable analytical technique to generate soil organic carbon data by weight to volume. The datasets (SOC, SIC, BD, areal extent of soil series) were brought to the required format for 0–0.3, 0–0.5, 0– 1.0 and 0–1.5 m of soil depth.

For India **Ravindranath *et al.*, (1996)** has estimated the net emission of carbon from the forest sector for the year 1986 based on the COPATH model developed by Makundi *et al.* (1996) and concluded that Indian forests could sequester around 5 Tg C (1 Tg = Tera gram (1012g)). Another recent study in India by **TERI (1998)** used the **IPCC (1997)** methodology in preparing the carbon emissions inventory from orests. Their study found that the net emissions from land use change and forestry sector were 0.4 Tg for the year 1990. The results are not comparable as these studies vary in methodology and assumptions used to calculate the inventories.

Tarafdar *et al.*, (2006) has done study of Rajasthan, India and used (Walkely and Black, 1934) method for soil organic carbon analysis.

Six study sites had been selected by **Dinakaran and Krishnayya, (2008)** in and around the vicinity of the Shoolpaneshwar Wildlife situated in Narmada District, Gujarat, India. Soils are reddish-brown in colour and loamy, with different depths. They had collected samples from different depths and used the wet oxidation method for analysis of soil samples.

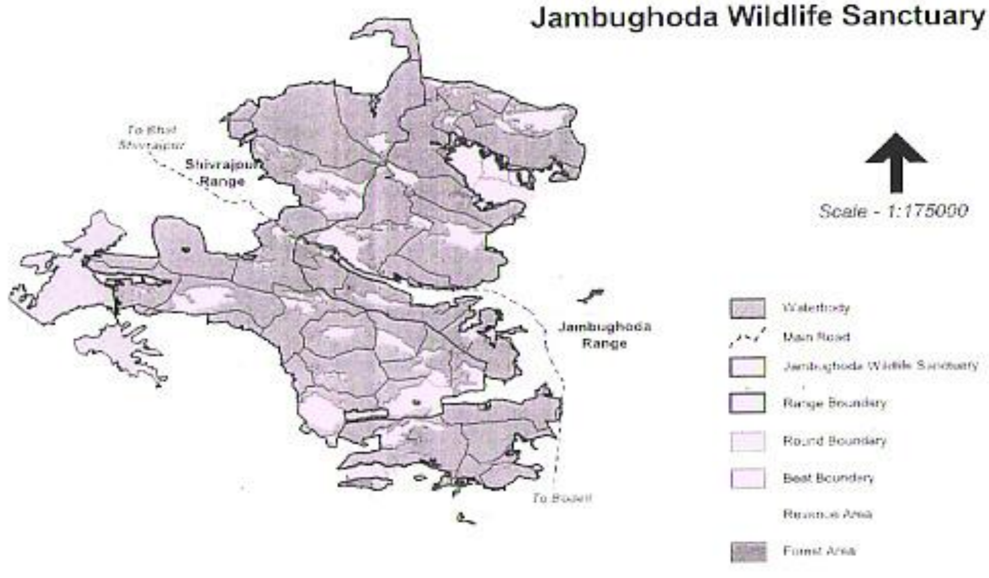
Study area which is selected by us is Jambughoda wildlife sanctuary situated in Panchmahals district, Gujarat, India. It is the sanctuary present in Jambughoda forest which is the dry deciduous forest. This paper shows the carbon sequestration potential of Jambughoda Wildlife Sanctury.

Gujarat

The state of Gujarat is on the Western Coast of India between the latitude of 20 01'N to 24 07'N and longitude of 68 04'E to 74 04'N E and has a 100 Km long Arabian sea-coastline with a total area of around 1,96,000 Sq. Km. The climate of the state is tropical; however, the same is considerably moderated due to the long coast line. The rainfall received in the state varies from region to region. The sun is often occluded during the monsoon season. Though mostly dry, it is deserted in the north-west, and wet in the southern districts due to a heavy monsoon season. Gujarat covers forest area which accounts up to 1,96,022 sq. km (FSI Report 2009).

IV. STUDY AREA

Jambughoda Wildlife Sanctuary



- **Study Area: Jambughoda Wildlife Sanctuary, Gujarat, India.**

The Sanctuary area is almost rectangular in shape and is spread over the Jambughoda and Halol Talukas of Panchmahals district and the Sankheda taluka of Vadodara district in Gujarat State. The entire area falls under the jurisdiction of Chhotaudepur Forest Division of Vadodara Forest Circle. On 22nd May, 1990, declared an area of 130.38 Sq.Kms. as Jambughoda Wildlife Sanctuary. It is of adequate, ecological, faunal, floral, geomorphologic, natural and zoological significance for the purpose of protecting, propagating and developing wildlife and its environment.

The climate is generally dry and, therefore, the humidity in the air is very less in most of the period of year. Due to steep slope and loose textured sandy soil, there is speedy runoff which results in quite high soil erosion in the area. Nevertheless, good vegetation cover and leaf litter have reduced the splash erosion to a large extent. The composition of vegetation in Sanctuary area varies greatly depending upon the soil, nature of slope, aspect, altitude and water retaining capacity of the soil.

- **Geology and Geomorphology :-**

Location: Jambughoda taluka, Panchmahal district, Central Gujarat

Sanctuary area: 130.38 sq. km

It is situated between(22-22 to 22-28'N - 73-38 to 73-44 E). The area of the Sanctuary is covered by numerous hills which rise above the plains which are about 50 Mts. High above MSL(Mean Sea Level) and the hills rise up to 280 to 320 Mts. The entire area is drained by small streams into Sukhi, Orsang and Dev rivers.

V. MATERIAL AND METHOD

Methodology:

We have selected the site for taking sample noted the name of that area. Than we took GPS point (latitude/longitude). After that we took the soil sample from the surface layer and put it in labeled zip lock plastic bag. Similarly we took soil sample from the depth of 10 cm, 20 cm and 30 cm and put it in labeled zip lock plastic bag. Likewise we took the samples from all the targeted places. Than analyzed the soil sample separately. (Harold Reetz)

Sampling Pattern

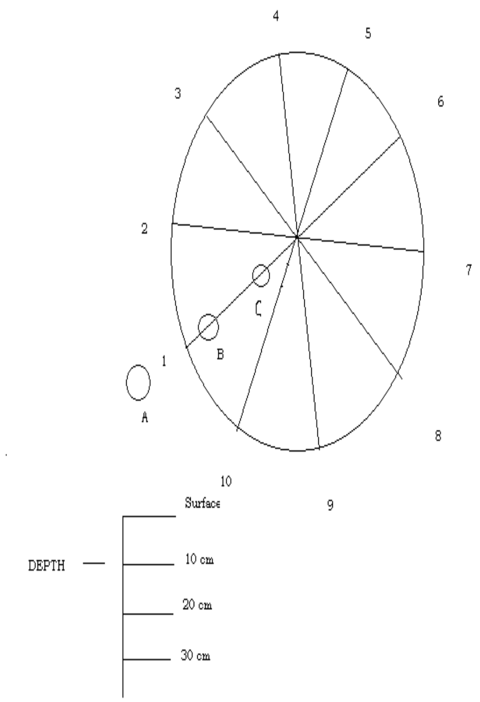


Figure 1

Figure 1 shows the type of sampling which is known "**Stratified random Sampling**". In this sampling we took the Sanctuary as circular shape. Sample "A" has been taken from the outside of the periphery of the Sanctuary. Sample "B" has been taken from the periphery of the Sanctuary and sample "C" has been taken from almost the center part of the Sanctuary. At all the sampling points we took 4 samples from the different depths. First from surface, second from 10 cm, third from 20 cm, forth from 30 cm.

VI. ANALYSIS OF SOIL

For the analysis of soil the soil samples must be dried in natural condition to remove moisture content from them. Figure 2 and figure 3 shows the samples which we had collected for our work.

Figure 2

Figure 2 shows the soil samples which we had put to let it dry.

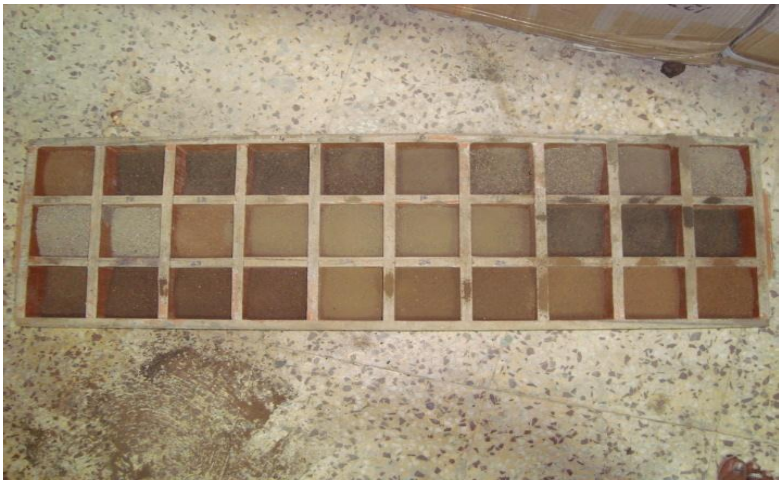


Figure 3

Figure 3 shows soil samples sieved and put into treys for analysis

- **Analysis of Org.-Carbon:-**

<u>Instrument</u>: Colorimeter

<u>Procedure:-</u>

Prepare one blank sample for calibration of Colorimeter. Blank sample do not contain soil sample in it but the other chemicals should be added same as in the mentioned in the procedure .Take 1.0 gm. Soil Sample in each conical flask and add 10 ml. 1N Potassium dichromate in it and stir it. After 30 minutes add 20ml.Conc. Sulfuric acid. Than after 2 hours add 20 ml. distilled water in all the samples. After 12 hour over night / Centrifuge take 15 to 20 ml. Solution into a Glass tub (Clear solution). Calibrate the colorimeter 0 to 100 reading red filter 660 nm using blank sample. Take readings and calculate org-carbon in % according to this formula:

Org.-Carbon in % = Reading * 0.008
Org,-Carbon in matter = Org.-Carbon % * 1.724
(IARI)

VII. RESULT AND DISCUSSION

In most of the soil samples average highest amount of carbon sequestration is in the surface layer. In the peripheral area of the sanctuary and at the central part of the sanctuary organic carbon content is higher. Location "B" which shows inside the sanctuary, away from the peripheral area shows lower amount of organic carbon. These areas contain hilly terrain therefore due to runoff some amount of the organic carbon content get removed and hence the area shows rocky soil due to erosion. Therefore near peripheral area and in almost the central part of the sanctuary the organic carbon content is higher. In the central part of the sanctuary human interference decreases so the leaves fallen from the trees and animal litter remains on the surface layer of the soil and due to microbial activity carbon content continue increasing in the surface layer. Therefore in all the locations organic carbon content is higher in surface layer.

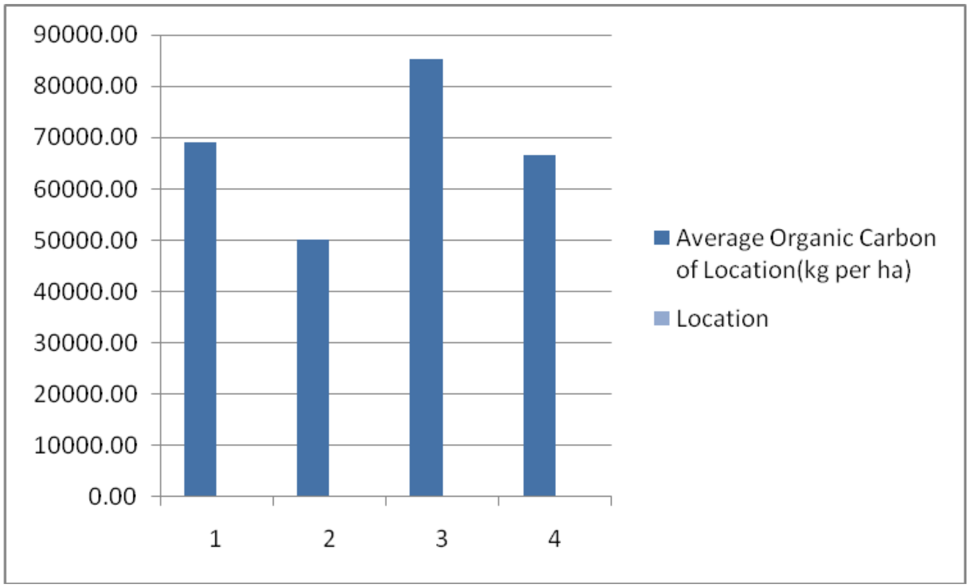


Figure 4

Location	**Average Organic carbon kg/ha**			
	Surface	**10 cm**	**20 cm**	**30 cm**
Average of Location "A"	**21547**	**18183**	**14413**	**14355**
Average of Location "B"	**18792**	**12412**	**13340**	**13543**
Average of Location "C"	**21605**	**19401**	**17632**	**17893**

Table 1.1

Location	**Average Organic carbon (kg/ha)**
Location 1	**68981.33**
Location 2	**50073.33**
Location 3	**85298.67**
Location 4	**66468.00**

Table 1.2

A, B, C are the locations(shown above in Figure 1) from where collection of samples have been done.
Table 1.1 shows the average organic carbon of the location A, B, and C from surface, 10 cm, 20 cm, 30 cm.
Table 1.2 shows average organic carbon (kg/ha) per location

Average organic carbon	Range of pH
54164.27 kg/ha	6.5 to 7.3

VIII. Conclusion

- **Highest** amount of carbon sequestration is in the **surface layer of soils** in the Sanctuary because humus content and microbial activity are higher in the surface layer.
- Location "B" which shows inside the sanctuary, away from the peripheral area shows lower amount of organic carbon. These areas contain hilly terrain therefore due to runoff some amount of the organic carbon content get removed and hence the area shows rocky soil due to erosion. Therefore near peripheral area and in almost the central part of the sanctuary the organic carbon content is higher.
- In the **central part** of the sanctuary **human interference decreases** so the leaves fallen from the

trees and animal litter remains on the surface layer of the soil and due to **microbial activity** carbon content continue increasing in the surface layer.

- **By this study** we got **location wise carbon sequestration potential of different layers of the soil** of Jambughoda Wildlife Sanctuary and we knew that the **highest amount** of **carbon sequestration** occurs in **surface layer** of the soil.

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