

# Carbon Sequestration in Soils of the Indo-Gangetic Plain



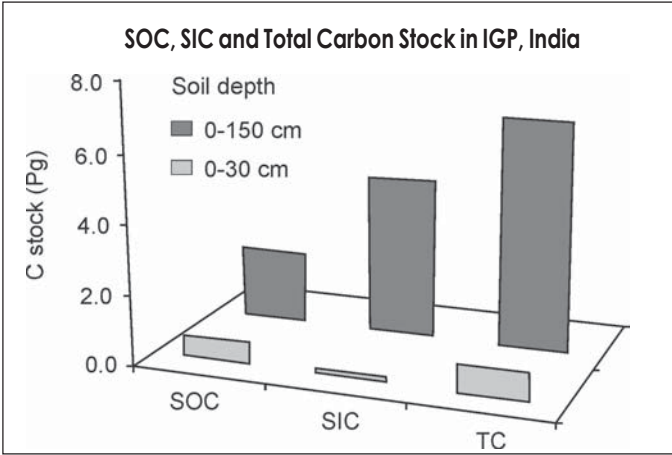
**T**he Indo-Gangetic Plain (IGP) of India, with about 13% geographical coverage, produces nearly 50% of the food grains for 40% of the total population of India. However, recently, there has been a general decline in soil fertility. Soils which earlier showed rarely single nutrient deficiency symptoms are now deficient in many nutritional elements. Long-term soil fertility studies have shown reduction in soil organic matter content, particularly in soils that had higher levels in earlier years (Abrol and Gupta, 1998).

The process of natural chemical degradation in soils of the semi-arid parts of the IGP is also proceeding at a fast rate. Attempts to increase and stabilize yields in arid regions by extension of irrigation, therefore, may fail if adequate care is not taken to prevent the menace of formation of calcium carbonate ( $\text{CaCO}_3$ ). The biology of soils has been gradually eroding resulting in reduced efficiency of applied inputs as a consequence of current aridic environments in parts of the IGP. Hence, the soils of the IGP of the Indian subcontinent require immediate attention for better carbon management.

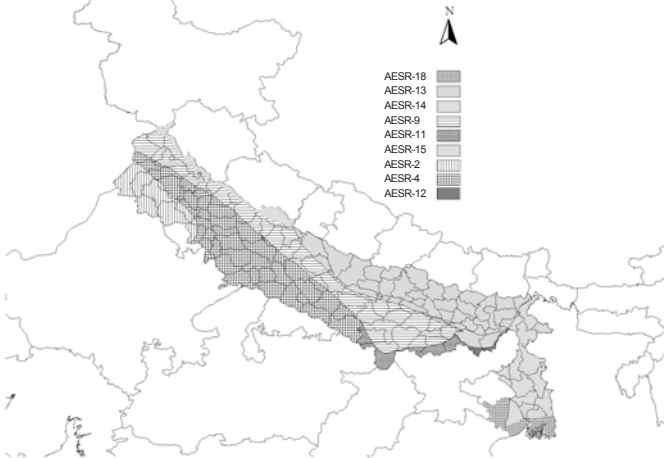
# Organic and Inorganic Carbon Stock

The total carbon stock includes soil organic carbon (SOC) and soil inorganic carbon (SIC). In India, the agro-ecological regions (AERs) 4 and 13 (hot, semi-arid and hot subhumid, moist) have the highest carbon stock followed by AERs 2, 9 and 15 (hot arid, hot subhumid, dry and hot subhumid, moist to humid) (Bhattacharyya *et al.*, 2001). The contribution of SOC stock in the overall total carbon stock decreases from 83% at 30cm soil depth to 30% at 150cm depth while the SIC stock increases. The areas under arid and semi-arid climate cover about 38% of the IGP. This climate induces decomposition of SOC but favors the accumulation of SIC, indicating an inverse relation between these two forms of carbon.

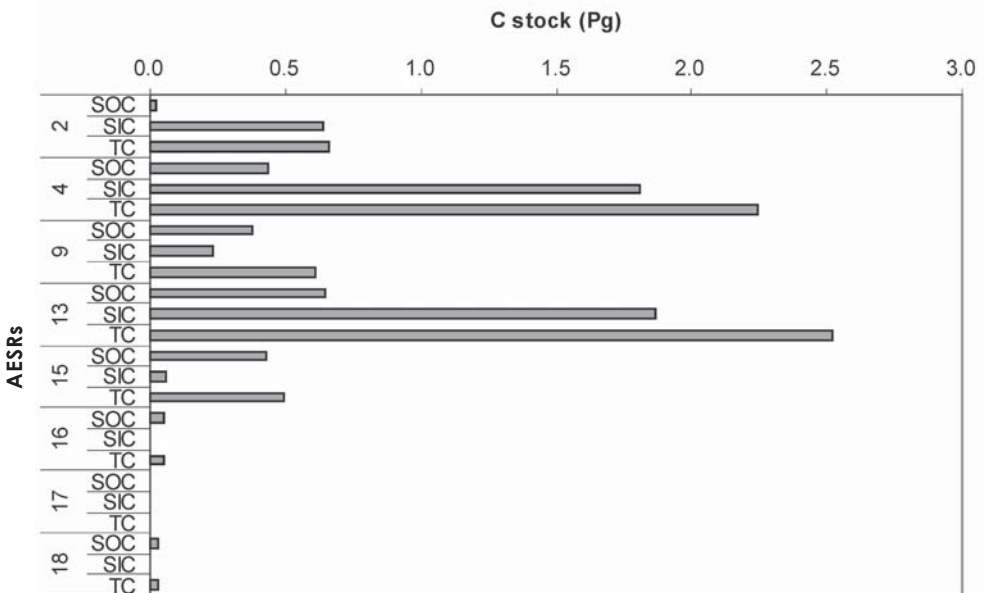
High calcareous IGP soils in arid and semi-arid ecosystem contain low SOC.



Indian IGP Showing Agro-ecological Sub-regions



Distribution of SOC, SIC and Total Carbon in Soil (0-150 cm depth) in Different AERS of IGP, India



## Carbon Removal and Restoration

High accumulation of SOC is related to vegetative cover supported by high rainfall. This is observed in the eastern part of the IGP under humid to perhumid AER. However, due to intensive agricultural practices, these areas have become impoverished in SOC over time. The cooler humid, and humid to perhumid climate is the most conducive situation for soils to be enriched in SOC as in Mollisols of the sub-Himalayan region, and in Central and Western India. This suggests that there is a greater scope of organic carbon sequestration of soils under semi-arid and humid tracts of the IGP.

Continuous application of farmyard manure and green manure in rice-wheat cropping system in sodic soils of the IGP has improved the organic carbon status substantially. The sequestration of organic carbon in these soils is also possible not only through agricultural practices but also through agroforestry and silviculture. The sustainability ratings of some soil series of the IGP for the rice-wheat cropping system indicate many soil constraints including low SOC.

Suitability of Different Soils for Rice and Wheat in the IGP, India							
AESR	Soil series	Rice	Wheat	AESR	Soil series	Rice	Wheat
2.1	Masitawali	S3sw	S2s	9.2	Basiaram	S2S1	S1
	Nihalkhera	S3sw	S2s		Itwa	S2S1	S1
2.3	Jassi Pauwali	S2sw	S3sw	13.1	Simri	S2S1	S2w
	Jodhpur Ramana	S3sw	S2sw		Akbarpur	N1n	N1n
4.1	Fatehpur	S3s	S3s	13.2	Bahraich	S2S	S2w
	Phaguwala	S2s	S3	15.1	Haldi	S2S1	S1
4.3	Zarifa Viran	N1n	N1n	15.1	Sasnaga	S2S1	S2w
	Ghjabdan	N1n	N1n		Konarpara	S2S1	S2w
	Bijapur	S2s	S1	Hangram	S1	S2w	
	Hirapur	N1n	N1n	Amarpur	S1	S2w	
	Sakit	N1n	N1n	Modhupur	S1	S2w	
9.1	Dhoda	S2sw	S1	15.3	Barak	S2S1	S1s
	Jagitpur	S3sn	S3n		Seoraguri	S1	S2w
	Bhanra	S3sw	S3sw	16.1	Singivila	S2S1	S2s
	Berpura	S2S1	S1		18.5	Sagar	S1

S1 = Suitable

S2 = Moderately suitable

S3 = Marginally suitable

N1 = Presently unsuitable but can be improved

s = Soil-related constraints (texture, structure, CaCO<sub>3</sub> content, depth and low organic carbon)

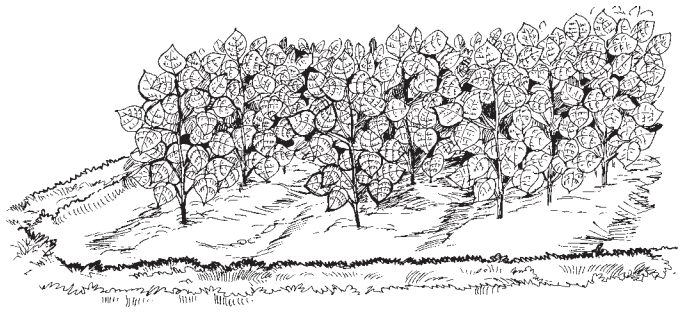
w = Wetness-related constraints (flooding and drainage)

n = Constraints related to salinity and alkalinity

Source: Velayutham *et al.* (1997)

## Organic and Inorganic Carbon Equation

The SIC in the form of  $\text{CaCO}_3$  is virtually immobile due to its insolubility in alkaline soil in arid and semi-arid environments. Therefore, this SIC stock is a source of available calcium for plants. By improving vegetative cover, these soils could be ameliorated with two-fold gains. Firstly, the vegetation itself will sequester soils with organic carbon and secondly, dissolution of  $\text{CaCO}_3$  through root exudates, will improve soil drainage with better soil structure.



## Perspective

The present scenario of temperature and shrinking of annual rainfall in the major geographical area of the IGP will continue to remain as a potential threat for soils of the region. The knowledge of SOC and SIC stock can, however, help in focusing areas of immediate rehabilitation for improving SOC. But the carbon stock equation vis-à-vis the cause-effect relationship of the various factors controlling both SOC and SIC stock in the IGP should be considered. Based on this, restoration of SOC balance and its follow up by enlarging the soil carbon pool by appropriate management techniques should form the strategic perspective for soils of the IGP.

## References

- Abrol, I.P. and R.K. Gupta. 1998. Indo-Gangetic Plains: Issues of Changing Land Use. LUCS Newsletter, No. 3. March 1998.
- Bhattacharyya, T., D.K. Pal, M. Velayutham, P. Chandran and C. Mandal. 2001. Total Carbon Stock in Indian Soils: Issues, Priorities and Management. pages 1-46 *In: Land Resource Management for Food and Environmental Security*. Soil Conservation Society of India, New Delhi, India.
- Velayutham, M., K.P.C. Rana, G.S. Sidhu, B.K. Kandpal, L. Tarsem, S. Singh and T. Bhattacharyya. 1997. Characterization of Agro-eco-subregions of the Indo-Gangetic Alluvial Plains for Sustainability of Rice-Wheat Cropping System. Presented at the Regional Technical Coordination Committee Meeting for Southeast Asian Countries held at Pokhara, Nepal, 25-26 June 1997.

Contributed by:

**T. Bhattacharyya and D. K. Pal**