Stable and radioactive carbon in Indian soils: implications to soil carbon dynamics

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by

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2011

CERTIFICATE

I feel great pleasure in certifying the thesis entitled "**Stable and radioactive carbon in Indian soils: implications to soil carbon dynamics**" by Mr. Amzad Hussain Laskar under my guidance. He has completed the following requirements as per Ph.D. regulations of the University

(a) Course work as per the university rules.

(b) Residential requirements of the university.

(c) Presented his work in the departmental committee.

(d) Published/accepted minimum of two research papers in referred research journals,

I am satisfied with the analysis of data, interpretation of results and conclusions drawn.

I recommend the submission of the thesis.

Date: 2011

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Countersigned by
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DECLARATION

*I Amzad Hussain Laskar, S/O Late Shamsul Huda Laskar, resident of E-204, PRL residences, Navrangpura, Ahmedabad - 380009, hereby declare that the research work incorporated in the present thesis entitled "***Stable and radioactive carbon in Indian soils: implications to soil carbon dynamics***" is my own work and is original. This work (in part or in full) has not been submitted to any university or institute for the award of a Degree or a Diploma. I have properly acknowledged the material collected from secondary sources wherever required. I solely own the responsibility for the originality of the entire content.*

Date: Amzad Hussain Laskar

(Author)

To my

Amma

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Amzad Hussain Laskar

Abstract

The mean residence time (MRT) of soil organic carbon has been estimated in ten soil profiles from three selected sites in India, with widely varying climate, geography and vegetation, based on the radiocarbon content of the soil. The MRT at the top 0-15 cm is about a century and increases with depth, reaching values ranging from 1 to 4 kyr at a depth of 100 cm. The MRT of soil organic carbon mainly depends on the soil texture or more precisely, the clay content; temperature dependence as expected by model studies is not very significant. Therefore, global warming may not alone stimulate this largest terrestrial carbon reservoir as predicted.

Stable carbon and oxygen isotopic composition (δ^{13}C and δ^{18}O) of carbonates and organic carbon in the soils and sediments have been used to reconstruct the paleoclimate and paeovegetation in the Lower Narmada valley, Gujarat, western India. The climate in the region was humid before the Holocene (15 - 10 kyr BP). It shifted to the sub-humid condition as the present day, sometimes before $\sim$3 ka. Two relatively arid phases are observed at around 2 and 1.3 ka, consistent with other proxy records. The vegetation was C3 during the late Pleistocene (15 - 10 kyr BP), shifted to mixed C3-C4 during the late Holocene and again to C3 very recently in most places. Probably the region was partially covered by tropical grasses (C4) in the late Holocene, which, because of anthropogenic disturbances, shifted to C3 in more recent times. The present day vegetation comprises mainly shrubs and woody plants, with tropical grasses only at limited places.

The Indian monsoon is a mesoscale weather system affecting a very densely populated area of the globe. It is important to reconstruct high-resolution paleoclimate for a better understanding of the monsoon and for modelling future climate. Stalagmites, one of the best land based climate proxies, from the Andamans, a region influenced by the Indian monsoon, have been used to reconstruct the late Holocene (last $\sim$3 kyr) climate, especially the monsoon rainfall variation in the region. The stalagmite recorded all the recent climate events. A significantly weaker Indian summer monsoon (less by 33%) compared to the present is

observed during 2.1-1.8 cal kyr BP, identified as the Roman warm period and is consistent with other proxy records. The strongest monsoonal activity is observed during the Medieval Warm period (1.3 - 0.9 cal kyr BP), while a slight weakening of the monsoon during the Little Ice Age (650 - 450 cal yr BP) is also observed.

Microbially respired CO_2 from the soil to the atmosphere is a major terrestrial carbon flux. Microbes decompose soil organic matter and either fractionate the isotopes kinetically or prefer isotopically lighter molecules. The Rayleigh model is widely used to study the evolution of the isotopic composition in a closed reservoir from which material is removed continuously, with isotopic fractionation. This model is modified incorporating a source term and applied to the soil system with organic matter from surface as input. The input is added without fractionation while decomposition causes fractionation with a continuous change in the residual isotopic composition of the reservoir. The model is useful to estimate the fresh input from the surface.

Key words: *radiocarbon, stable isotopes, mean residence time, paleoclimate, soil organic carbon, soil carbonate, speleothem*

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