Carbon Dynamics of Different Soil Types in Peri-Urban Lucknow, India

SUMMARY OF THE THESIS

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SUMMARY

1. Introduction

The express need to stabilize the concentration of greenhouse gases in the atmosphere is the biggest environmental challenge of this century; in order to control these concentrations. Humans can reduce the emissions of fossil fuels and determine the mechanism for removing them after they are released. This problem is phenomenal due to the size of the threats involved. Currently, industry, transportation and households emit nearly 10 Gt C into the atmosphere each year and there is no hope of immediate and significant reduction of these emissions for number of reasons. But the silver lining is two large ecosystem one acting as carbon sink and the other as carbon sequester namely ocean and the land or soil. Thus, sequestration of atmospheric carbon dioxide as organic carbon in the biosphere attracts attention as an alternate way to help stem the rate of greenhouse gas growth and associated changes in our climate. Since last two decades, researchers in the soil science community have studied and estimated the potential of sequestering carbon in soil organic matter. The premise is inherently rational: nearly 10,000 years of cultivated agriculture has reduced global soil carbon by 116 Gt, an amount equivalent to more than a decade of the present rates of industrial emissions. Soil health has become a scientific, technological, socio-cultural and even political priority because it can simultaneously solve some of the most pressing problems of our time, such as food insecurity and rising temperatures.

The concept of soil health includes the ability of the soil to support life (plants, microorganisms and insects), withstand environmental pressures (floods, droughts, erosion) and function as an integral part of the ecosystem (through biogeochemical cycles and processes). It can usually be classified in many ways from the perspectives of biological health. Agricultural conservation programs can improve soil quality by improving and maintaining land management practices in these three healthy categories. Some people believe that changing agricultural practices can recycle most of the carbon in domesticated soils, and therefore, can be used as an important tool for mitigating climate change in a wider time frame. Soils suggest that changes in agricultural practices may help restore large amounts of carbon in domesticated soils, thereby mitigating the effects of climate change. Secondly for variety of reasons Climate induced threats extend beyond food production in India. The agricultural sector employs more than half of India's 1.3 billion populations, meaning many people working in agriculture and young people looking for new jobs may find it harder to earn a living, hence along with employment. There is an urgent need to sustain employment growth in unorganized agricultural sector which employs a huge lot of young people almost 10 million-12 million people, joining the workforce every year. The real issue is to create good jobs for them to sustain their livelihood security.

2. Green House Gases (GHG) and Our Commitments

In the global frame the situation is equally complex as issues on important global environmental challenges with implications for food production, Green House Gases (GHG) emissions, health, energy and water supply etc. It is high time that the countries adhere to the climate efforts that they have by now committed because it could lead to long term temperature rise to around three degree Celsius one degree above the goal of limiting global warming to two degree Celsius is a matter of serious thought. Although a total of over 200 countries which represent about 95 per cent of global emissions have already submitted their Intended Nationally Determined Contributions (INDCs) on climate policy under the umbrella of the United Nations Framework Convention on Climate Change (UNFCC), in order to get prepared for new climate negotiations at Conference of Parties on Climate Change (COP 21) held at Paris.

The impacts of climate change in Indian subcontinent are important in many ways due to diverse topography, seasons etc. Indian subcontinent in fact is considered to be highly vulnerable not only because of large physical exposure to climate related disasters as 65 % of India is drought prone, 12 % Flood prone and 8 % susceptible to cyclones. With a large land area and diversity of agro climatic and ecological regions makes it a more vulnerable to the impending threat of climate change that threatens livelihood security of large rural masses of India. It is a giant rain fed ecosystem and also because of its contribution to economic growth and primarily because majority of its population and the work force on natural resources viz., water resources, agriculture, forests animal husbandry, fisheries etc. for employment. With a large land area and diversity of agro climatic and ecological regions makes it a more vulnerable to the impending threat of climate change that threatens livelihood security of large rural masses of the Country.

Soil carbon forms the largest amount of organic carbon stored on land. In the present context of climate change, it is pertinent to know how stable the carbon in this large reservoir is? In this study an attempt has been made towards better understanding of the role of soil carbon in a complex environment. This includes its types and textures vis-à-vis geographical realms.

3. Soil and Carbon Sequestration Link

Soil Organic Matter (SOM) represents an active and essential pool of the total organic carbon on the planet. Consequently, even small changes in this SOM carbon pool may have a significant impact on the concentration of atmospheric CO_2. Recent new understanding of the chemical nature of SOM indicates that innovative and sustainable technologies may be applied to sequester carbon in agricultural soils. Overall results of the project have been applied to develop an innovative model for the prediction and description, both quantitatively and qualitatively, of carbon sequestration in agricultural soils.

Ecosystem functions deliver goods and services (ecosystem services (ES)) that satisfy human needs, both directly and indirectly (De Groot et al. 2002; Sandhu & Wratten 2013). Ecosystem Services are the basis of economic and social well-being of human beings (UNEP 2010; TEEB 2010). Ecosystem Services are classified into four major categories (i) provisioning services like food, fibre, bio-energy, etc., (ii) supporting services like soil fertility, nutrient cycling, provision of water, etc., (iii) regulating services like pollination, biological control of pests and diseases, etc., and (iv) cultural services like recreation, education. Ecosystem Services provision occurs at multiple scales from carbon sequestration for climate regulation at the global scale to soil structure maintenance and fertility at the local scale.

To summarise Carbon Sequestration is the process of capturing and storing atmospheric carbon dioxide. Carbon dioxide is naturally captured form the atmosphere through biological, chemical and physical processes. These changes can be accelerated through changes in land use. But due to urbanization, Greenhouse gas emissions continue to increase resulting in Global warming. Next is deforestation by humans for unplanned development is also contributing. The plants (Sequesters or accumulators), which sequester the carbon naturally through photosynthesis become less in number. with the urbanization or development, carbon capture and sequestration technology us developed. Carbon capture and sequestration technology is a process of capturing waste CO_2 from large point sources, such as fossil fuel stations, so that it will not enter the atmosphere, carbon capture and sequestration technology is seen a crucial climate protection technology for coal-rich countries like India as fourth largest Green house gas emitter, India's total emission are 7% of global emissions and is increasing at 4.5% Per annum.

4. Rationale:

The present study is an attempt to determine soil organic carbon (SOC) along with other linked constituents and a comparative investigation have been carried out on the influence of organic amendments in differential manner not only on the nature and properties but also fertility issues, productivity etc., and to ascertain its important linkage with complex soil carbon dynamics using standard methods under listed flowcharts with selected details.

5. Methodology Flowchart:

- Collection of Data of Lucknow, UP, India
- Collection of Soil Samples with site
- Sandy, Loamy and Clay soil data/observations with seasons
- Analysis of Soil Samples with reference carbon, nitrate, phosphate etc
- Microbial Analysis from samples
- FTIR, SEM & EDS analysis
- Walkley-Black Method (Walkley and Black, 1934) and Gerhardt Kjeldhal Method (Misra, 1968) for Determination of SOC:

- Colony Forming Unit (CFU) Count By Plate Count or Serial Dilution Agar Plate Technique

- Lastly, the samples were analysed using FTIR, SEM and EDS techniques to correlate advanced structural dynamics using standard operating procedures (SOP)

Investigations of soil samples revealed that Soil Organic Carbon (SOC) is composed of recalcitrant and labile carbon pools hence; labile and recalcitrant fractions were analyzed by using different concentrations of sulphuric acid (H_2SO_4). Samples were analyzed individually for sampled soil types revealed to be sandy, clay and loam, with pH ranged between 8.3 to 9.3. The TOC ranged between 8.9 -11.9 gm/kg whereas SOC ranged between 7.4-9.19 g/kg, TN ranged from 0.82-1.12 g/Kg . Electric Conductivity (EC), Phosphate (P) and potassium (K) are ranged between 0.60 – 0.96 (dSm-1); 21.2 – 46.4 (kg ha-1) and 167 -258 (kg ha-1) respectively. Labile carbon pools (Pool I + Pool II) together known as the labile pool, which ranged from 3.6 to 4.5 g kg -1 and on recalcitrant carbon pools (Pool III+ Pool IV) constitute together the recalcitrant/refractory pool, which ranged from 3.2 to 3.8 g kg -1. Secondly oxidizable fraction is labile carbon which very rapidly responds to changes that are taking place in soil and surrounding environment.

6. Soil Parameters investigations with amendments

1. **pH :**The pH varied from (8.52-7.46) in all plots, the maximum pH was 8.52 observed in the month of Feb in the sample 1 and the minimum pH was 7.46 observed in the month of December in the sample 12. In this we can see that in sample S3 pH decreased in the month of February i.e. treated with compost.

2. **Electrical Conductivity :** The electrical conductivity varied from (236-103) in sites, the maximum EC was (236μS) observed in the month of December in sample 1 and the minimum EC was (103μS) observed in the month of Feb in sample 12.

3. **NITRATE:** The Nitrate varied from (9.78-3.22 mg/kg) at sites. The maximum nitrate is (9.78 mg/kg) in the month of December at sites. The minimum nitrate is (3.22mg/kg) at site in the month of February

4. **NITRITE:** The nitrite varied from (0.6-0.88 mg / kg) at site. The maximum nitrite is (0.88) observed in the month of December in the sample 7. The minimum nitrite is (0.6) observed in the month of February in the sample 6.

5. **Phosphate:** Phosphate varied from (0.6-1.56) at selected site. The maximum phosphate (1.56) observed in the month of February in sample no 12. The minimum phosphate (0.6) observed in the month of December in sample no 6.

6. **CFU Count of Bacteria:** The CFU Count of bacteria varied from (15800000-1600000) at different sites. The maximum CFU was observed in the month of February in S10. The minimum CFU was noticed in the month of December in S1

7. **CFU COUNT OF FUNGI:** The CFU Count of fungi varied from (71600-700). The maximum CFU observed was in month of February in S10. The minimum CFU observed is in the month of December in S1.

8. **Total Organic Carbon:** The SOC varied from (12.76-6.44) at sites. The maximum SOC is (12.76%) observed in the month of February in sample 10. The minimum SOC was noticed is (6.44%) in the month of December in sample 2

9. **Carbon/ Nitrogen Ratio and Seasonality: A Statistical Analysis :** A derivatized statistical analysis using standard method of percentage and ratio of Carbon and Nitrogen with special refernece to seasonality reveal direct propornality in the three prominent seasons of Monsoon, Summer and Winter. Ratio of Carbon and Nitrogen is singnifiacntly influenced by season per se. Its hightest value of 15.6 recorded in Monsoon season and lowest value of 9.4 is derived in Summer season. Similar trend is observed in the statically derived values. Thus obtained values are camparable to seasonality.

10. **Scanning Electron Microscopy (SEM) and (EDS) Analysis:** SEM Analysis with reference to Sample 1 to 10 reveals textural and structural variation. Such variations determine its type like sandy, silt and clay etc., however there is qualitative difference with its collection site also. The size of the granules and intergranular space is clearly visible in all the studies samples.

11. **FTIR Analysis:** FTIR analysis of samples revealed differential functions groups with reference to the sample its nature and type. Most of the functional groups that are seen the spectral images do correspond with I R frequency stretching limits and standards as seen the in the table of wave numbers and its functional groups. Carbon = Carbon stretching is predominant in all the samples this is followed by other functions groups observed in the spectral images of Samples 1 to 10. Interpretation of various functional group species and stretching frequencies is indicative of varietal nature.

At last quantification as demonstrated above of various fractions of soil organic carbon its content is also influenced by management practices. These are necessary factors in determination of carbon sequestration dynamics as well as indicators of fertility status of soil to a great extent. It has been ascertained by the interactions of biotic and abiotic factors in a sampled agro ecosystem. SEM Analysis with reference to Sample 1 to 10 reveals textural and structural variation. Such variations determine its type like sandy, silt and clay etc., however there is qualitative difference with its collection site also. The size of the granules and intergranular space is clearly visible in all the studies samples. FTIR analysis of samples revealed differential functions groups with reference to the sample its nature and type. Most of the functional groups that are seen the spectral images do correspond with I R frequency stretching limits and standards as seen the in the table of wave numbers and its functional groups. Carbon = Carbon stretching is predominant in all the samples this is followed by other functions groups observed in the spectral images of Samples 1 to 10. There is differential nature of occurrence of organic groups as indicated in the soil type and site specificity of the collected and investigated samples.

Soil acts as a major sink to atmospheric carbon, thus plays a key role in global carbon cycle. Soil organic carbon (SOC) is composed of recalcitrant and labile carbon pools. Recalcitrant pool of carbon (humin and humic substances) is resistant to microbial degradation due to its complex chemical structure. SOC has beneficial effects on soil quality and productivity. Labile organic carbon (LOC) fraction is mainly composed of three components, i.e. physical fraction (including particulate organic matter), oxidizable fraction and biological fraction (microbial biomass). Agricultural practices also affect the soil organic pool as well as composition of SOC. Quantification of soil carbon (C) cycling which is influenced by management practices is necessary for determining carbon sequestration dynamics. In this way soil carbon cycling as demonstrated in the experiments provides a crucial linkage of its interrelationship with other functions indicate intricate complexities in the given ecosystem as hypothesised is justified.