SOIL CARBON SEQUESTRATION IN INDIA

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Abstract. With a large land area and diverse ecoregions, there is a considerable potential of terrestrial/soil carbon sequestration in India. Of the total land area of 329 million hectares (Mha), 297 Mha is the land area comprising 162 Mha of arable land, 69 Mha of forest and woodland, 11 Mha of permanent pasture, 8 Mha of permanent crops and 58 Mha is other land uses. The soil organic carbon (SOC) pool is estimated at 21 Pg (petagram = Pg = 1 × 10^{15} g = billion ton) to 30-cm depth and 63 Pg to 150-cm depth. The soil inorganic carbon (SIC) pool is estimated at 196 Pg to 1-m depth. The SOC concentration in most cultivated soils is less than 5 g/kg compared with 15 to 20 g/kg in uncultivated soils. Low SOC concentration is attributed to plowing, removal of crop residue and other biosolids, and mining of soil fertility. Accelerated soil erosion by water leads to emission of 6 Tg C/y. Important strategies of soil C sequestration include restoration of degraded soils, and adoption of recommended management practices (RMPs) of agricultural and forestry soils. Potential of soil C sequestration in India is estimated at 7 to 10 Tg C/y for restoration of degraded soils and ecosystems, 5 to 7 Tg C/y for erosion control, 6 to 7 Tg C/y for adoption of RMPs on agricultural soils, and 22 to 26 Tg C/y for secondary carbonates. Thus, total potential of soil C sequestration is 39 to 49 (44 ± 5) Tg C/y.

1. Introduction

Despite impressive gains in cereal production by India, from 50 million tonnes in 1947 to more than 219 million tonnes in 2000 (Swaminathan, 2000; FAO, 2001), there remain two serious but inter-related problems. One, expected food demand by 2050 is 300 million tonnes of cereals and must be met from the shrinking land resource base. Two, there are severe problems of degradation of soil and water resources leading to reduction in use efficiency of inputs (e.g., fertilizer, irrigation, tillage), pollution of surface and ground waters, and emission of greenhouse gases (GHGs) from soil/terrestrial/aquatic ecosystems into the atmosphere. Thus, the objective of sustainable development is to increase production per unit area, time and input; enhance quality of soil and water resources; and sequester carbon (C) in terrestrial and aquatic ecosystems leading to improvements in quality of natural resources (soil, water and atmosphere).

Climate change is among the major global issues of the 21st century. Anthropogenic activities have led to notable changes in the earth’s climate including...
increase in the global temperature over the 20th century by 0.6 ± 0.2 °C at an average rate of increase of 0.17 °C/decade since 1950, sea level rise over the 20th century of 0.1 to 0.2 m, increase in precipitation of 0.5 to 1.0%/decade, and increase in frequency of extreme events and heavy precipitation by 2 to 4% (IPCC, 2001). Climate change is attributed to increase in atmospheric concentration of several GHGs by fossil fuel combustion, land use change and deforestation, and human-induced soil degradation. Whereas the contributions of fossil fuel combustion to increase in atmospheric concentration of GHGs are known, those of terrestrial ecosystems are not widely recognized either in relation to emissions (by deforestation and soil cultivation) or C sequestration by ecosystem restoration, conversion to judicious land use and adoption of RMPs in managed ecosystems.

This manuscript reviews the status of soil resources of India, specifically addresses the issue of soil C sequestration through restoration of degraded soils and ecosystems and adoption of recommended practices (RMPs) on managed ecosystems, establishes a link between soil quality and soil organic carbon (SOC) concentration, and identifies policies towards sustainable management of natural resources for achieving food security and mitigating climate change.

2. Land Use and Soil Resources of India

The total geographical area of India is 328.7 million hectares (Mha) or about 2.5% of the total land area of the world (Table I). It is home to 1.1 billion or 16% of the world population. India is the second most populous and densely populated country in the world. Principal land uses include 161.8 Mha of arable land (11.8% of the world) of which 57.0 Mha (21.3% of the world) is irrigated, 68.5 Mha of forest and woodland (1.6% of the world), 11.05 Mha of permanent pasture (0.3% of the world) and 7.95 Mha of permanent crops (6.0% of the world). The large land base, similar to that of the U.S.A. and China or Australia, has a potential to sequester C and enhance productivity while improving environment quality. The Green Revolution of the 1970s needs to be revisited to enhance production once again and to address environment issues of the 21st century including climate change.

3. Soils of India and their Soil Carbon Pool

In accord with a wide range of ecoregions (Sehgal et al., 1990), India is also endowed with diverse soils of varying characteristics (Table II). Out of the total land area of 297.3 Mha, the principal soil types include 81.1 Mha of Alfisols (27.3%), 60.4 Mha of Vertisols (20.3%), 51.7 Mha of Inceptisols (17.4%), 36.6 Mha of Ultisols (12.3%), 24.8 Mha of Entisols (8.3%), 18.3 Mha of Aridisols (6.2%), 1.8 Mha of Mollisols (0.6%), and 0.8 Mha of Gelisols (0.27%). These diverse soils