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

THESIS

SUBMITTED TO
BABASAHEB BHIMRAO AMBEDKAR UNIVERSITY, LUCKNOW

BABASAHEB BHIMRAO AMBEDKAR UNIVERSITY
LUCKNOW
प्रज्ञा शील करुणा
ESTABLISHED 1996

FOR THE DEGREE OF

Doctor of Philosophy

IN

ENVIRONMENTAL SCIENCE

Submitted By
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Under the supervision of
Prof. Rana P. Singh

DEPARTMENT OF ENVIRONMENTAL SCIENCE
SCHOOL FOR ENVIRONMENTAL SCIENCES
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(A CENTRAL UNIVERSITY, NAAC ACCREDITATION 'A' GRADE)
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UTTAR PRADESH, INDIA

Enrolment No. : 1189/15 2021

DECLARATION

I hereby declare that the thesis entitled **"Carbon Dynamics of Different Soil Types in Peri Urban Lucknow, India"** is my own work conducted under the supervision of **Prof. Rana P. Singh**, Department of Environmental Science, Babasaheb Bhimrao Ambedkar University, Lucknow, and U.P.

I further declare that to the best of my knowledge, the thesis work does not contain any work or part of work, which has been submitted for the award of any degree either in this University or in any other University.

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This is to certify that the thesis titled **"Carbon Dynamics of Different Soil Types in Peri-Urban Lucknow, India"** submitted by **Mr Nandkishor Sonu More** is an original research work and has not been previously submitted in part or full for the award of any other degree or diploma to this or any other university.

The thesis submitted to Babasaheb Bhimrao Ambedkar University, Lucknow satisfies all the requirements as stipulated in the ***Doctor of Philosophy (Ph.D.)*** *regulations -1999 as amended in 2008/2010/2013* and it is fit for submission and evaluation for the award of the degree of Doctor of Philosophy of the University.

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ACKNOWLEDGEMENT

It is by the grace of the Almighty that I have reached the finishing stage of my doctoral work and it feels good. I would like to take this opportunity to humbly express my deep sense of gratitude for the innumerable help, co-operation and inspiration that I have received from my teachers, elders, friends and well-wishers during the course of this research work.

I extend my sincere gratitude and appreciation to my supervisor, ***Prof. Rana P. Singh,*** *Department of Environmental Sciences, Babasheb Bhimrao Ambedkar University, Lucknow, U.P. India, for introducing and leading me to this field of research in Environmental Sciences. I shall ever remain grateful to him for his invaluable guidance, pointed suggestions, unending encouragement and constant cooperation throughout the tenure of this research work.*

I do express my gratitude to ***Prof. Naveen Kumar Arora, Head,*** *Department of Environmental Science, and* ***Dean,*** *School of Earth and* ***Environmental*** *Sciences, Babasheb Bhimrao Ambedkar University, Lucknow, U.P. India, for the support and valuable suggestion during the tough situations that served as the starting point of this research.*

I do express my sense of gratitude to ***Prof. R. C. Sobti*** *former Vice Chancellor for allowing me join Ph. D degree programme and* ***Prof. Sanjay Singh*** *the Vice Chancellor Babasheb Bhimrao Ambedkar University, Lucknow, U.P. for encouragement.*

I am immensely thankful to the teachers of Department of Environmental Sciences, namely Late ***Prof. D. P. Singh, Prof. S. K. Dwivedi****,* ***Prof. Shikha, Prof. Venkatesh Dutta, Dr. Narendra Kumar*** *and* ***Dr. Jiwan Singh*** *for necessary help and suggestions that enabled me to proceed smoothly in the work.*

I have no words to express my humble gratitude and feel indebted to ***my Father Mr. S. K. More, my Brother Mr. Vidyadhar S. More****, Brother in Law* ***Mr. Milind Surwade, Sister Mrs Sandhya Surwade and Sister in Law Mrs Pooja More*** *for their blessings, love, encouragement and for being a source of strength and motivation over the years in every walk of my life.*

My sincere thanks are due to our Guest faculty namely ***Dr. Anjali Verma, Dr. Mukesh Kumar*** *of USIC***,** *research scholars, students and staff of the Department and my colleagues from other Departments for invaluable support.*

I express my profound thanks to my spouse ***Namita*** *and Love to son* ***Master Parineet*** *and daughter* ***Miss Shrishti*** *for being nice to allow me their time to remain in the Department for longer duration which is otherwise rightfully theirs.*

Last but not the least I dedicate this work to my mother Late ***Mrs. Meera More.***

Nandkishor Sonu More

PREFACE

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 soil. The concept of soil health includes the ability of the soil to support life (plants, microorganisms, 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.

The whole gamut of research work is arranged in few Chapters as under:-

Chapter 1 - An **Introduction** about the subject of research. It provides the fundamentals and concept of the research area, and underlines the basic outlines of Objectives.

Chapter 2 - A **Review of Literature** starting from Policy Framework to various experimental and hypothetical areas of the work carried out by various workers worldwide.

Chapter 3 - It deals with **Materials and** Methods framework of the experiments. It includes the experimental observations and collection of data to draw inference.

Chapter 4 - It illustrates the Results and Discussion of various experimental observations that are recorded, analyzed and inferences drawn.

Chapter 5 - It provides with the **Conclusions of** the work.

Chapter 7 - It is the **References** that are referred and cited both from online and offline sources in the text as a part of the research work.

Lastly to supplement the narration good number of flow charts, Tables, Graphs, Figure and Photographs have been attached along with.

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ABBREVIATIONS AND ITS FULL FORMS

1. CDM: Clean Development Mechanisms
2. CFCC15: International Scientific Conference on Our Common Future under Climate Change (A pre CoP 21 Conference)
3. CFU: Colony Forming Unit
4. CMP: Common Ministerial Parties
5. CO_2: Carbon Dioxide
6. CoP 21: 21^{st} Conference of Parties
7. CoP: Conference of Parties
8. CRED: Centre for Research in Epidemiology of Disasters
9. EC: Electrical Conductivity
10. EDS: Electron Dispersal X ray Spectroscopy
11. ES: Ecosystem Services**.**
12. ESP: Exchangeable Sodium Percentage
13. ET: Emission Trading
14. EU JRC: European Union's Joint Research Centre
15. EU: European Union
16. FTIR: Fourier Transform Infra-Red Spectroscopy
17. FYM: Farm Yard Manure
18. GDP: Gross Domestic Product
19. GHG: Green House Gases
20. Gt C: Gigatons of Carbon
21. INDCs: Intended Nationally Determined Contributions
22. LDC: Least Developed Countries
23. LOC: Labile Organic Carbon
24. NOAA: National Oceanic and Atmospheric Administration
25. NOx: Oxides of Nitrate
26. NPK: Nitrogen, Phosphate and Potassium
27. SD: Standard Deviation
28. SEM: Scanning Electron Microscopy
29. SOC: Soil Organic Carbon

30. SOM: Soil Organic Matter
31. TN: Total Nitrogen
32. TOC: Total Organic Carbon
33. TON: Total Organic Nitrogen
34. TP: Total Phosphate
35. UNEP: United Nations Environment Programme
36. UNESCO: United Nations Educational Scientific and Cultural Organization
37. UNFCCC: United Nations Framework Convention on Climate Change
38. UNISDR: United Nations Office of Disaster Risk Reduction
39. UNO: United Nations Organization
40. VC: Vermicompost
41. WHO: World Health Organization

CHAPTER-1

INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1 Preamble

The urgent 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. 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, 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. The United Nations Framework Convention on Climate Change, or "UNFCCC", was adopted during the Rio de Janeiro Earth Summit in 1992. It entered into force on 21 March 1994 and has been ratified by more than 196 Nations/States, which constitute the "Parties" to the Convention its stakeholders. This Framework Convention therefore is a universal convention of principle, acknowledging the existence of anthropogenic climate change and giving industrialized countries the major part of responsibility for combating it. The Conference of the Parties (COP), made up of all "States Parties", is the Convention's supreme decision-making body. It meets every year in a global session where decisions are made to meet goals for combating climate change. Decisions can only be made unanimously by the States Parties or by consensus.

1.2 Background

One of the most important outcomes of Kyoto Protocol has been the consensus of signatory nations barring couple of major economies on agreement to initiate Clean Development Mechanisms (CDM) and Emission Trading (ET) is not a gross understatement. The reason for such protocol was due to high degree of environmental degradation all over reflecting negatively on environmental and human health. The issue of global warming owing to alarming levels of GHG's was again on anvil. The levels of CO_2, NOx, Methane and others reflected grave ecological and health consequences. To top it all Climate change became one of the major issues of 21st century. Earth's mean global temperature rose by 0.6±0.2°C during the second half of 20th century, at a rate of 0.17°C / decade. If the present trend continues, a drastic increase in global temperature is projected by the end of 21st century with rise in sea level and accelerated meltdown of polar ice sheets. Weather events such as the European heat wave in 2003 killed more than 30,000 people, Hurricane Katrina in the United States in 2005 and the droughts, snow (almost simultaneously) in Australia in 2006 and breaking of 160-square-mile section of the Wilkins Ice Shelf from the coast of Antarctica made climate change as political agenda. So, there is requirement of continuous research towards the development of techniques to manage increasing concentration of atmospheric carbon. Carbon dioxide (CO_2) is the primary GHG produced by anthropogenic activities leading to climate change. The atmospheric concentration of CO_2, 255 to 280 ppm in preindustrial time, has increased to ~400 ppm at present as reported by US science agency National Oceanic and Atmospheric Administration (NOAA). Carbon management covers the various activities like CO_2 capture and utilization, waste management involving both chemical and biological tools. Many natural and anthropogenic events have to be considered before projecting sustainable carbon management strategies. General plans be focused on (a) minimizing emission (b) maximizing environmentally sound reuse, reduce and recycling (c) effective treatment and (d) converting carbon into valuable products with atom economy.

1.2.1 Indian scenario grappling with Food Security, Sustainable Agriculture and Impending Threats of Climate Change

Drought conditions are crippling vast swaths of India's farmland as the country faces its driest monsoon ever since 2009. With more than 60 percent of India's agriculture reliant on monsoon rains, farmers are highly vulnerable to changes in rainfall patterns and rising global temperatures, the Indian Council for Research on International Economic Relations observed in a recent report. Further, it is also true that Government of India has imported stapled key food this year as water-starved soil in major producing states showed declined production of rice, sugar and corn. Needless to state that economy based mainly on agriculture amounting to 70 % that took a giant rain fed agro ecosystem puts India in a perilous situation.

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.

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.

1.2.2 Soil and Carbon Sequestration Potentials

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.

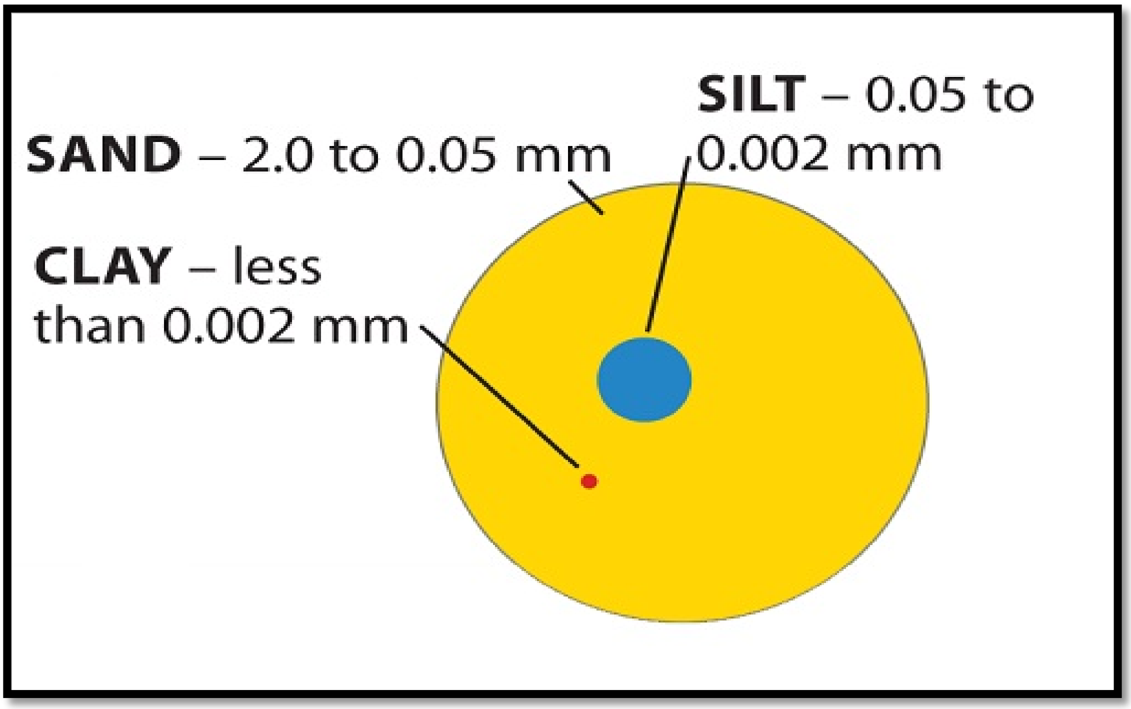

Fig. 1.1 Soil Type and Particle/ Granular Size

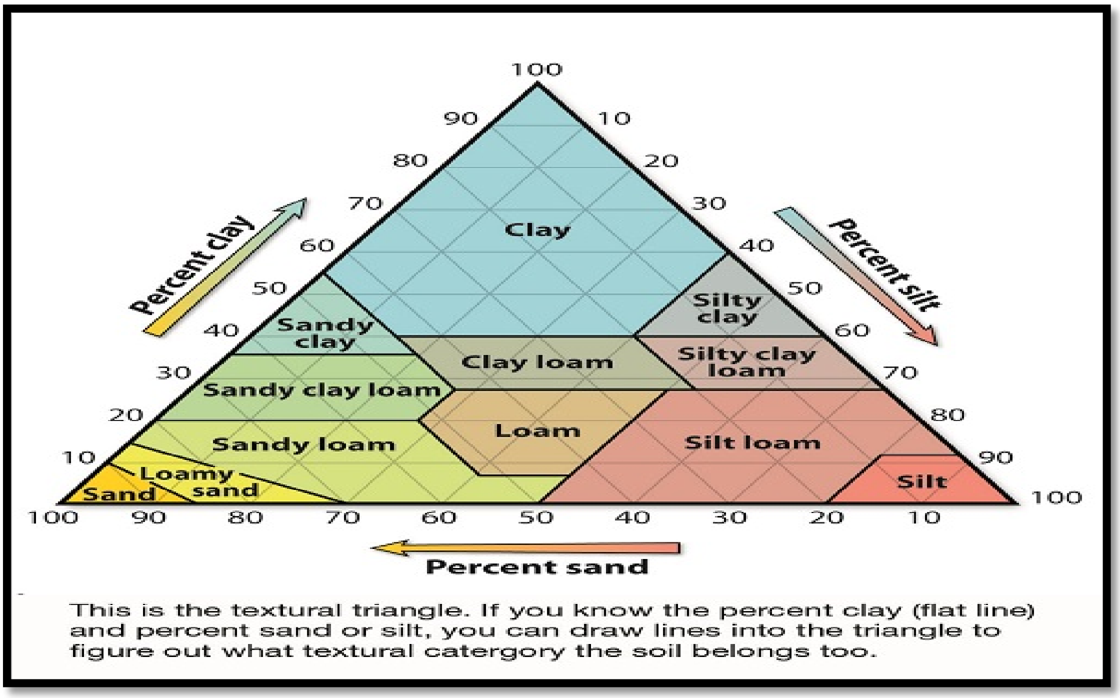

Fig.1.2 Soil: Textural Triangle

1.2.3 A Bottleneck

As Indian nation confronts with the effects of climate change, Indian administration is also grappling with as to how to limit the nation's greenhouse gas emissions. India is the world's third-biggest carbon emitter, after China and the U.S. Indian officials have said repeatedly that the nation's top priorities are expanding the economy, reducing rates of poverty and providing electricity to the 400 million people without access to power. Yet India's emissions will soar if leaders depend on building new coal plants and guzzling more diesel and gasoline to meet those targets.

Although India has recently announced its plans for cutting emissions as part of the United Nations-backed talks on climate change. Since more than 150 countries this year have submitted individual climate plans, it will form an important backbone of broader negotiations at the U.N. climate summit in Paris in December. In our plan, India pledged to cut its emissions intensity of CO_2 emissions per unit of Gross Domestic Product (GDP) by up to 35 percent from 2005 to 2030. Climate policy experts though have doubts over India's plan but said the climate strategy is vague on details and can be achieved, suggesting the country could do more to curb emissions with more stringent measures. To that end, Government has pledged to boost India's solar power capacity by 100,000 megawatts within the decade, a 30-fold rise from today. India also aims to add 60,000 megawatts of wind power, 10,000 megawatts of biomass and 5,000 megawatts of hydroelectric projects by 2022. To meet these targets, the country needs to raise at least $100 billion in total financing which could spell a huge opportunity for banks and global companies to enter the sector and make investments.

1.3 GHG and Intended Nationally Determined Contributions (INDC)

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 percent 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) to be held at Paris. If wishes are compiled and effectively implemented fully would set overall growth of global emissions around 15 percent above 2010 level by the year 2030 that too without International climate fund support or other International cooperation mechanism has been vetted by report of European Commissions Joint Research Centre. The said report points out that owing to variety of reasons natural and manmade reasons the global emission would peak in 2020 and would tend to decline by 10 percent below 2010 levels by stipulated 2030. Lets us assume that most of the countries would continue keep their efforts even after 2030 only then the three degree rise would be possible. It was deliberated at preparatory meeting for INDC forum at Rabat, Morocco. Thus limiting emissions is going to be top agenda of climate negotiations at COP 21 on climate change.

1.4 World Health Organization (WHO) report linking Environment and Health

Another important issue for negotiations to be considered is of United Nations Health agency WHOs report linking environment and health, it has stressed for quick action to limit climate change by reducing emissions of black carbon, ozone and methane as well as carbon dioxide mainly. It noteworthy that WHO felt is more crucial at this juncture to recommend actions to reduce emissions that alone account for more than seven million premature deaths every year. Other suggested measures include encouraging people to go for vegetarian or eat plant based foods and reduce methane emissions associated with paddy fields, ruminants and animal sourced food. Other recommendations have longstanding impacts like reduction of vehicular emissions making it obligatory for the automobile industry and consumers, It calls upon more investments over and above the existing one as policy and to provide alternative cooking fuel to the billions of households in the low income and Least Developed Countries (LDC) which are dependent on wood, dung and other solid fuels for domestic heating and cooking and one of the cause of emission associated health risks among women population. This intervention of WHO comes at a time when COP 21 is scheduled later this year thus thrust for fast track actions to reduce emission dependent global warming and underlines major health risks associated with air pollution. WHO further recommends ancillary measures like improved diets, increase in physical activity, food security and its direct relationship with air pollution, it further accelerate the debate of investments by governments in rapid public transport system of buses and trains along with safe pedestrian and cycle network which is missing in many countries. It is envisaged to promote numerous benefits of rapid safe travel reduced health risks for pollutions of air and noise, do away with physical inactivity and road traffic injuries which second important cause of millions of deaths annually.

1.5 Changing Climate and Disasters

Under the aegis United Nations Office of Disaster Risk Reduction (UNISDR), the Centre for Research in Epidemiology of Disasters (CRED) in its recent report named the *Human Cost of Weather Related Disasters* brought out few more facts that India along with China, USA, Philippines and Indonesia are greatly affected due to Changing Climate. The South Asian countries toll of disasters is much more and so is its impact as compared to USA and China because of their preparedness. The data from 1995 to 2015 indicates that out 4.1billion affected people India and China constitute 75 % with 80.5 and 227.4 crores in India and China respectively. In last 20 years Climate related disasters in India were 288 where as 472 in USA and 411 in China. During this period Philippines and Indonesia encountered 274 and 163 disasters. Although there are indications of reductions in the events, diseases and casualties owing to preparedness but still a long way to go. So it makes it an agenda along with China for the block BRICS and for table discussion at COP.

Lastly COP 21 would have number of agendas on funding from a Conference on Funding in September and deliberations of International Scientific Conference on Our Common Future under Climate Change (CFCC15) held under the aegis of UNESCO and other partners in July 2015. COP 21 was scheduled at an interesting juncture when the reports of European Unions (EUs) Joint Research Centre's report differs with the pledges of INDC but had provided an essential global context of transparency, assessment with common accounting rules which Lima, Conference of Parties repeated to keeping global warming to 2 degree Celsius which as per above report stands deviated. COP 21 has in store such speculations as to how to reach consensus and frame new guidelines on a plethora of issues on important global environmental challenges with implications for food production and its security, Green House Gases (GHG) emissions, health, energy and water supply etc for resolution and subsequent negotiations. In a nutshell from 20th session at Lima to 21st at Paris many new intriguing challenges would be on the platter before it concludes.

1.6 Paris Agreement in a nutshell: Its Deliberations Achievements and grey areas

On December 12, 2015 the United Nations Framework Convention on Climate Change finally came to a landmark agreement in Paris. It could be considered as successful on many counts one important was the same city faced an onslaught of terror eliminating innocent French Nationals who were hosting and thus crushed the fear it might have generated in the first half of November. It has been signed by almost 196 nations the Paris Agreement is first recent comprehensive global treaty to combat climate change, and would effectively follow on from the Kyoto Protocol when it ceases in 2020. Further on technicality would enter into force once it is ratified by at least 55 countries that are covering at least 55% of global greenhouse gas emissions. The agreement commits nations to restrict temperatures "well below 2 degrees Celsius" above pre-industrial levels, and work to limit them further. Limiting the temperature increase to 1.5 degree Celsius is therefore mandatory. It further envisages the nations on carbon budget that in order to keep warming below 2 degree Celsius we can emit a total of around 3.6 trillion tones of greenhouse gases but it only provides us 66 % chance for a better management or for a lower warming limit we have emit even lesser in practice. This global agreement calls the parties for global emissions to peak for a balance to be achieved between the rate of GHG emissions and their removal from the atmosphere by sometime between 2050 and 2100. As of today the coverage of countries pledges INDC submitted by 185 countries ahead of COP 21 cover 94 % of global emissions and 97 % of global population so the remaining 11 countries have been asked to submit their INDC before the next years Climate talk in Marrakech.

Moreover, it is also said that the targets are not yet enough to limit warming below 2 degree Celsius. Next is under the frame of the agreement the targets would be reviewed every five years, after the first stock take in 2023. Nations would be expected to reaffirm their pledge each time to eliminate deviations. The argument of Developed versus developing countries have been desharpened as it makes no formal distinction between their responsibility to cut emissions, but rich countries are required to take lead by undertaking economy-wide absolute emission reduction targets and developing countries are encouraged to this over time thus protecting environment is everyone's baby. One of most significant resolutions was on funding for the developing countries to assist reduce their emissions, under the agreement developed countries would provide at US$ 100 billion a year in climate finance from 2020. On the legality this agreement is legally binding but on some specific details such as exact amount of climate finance involved are exceptions.

On two accounts, one on no compensations for loss and damage as some of the nations would inevitably experience damages from climate change known as loss and damage. Though the agreement acknowledges the significance of such impacts, the treaty rules out any liability or compensation payable by most nations mostly responsible for climate change. However on the issue of transparency and accountability it makes it clear that developed nations will have to disclose their GHG emissions, progress on targets, climate adaptations and important finance at least every two years while the others have been asked to do it voluntarily in a general interest. Finally the issues before COP 21 and its precipitate in an agreement are of paramount importance. Numerous viewpoints have been expressed by many, some have called Paris Climate summit as historic and political achievement but unclear how and when the hard problem of emission cuts and climate finance get tackled. On the other hand some feel that the agreement clearly establishes a new international carbon market mechanism. While concluding the meet the French Foreign minister Laurent Fabius and the President of COP 21 summit said “This agreement is differentiated, fair, durable, dynamic, balanced and legally binding”

In this background interplay of biotic and abiotic factors viz-a-viz organic and inorganic constituents need to be revealed in terms of its complexities, linkages and dynamics. An attempt has been made to investigate some fundamental issues be it soil carbon dynamics and seasonal variations in it along with soil microbe interactions and even the textural and structural complexities etc. It is mandated primarily because soil carbon forms the largest amount of organic carbon stored on land and the other being ocean. (Please see Flowchart 1 and Flowchart 2 for illustrative details). To prove the hypothesis the samples have been collected using standard techniques and the laid down parameters have been analyzed. The details have been illustrated in the subsequent chapters of materials and methods and results and discussion in a specific manner.

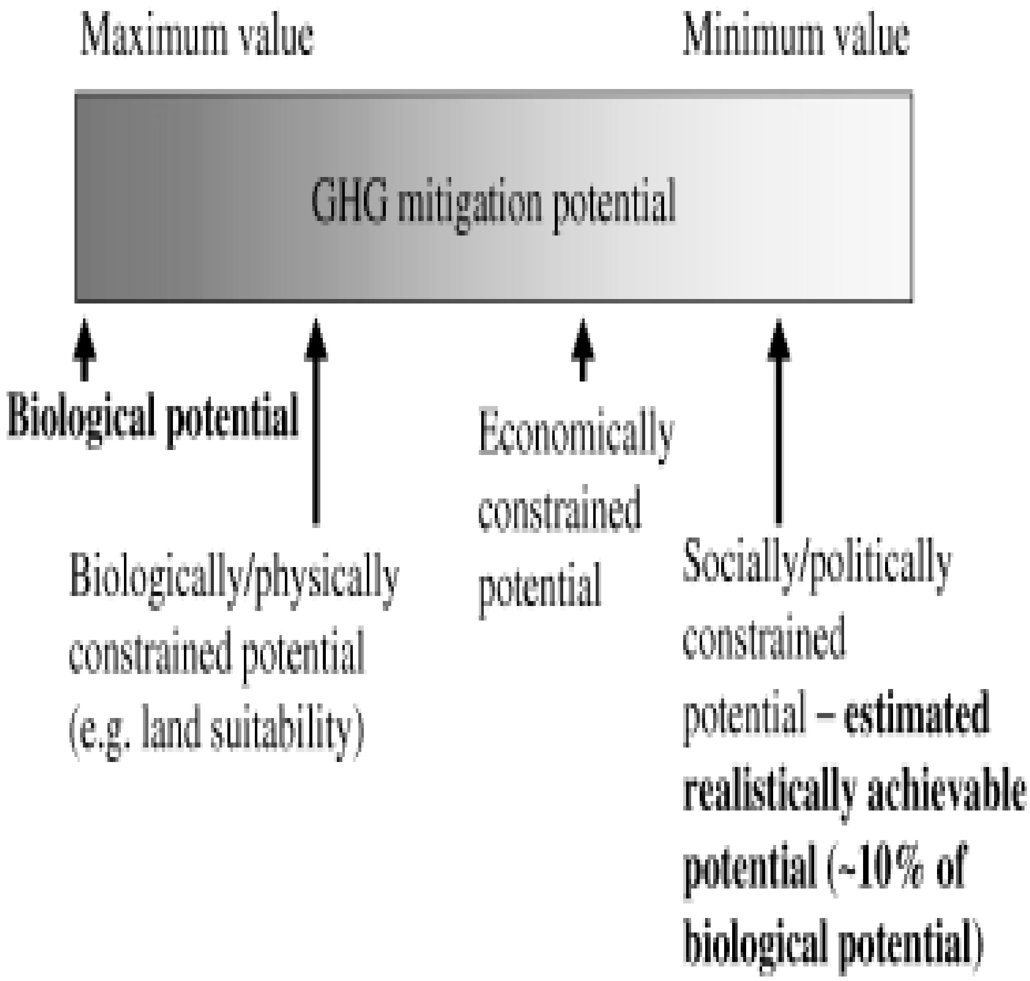

Fig.1.3 Flow chart of Limiting GHG’s and Mitigation Potential

Carbon Mitigation Process

Reduction in Carbon Input Sources

- **Diminution of carbon emission**
  (Use of latest separation techniques, absorption membrane system etc in various production Industries)
- **Minimizing soil erosion**
  (Afforestation, Use of Proper irrigation technique, degraded land mitigation etc)
- **Energy conservation**
  (Reduce forest fire, land use changes, reduced coal burning, oil and natural gas)
- **Aerobic rice growth promotion**

Endorsement in Carbon sink

- **Emphasis on Afforestation**
  (use of recommended Agriculture techniques, Prevention of deforestation etc)
- **Mitigation of Degraded land**
  (Use of alkaline and acidic soil mitigation techniques, Use of land adoring farming process)
- **Increase in grassland area**
  (Preservation of natural grassland and creating artificial grass land)
- **Use of Geo-engineering techniques of carbon capture and storage**

Fig.1.4 Flow Chart Significance of ecological services in climate change mitigation process (*Source: Ashima Singh et al, 2021*)

AIMS AND OBJECTIVES

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1. Selection and Collection of various soil types (samples) in the regions of peri-urban Lucknow, UP, India.

2. To analyze obtained soil samples for its compositional details with reference to Carbon, Nitrogen and Phosphate other related organic and inorganic components

3. To ascertain soil-microbe interactions in the sampled zone like Colony Forming Units of Bacteria and Fungi (CFU), Biomass index etc

4. Collection and analysis of obtained data with focus on soil carbon dynamics with relations to seasonality, biotic and abiotic factors.

5. To ascertain the linkage between ecosystems processes with state of the art technique like Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM) and Electron Dispersal X ray Spectroscopy (EDS).

6. To demonstrate Soil carbon dynamics with ecosystem services with reference to climate change variables

7. To establish relationship of carbon dynamics with Global Warming and Climate Change in a regional perspective

CHAPTER-2

REVIEW OF LITERATURE

CHAPTER-2

REVIEW OF LITERATURE

2.1 Framework of Review

- Importance of soil carbon dynamics in relation to Climate Change and Global warming
- Factors affecting soil carbon viz., abiotic and biotic ones including biomass
- Linkage of soil type with soil carbon biomass
- Specific relation of soil carbon biomass with seasonality
- Soil carbon microbe interactions
- Interrelationship of soil carbon dynamics with climate change mitigation and productivity of agro-ecosystem/forest ecosystem
- Rationale of locating carbon dynamics studies done globally and regionally
- Global warming and incessant threat of Climate change impacts particularly at the global forums
- National initiatives in India before and after Paris Agreement
- Regional indicators of peri-urban Lucknow, Uttar Pradesh

2.2 Importance of Soil Carbon Dynamics In Relation To Climate Change And Global Warming

2.2.1 Why Carbon and its dynamics?

In light of international agreements such as the Paris Agreement—which emerged from the 21st Conference of the Parties of the United Nations Framework Convention on Climate Change (UNFCC) in 2015, and governs greenhouse gas emissions mitigation, adaptation and finance from 2020—the management and monitoring of soil carbon is a matter of national and international importance. It is estimated that by putting back an additional 0.4 per cent of carbon into the soil every year could neutralize the impact of greenhouse gases released into the atmosphere. Soil carbon can be a significant source or sink for greenhouse gases, depending on how land is used and managed, and whether the soil carbon is organic or inorganic

(Sanderman 2012, Monger et al. 2015). Management of soil carbon is also central to maintaining soil health and ensuring global food security. The organic carbon content of soil is a key indicator of its health. It is a variable that indicates the functioning of many ecosystem processes (e.g. nutrient and waste cycling, water storage, biodiversity). The carbon comes primarily from plant materials that are created through the capture of atmospheric carbon dioxide via the process of photosynthesis. These organic materials are cycled through the soil, and used by organisms as a source of energy and nutrients. A significant amount of carbon dioxide is returned to the atmosphere as a result of respiration. The maximum equilibrium carbon content for a soil at a given location is determined by environmental factors such as rainfall, evaporation, solar radiation and temperature. SOC content is generally higher in cool, wet environments, whereas inorganic carbon, in the form of carbonate minerals, is higher in semi-arid environments. A lack of nutrients and a limited capacity of the soil to store and supply water can reduce this potential maximum, as can other constraints to plant growth (e.g. toxicities). Within these constraints, the actual amount of organic carbon contained in a soil will be determined by the balance between carbon inputs and losses, which are strongly influenced by land management and soil type. Agricultural practices that alter rates of carbon input (e.g. plant residues, compost, mulch) or loss (e.g. removal of crops, cultivation) change the stock of SOC. The Food and Agriculture Organization of the United Nations (FAO) recently release a map showing that the top 30 cm of the world's soil contains about twice as much carbon as the entire atmosphere. After oceans, soil is the second largest natural carbon sink, surpassing forests and other vegetation in its capacity to capture carbon dioxide from air. These facts remind us how important healthy soils are, not just for our food production but also for our

2.2.2 Climate Change Impacts

Climate change refers to significant, long-term changes in the global climate. The global climate is the connected system of sun, earth and oceans, wind, rain and snow, forests, deserts and savannas, and everything people do, too. The climate of a place, say New York, can be described as its rainfall, changing temperatures during the year and so on. But the global climate is more than the "average" of the climates of specific places. A description of the global climate includes how, for example, the rising temperature of the Pacific feeds typhoons which blow harder, drop more rain and cause more damage, but also shifts global ocean currents that melt Antarctica ice which slowly makes sea level rise until New York will be under water. It is this systemic connection that makes global climate change so important and so complicated.

2.3 Factors Affecting Soil Carbon Viz., Abiotic and Biotic Ones Including Biomass

(Tian F.P, *et al,* 2016) explore that Carbon sequestration in grassland soil has been paid considerable attention in recent decades. However, the changes of soil organic carbon (SOC) still need more investigations due to under lying effects of environmental factors in semi-arid area in particular. Here, twenty sampling sites were selected to study the effects of plant community (plant cover, biomass, litter, composition and diversity) and environmental factors (i.e. mean annual precipitation, mean annual temperature) on SOC sequestration in the semi-arid grasslands. The results showed that SOC was significant positively related to mean annual precipitation, soil water content and soil pH. The higher above- and below-ground biomass, species evenness and diversity presented the higher SOC. Specially, the species richness and proportion of gramineous species functional group significantly increased SOC. Below-ground biomass affected SOC mainly in the top 30 cm soil. Our results suggest that higher plant species richness and gramineous species proportion play a positive role in increasing the potential of soil carbon sequestration in semi-arid grassland. (Barton E.K., *et al*., 2010) Soil aggregation is an important ecosystem process. Through the intensification of land use, it can be directly affected by soil disturbance, and it can also be indirectly affected by the influence of biotic and abiotic factors that affect soil agglomeration. Mowing, grazing, and fertilizing to test the importance of selected direct and indirect effects on soil aggregation. They measured root length and weight, root colonization of Arbuscular Mycorrhizal Fungi (AMF), hypha length of super free radical AMF, soil aggregation, and soil hydrophobicity. The content of phosphorus, nitrogen, organic carbon, persistent and unstable carbon in the soil has also been quantified. (Hui,D et al., 2011) The relationship between tree productivity and biomass not only reflects plant adaptation and the inter-action of plants and the environment, but also has significant implications in global carbon cycling, climate change, and forest management. However, how biotic factors (e.g. tree age, diameter at breast height [DBH], height) and abiotic factors (e.g. elevation, latitude, and longitude) influence the relationship between tree productivity and biomass has not been well investigated. We analyzed a large database on tree productivity and biomass in China to derive the relationships between these two variables. The entire database was split into different groups by tree age, DBH, height, latitude, longitude and elevation. The relationship between productivity and biomass was developed using both a linear regression model and an allometric equation (i.e. power function) for each group. Differences in model parameters among groupings based on biotic or abiotic factors indicate the effect of each factor on the relationship between productivity and biomass. The slope of the linear regression model decreased with tree age, DBH, height, and elevation, but increased with tree density and longitude. The scaling exponent of the power function varied with tree age, height, and density following a quadratic pattern, but decreased linearly with elevation. The result of above indicated that there is a significant relationship between tree productivity and biomass in China, but the relationship varies with some biotic and abiotic factors. To better predict tree productivity from biomass, tree age and size need to be considered.

(Yong, L, et al., 2019) Coastal wetlands are considered as a significant sink of global carbon due to their tremendous organic carbon storage. Coastal CO_2 and CH_4 flux rates play an important role in regulating atmospheric CO_2 and CH_4 concentrations. However, the relative contributions of vegetation, soil properties, and spatial structure on dry-season ecosystem carbon (C) rates (net ecosystem CO_2 exchange, NEE; ecosystem respiration, ER; gross ecosystem productivity, GEP; and CH_4) remain unclear at a regional scale. Here, we compared dry-season ecosystem C rates, plant, and soil properties across three vegetation types from 13 locations at a regional scale in the Yellow River Delta (YRD). The results showed that the *Phragmites australis* stand had the greatest NEE (-1365.4 μmol m^{-2} s^{-1}), ER (660.2 μmol m^{-2} s^{-1}), GEP (-2025.5 μmol m^{-2} s^{-1}) and acted as a CH_4 source (0.27 μmol m^{-2} s^{-1}), whereas the *Suaeda heteroptera* and *Tamarix chinensis* stands uptook CH_4 (-0.02 to -0.12 μmol m^{-2} s^{-1}). Stepwise multiple regression analysis demonstrated that plant biomass was the main factor explaining all of the investigated carbon rates (GEP, ER, NEE, and CH_4); while soil organic carbon was shown to be the most important for explaining the variability in the processes of carbon release to the atmosphere, i.e., ER and CH_4. Variation partitioning results showed that vegetation and soil properties played equally important roles in shaping the pattern of C rates in the YRD. These results provide a better understanding of the link between ecosystem C rates and environmental drivers, and provide a framework to predict regional-scale ecosystem C fluxes under future climate change.

(Nair R.M., 2019) Mungbean [*Vigna radiata* (L.) R. Wilczek var. *radiata*] is an important food and cash legume crop in Asia. Development of short duration varieties has paved the way for the expansion of mungbean into other regions such as Sub-Saharan Africa and South America. Mungbean productivity is constrained by biotic and abiotic factors. Bruchids, whitefly, thrips, stem fly, aphids, and pod borers are the major insect-pests. The major diseases of mungbean are yellow mosaic, anthracnose, powdery mildew, Cercospora leaf spot, halo blight, bacterial leaf spot, and tan spot. Key abiotic stresses affecting mungbean production are drought, waterlogging, salinity, and heat stress. Mungbean breeding has been critical in developing varieties with resistance to biotic and abiotic factors, but there are many constraints still to address that include the precise and accurate identification of resistance source(s) for some of the traits and the traits conferred by multi genes. Latest technologies in phenotyping, genomics, proteomics, and metabolomics could be of great help to understand insect/pathogen-plant, plant-environment interactions and the key components responsible for resistance to biotic and abiotic stresses. This review discusses current biotic and abiotic constraints in mungbean production and the challenges in genetic improvement.

2.4 Linkage of Soil Type with Soil Carbon Biomass

(Chengjie R, *et al.*, 2018) Land-use change can modify terrestrial ecosystem processes with potentially important effects on below-ground carbon dynamics. Soil microbes are considered the rate-limiting factor in carbon decomposition. However, the effect of land-use change on soil microbial community and the mechanism of soil carbon dynamics remain unclear. In this study, soil samples were collected during four periods (April, June, August, and October) at sites in the Loess Plateau in China with different land-use types: Robinia pseudoacacia L. (RP) and abandoned land (AL); these areas were converted 40 years ago from similar farmlands, while the millet (Setaria italica) farmlands (FL) were selected as a control in our study. Quantitative PCR and Illumina sequencing of the 16S rRNA and ITS genes were performed to analyze the abundance, diversity, and compositions of the soil microbes (bacteria and fungi). Additionally, soil organic carbon fractions (Soil Organic Carbon: (SOC), Dissolved Organic Carbon: (DOC), Microbial Biomass Carbon: (MBC). Soil respiration components (Soil Respiration: (SR), Heterotrophic Respiration: (HR), Autotrophic Respiration: (AR) were evaluated. The results showed that SOC fractions and soil respiration increased after land-use change, with significant correlation being observed. In particular, DOC was more related to SR and HR than to the other fractions. Moreover, the abundance and diversity of the microbes (bacteria and fungi) were greatly affected by the land-use change; both of them were significantly and positively correlated with soil organic carbon fractions and soil respiration components. For dominant bacterial phyla, both Proteobacteria and Bacteroidetes were significantly more abundant in the afforested soil than in the FL, while the abundances of Acti-nobacteria and Chloroflexi ranked as FL > AL > RP. For dominant fungal phyla, Ascomycota responded positively to land-use changes, whereas Basidiomycota responded negatively. Such changes in the abundances of microbial phyla were significantly correlated with the linkage of soil organic carbon fractions and respiration components. Altogether, these results suggest that the changes in components of soil respiration may be highly susceptible to soil organic carbon fractions, especially to DOC, and this linkage is largely modulated by microbial community across land-use changes.

Rattan L, (2016) Soil, a natural four-dimensional body at the atmosphere–lithosphere interface, is organic-carbon-mediated realm in which solid, liquid, and gaseous phases interact at a range of scales and generate numerous ecosystem goods and services. Soil organic carbon (SOC) strongly impacts soil quality, functionality and health. Terms soil quality and soil health should not be used interchangeable. Soil quality is related to what it does (functions), whereas soil health treats soil as a living biological entity that affects plant health. Through plant growth, soil health is also connected with the health of animals, humans, and ecosystems within its domain. Through supply of macro- and micronutrients, soil health, mediated by SOC dynamics is a strong determinant of global food and nutritional security. Soil C pool consists of two related but distinct components: SOC and soil inorganic C (SIC). The

SIC pool comprises of primary and secondary carbonates, and the latter consists of calcitic (no net sequestration of atmospheric CO_2) and silicatic (net sequestration). While SOC is highly dynamic, its mean residence time depends on the degree of protection (physical, chemical, biological, and ecological) within the soil matrix. Formation of stable micro aggregates and of organo–mineral complexes can protect SOC against microbial processes for millennia. In addition to formation of silicatic type of secondary carbonates, leaching of bicarbonates into the subsoil or shallow water table is also an important mechanism of sequestration of CO_2 as SIC. Numerous soil functions and ecosystem services depend on SOC and its dynamics. Improvements in soil health, along with increase in availability of water and nutrients, increases soil's resilience against extreme climate events (e.g., drought, heat wave) and impart disease-suppressive attributes. Enhancing and sustaining soil health is also pertinent to advancing Sustainable Development Goals of the U.N. such as alleviating poverty, reducing hunger, improving health, and promoting economic development.

R. Balestrini, V. Bianciotto, in Soil Microbiology, Ecology and Biochemistry (Fourth Edition), 2015.

Soil functions are essential for the biosphere, and yet soil is perhaps the most difficult and least understood matrix. The main ecological functions of soil include nutrient cycling, C storage and turnover, water maintenance, soil structure arrangement, regulation of aboveground diversity, biotic regulation, buffering, and the transformation of potentially harmful elements and compounds (e.g., heavy metals and pesticides; Haygarth and Ritz, 2009). "Soil biota" is a term that refers to the complete community within a given soil system (Jeffery et al., 2010), although biodiversity can vary from soil to soil (i.e., grassland, arable, forest) and also among different plant species (Wardle et al., 2004). The most dominant group in soil biota, both in terms of number and biomass, is represented by microorganisms (i.e., bacteria, archae, and fungi), which show different nutrient strategies and lifestyles (saprotrophs, pathogens, symbionts). The rhizosphere also contains nematodes, microarthropods (mites and collembola), enchytraeids, and earthworms. Nematodes are considered very important in the soil food web. Only a few nematode species are considered pest organisms, which can cause severe damage to crops (i.e., soybean), whereas others have an applicative interest for the control of insect pests without using pesticides (Neher, 2010). The soil surface and litter layer also contain numerous macrofauna species (mainly arthropods: beetles, spiders, diplopods, chilopods, snails). Because soil functionality depends on the activity of soil biota, measures of their activity, biomass, and diversity (including the presence and health of root symbionts) have often been proposed as indicators of soil quality. A wide range of soil microbial diversity and activity remains unexplored despite new strategies and more sophisticated methods for characterizing plant-soil interfaces in terms of variety and structure.

(Devan A., *et al*, 2014) Soils contain much of Earth's terrestrial organic carbon but are sensitive to land-use. Rangelands are important to carbon dynamics and are among ecosystems most widely impacted by land-use. While common practices like grazing, fire, and tillage affect soil properties directly related to soil carbon dynamics, their magnitude and direction of change vary among ecosystems and with intensity of disturbance. We describe variability in soil organic carbon (SOC) and root biomass—sampled from 0–170 cm and 0–100 cm, respectively—in terms of soil properties, land-use history, current management, and plant community composition using linear regression and multivariate ordination. Despite consistency in average values of SOC and root biomass between our data and data from rangelands worldwide, broad ranges in root biomass and SOC in our data suggest these variables are affected by other site-specific factors. Pastures with a recent history of severe grazing had reduced root biomass and greater bulk density. Ordination suggests greater exotic species richness is associated with lower root biomass but the relationship was not apparent when an invasive species of management concern was specifically tested. We discuss how unexplained variability in belowground properties can complicate measurement and prediction of ecosystem processes such as carbon sequestration.

2.5 Specific Relation of Soil Carbon Biomass with Seasonality

(Classen, A.T., 2015) Global changes have changed the distribution of species and thus the interaction between organisms. Organisms coexist with thousands of other species, some of which are useful, some are pathogenic, and some have little effect on complex communities. Natural communities are composed of organisms with completely different lifestyles. Historical characteristics and dispersive capabilities are unlikely to respond to climate change in the same way. In the face of global change, the gap in the interaction between pollinators and herbivorous plants is well described, but the relationship between plants and soil is the relationship between microorganisms, and soil is the relationship between microorganisms and microorganisms. Because soil microorganisms regulate nutrient transformation, provide nutrients for plants, and enable neighbors to coexist and control plant populations, changes in the interaction between soil microorganisms and plants will have a significant impact on soil composition, plant communities, and ecosystem functions. In this article, we study how climate change directly and indirectly affect soil microbes and microbial-plant interactions, discuss emerging and interesting issues and future research areas, and discuss the possible effects of these changes. Ecosystem function. (Vidal A., et al 2018) Plant roots are the main carriers of atmospheric carbon in the soil. The rhizosphere is the volume of soil around living roots affected by root activity, and is a hot spot for organic carbon (OC) input, microbial activity, and carbon cycle. The rhizosphere process is still poorly understood, and it is challenging to monitor the key mechanisms of carbon transfer and protection in the complete rhizosphere microenvironment. We have deciphered the fate of complete wheat rhizosphere OC photosynthetic derivatives by combining stable field isotope labeling with high-resolution 3D images. The microscope obtains information about the rhizosphere process at the nanometer level. In the immature wheat roots, carbon circulates along the apoplast pathway, from the stele to the crust through the cell wall. Root cells. Oxides form bridges between roots and larger mineral particles (such as quartz) and surround bacteria in micro-aggregates near the root surface. The carbon at the biogeochemical boundary of the rhizosphere is at the forefront of root growth.We have observed complex interactions between carriers (roots, fungi, bacteria), transfer of organic carbon from plants to soil without roots, and stabilizers (iron oxides, root products, and microorganisms). These stabilizers can protect potential Protective organic carbon from damage by plants in rhizosphere microaggregates. .. Zhu,X et al., 2017) Biochar has attracted much attention because of its effect on soil improvement; improving carbon storage, soil fertility and quality, and the fixation and conversion of pollutants (organic and heavy metals). These effects can be achieved by changing the habitat of soil microbes and/or directly affecting microbial metabolism, which together cause changes in microbes and microbial activities. This review links microbial responses (including microbial activity, community structure, and soil enzyme activity) to changes in soil properties caused by bioconverters. Special attention is paid to the formation and protection of soil aggregates by biochar, the adsorption of pollutants by biochar, the transformation of biological focus of pollutants in soil by microorganisms, and the promotion of transfer of biochar electrons between microbial cells and pollutants effect. Destroy the organic matter in the soil. Some active organic compounds and heavy metals in biochar are toxic to soil microorganisms. The adsorption and hydrolysis of biochar signal molecules disrupt the microbial communication between species and may change the structure of the microbial community in the soil. More research is needed to confirm the mechanisms that may involve the biochar microbiota. Restore and improve soil interaction.

2.6 Soil Carbon Microbe Interaction

Like the ocean, soil is a highly complex ecosystem in which the carbon cycle interacts with other biogeochemical cycles (such as nitrogen, phosphorus, and sulfur). What complicates the soil is that soil microorganisms mediate many of these biogeochemical interactions and power important interactions. When we are on the ground, we are in a huge carbon cycle pool. If the global climate continues to warm, it is likely to release a large amount of carbon into the atmosphere. This kind of soil can also solve the problem of increasing carbon dioxide content in the atmosphere. Active microorganisms in the soil absorb carbon dioxide faster. Soil microorganisms are active! Energy: Burning sugar through breathing provides this energy and releases carbon dioxide as a by-product. This CO2 can be used to cover the soil surface and/or absorb into the air by plants for photosynthesis, in order to combine with other CO2 molecules in the atmosphere. Some non-biological and biological environmental factors can make microorganisms very active or slow down their speed. Dormant microorganisms depend on many ecosystem interactions between microorganisms, minerals, SOM, humidity and temperature. The carbon stored in the soil is more than the sum of the earth's vegetation and the atmosphere in the soil. Carbon can be found in organic carbon compounds and inorganic carbon compounds. In most soils, carbon mainly exists in the form of soil organic carbon (SOC). Soil organic carbon (SOC) is the main component of soil organic matter (SOM). SOM is produced through the biological, chemical and physical decomposition of organic matter on and below the soil surface.

Basically, Soil Organic Matter (SOM) is made up of everything that has ever existed, including:

- The organic debris of plants and animals in different decomposition stages, separated from the cells and tissues of soil organisms, and substances from plant roots and soil microorganisms.
- Live soil microorganisms (bacteria, fungi, archaea, nematodes and protozoa) and plant roots. If we weigh all the organisms found in the soil, the microorganisms in the soil account for about 90-95% of the weight.
- Humus, a chemically stable organic material consisting of large complex organic compounds of carbon, minerals and soil particles. If not disturbed by changes in environmental conditions, humus can resist further decomposition. Undeveloped humus can store soil carbon for hundreds to thousands of years, making it a very important carbon sink.
- Charcoal (biochar), unburned plant material. Charcoal can remain undecomposed underground for decades or hundreds of years.

The carbon balance within soil is controlled by carbon inputs from photosynthesis, carbon losses by respiration and carbon storage in humus etc.

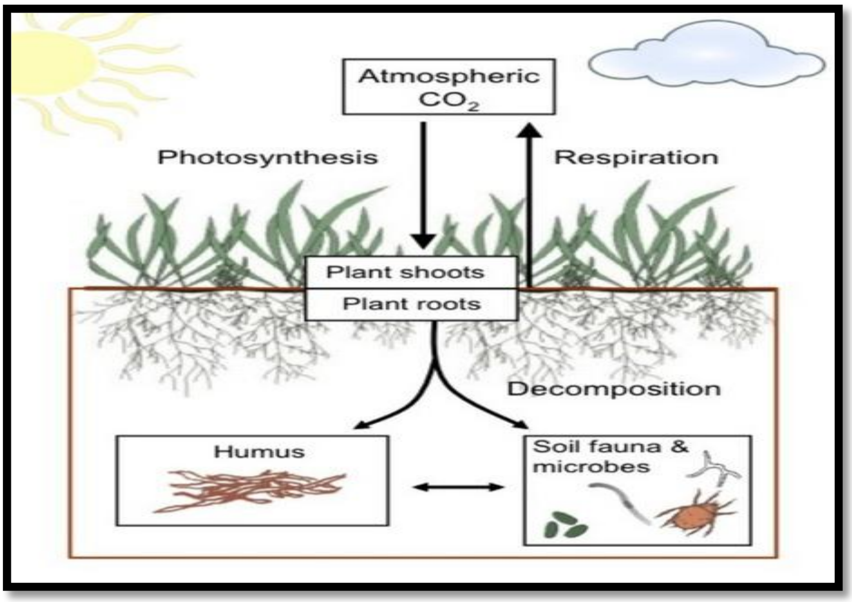


Fig.2.1 Soil Carbon Storage: Carbon balance within the soil (medium box) is controlled by carbon inputs from photosynthesis and carbon losses by respiration.

Please see the image in detail on the right showing the flow of carbon into and out of soil. If plants transfer more carbon into soil than is released via soil respiration, more carbon will get stored in humus via the process of humification. For years, soil scientists and farmers have known that carbon can persist for long periods of time in carbon-rich humus. Humus is formed when soil organic material is degraded by soil microbes that reside in the soil. However, humus is a very complex substance and not fully understood. Current research indicates that the length of time soil carbon persists in humus and other SOM components depends on many ecosystem interactions between SOM and microbes, minerals, moisture and temperature. (Schmidt, M., Torn, M., et al). Scientists do not know yet how long this carbon will stayed stored in soil or if environmental disturbances will move large amounts into the atmosphere amplifying climate change. Plant root exudation transfers a variety of complex organic carbon compounds such as acids, sugars and protein enzymes from the roots of trees and shrubs into the surrounding soil and into a symbiotic ecosystem of mycorrhizal fungi. These fungi get sugars from the plant in return for greatly enhancing the plant's ability to take up water and nutrients from the soil. Mycorrizal fungi eat the sugars and then deposit carbon-containing residue in the surrounding soil. Recent research indicates some types of these fungi (ectomycorrhizal fungi) can lead to up to 70% more carbon stored in soil. (Averill, C., et al)

Decomposers make nitrogen available to plants

Some of the smallest organisms in both soil and the oceans have key roles in moving and transforming carbon compounds in their ecosystems. In soils, microbes directly and indirectly mediate about 90% of soil functions, such as:

- decomposing dead matter into SOM;
- respiring CO_2 and methane (CH_4) to the surrounding soil and air;
- making essential biogeochemical nutrients such as nitrogen compounds bioavailable to plants and other soil organisms;
- storing carbon in soil humus; and
- decomposing humus which releases CO_2 to the air via soil respiration.

All organisms in the Biosphere need nitrogen to build their DNA, RNA and protein molecules. Because plants transfer carbon into the soil via photosynthesis, the nitrogen cycle becomes critical to building strong healthy soil. Take a few minutes to examine the image of the nitrogen cycle above and then watch the Soil Microbes video. Then answer the discussion questions that follow.

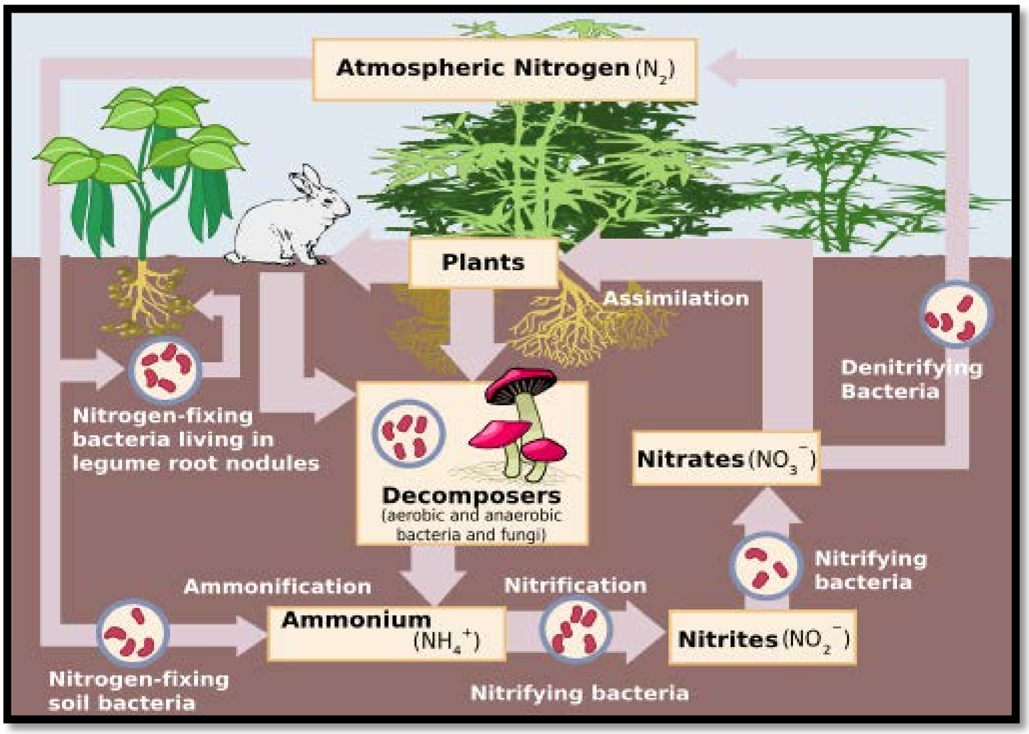


Fig 2.2 Operational Nitrogen Cycle schematic
Source: Environmental Pollution Volume 227, August 2017, Pages 98-115

(Zhu X *et al.,* 2017) reported that biochar has received widespread attention due to its impact on soil improvement; improving carbon storage, soil fertility and quality, and the fixation and transformation of pollutants (organic and heavy metals). These effects can be achieved by changing the habitat of soil microbes and/or directly affecting microbial metabolism, which together cause changes in microbes and microbial activities. This review links microbial responses (including microbial activity, community structure, and soil enzyme activity) to changes in soil properties caused by biotransformants. Special attention is paid to the formation and protection of soil aggregates by biochar, the adsorption of pollutants by biochar, the conversion of microbes to the biological focus of pollutants in the soil, and the promotion of the transfer of biochar electrons between microbial cells and pollutants. effect. Destroy the organic matter in the soil. ... R. Some active organic compounds and heavy metals in biochar are toxic to soil microorganisms. The adsorption and hydrolysis of biochar signal molecules disrupt the microbial communication between species and may change the structure of the microbial community in the soil. More research is needed to confirm the proposed mechanism involving biochar microbiota restore and improve soil interactions.

C. Merino[1], P. Nannipieri[2], F, Matus[3, 4*] J. Soil Sci. Plant Nutr. vol.15 no.2 Temuco jun. 2015 Epub 30-Abr-2015

Rhizosphere, a thin area of soil surrounding roots receiving carbon (C) exudation from plants, represents a site of intense competition for available C and nutrient between surface-reactive particles and soil microorganisms. This competition can reduce the amount of available C to a critical level, it becomes limiting for microbial growth and soil organic matter decomposition. On the other hand, acceleration or retardation of decomposition of soil organic C caused by root activity is termed rhizosphere priming effect (RPE). This effect has been increasingly recognized to play a crucial role on native C destabilization as influenced by fresh C availability, microbial activity and soil mineralogy such as crystallinity of clay minerals and Al-, Fe-oxides. Combining microbial ecology and soil mineral interactions, we can understand how soil characteristics and climate change can influence below ground competition and finally RPE. In this review, we focus on the competition for available C in soil, limiting our analyses to the interaction at rhizospheric space, where most processes between microorganisms and mineral phase occurs.

Christos Gougoulias,* Joanna M Clark, and Liz J ShawJ Sci Food Agric. 2014 Sep; 94(12): 2362–2371. These workers have revealed the role of soil microorganisms in the global carbon cycle: tracking the underground microbial processing of plant carbon in order to control the carbon dynamics in the agricultural system.

2.7 Interrelationship of Soil Carbon Dynamics With Climate Change Mitigation And Productivity Of Agro-Ecosystem/Forest Ecosystem: Forests and climate change

Forests and trees are important goods and services of the ecosystem (Please see Forests and Ecosystem services diagram). They ensure an uninterrupted supply of wood, cellulose, bioenergy, water, food and medicine. They also provide entertainment opportunities and play an important role in many cultural traditions. Forests are home to a large part of the world's flora and fauna. Forests, especially biodiversity hotspots (Gibson *et al*., 2011). Forests are essential for sustainable agricultural development because they play a role in water and carbon cycles, soil protection, pest control, improvement of the local climate, and protection of pollinator habitats. Climate change is closely related to forests. Temperature, solar radiation, precipitation and atmospheric carbon dioxide are important factors affecting forest productivity and dynamics. In turn, forests affect the climate by extracting large amounts of carbon from the atmosphere and releasing it again by absorbing or reflecting solar radiation (albedo). , Which is cooled by evaporation and produces cloud-forming aerosols (Arneth *et al*., 2010; Pielke *et al*., 2011).

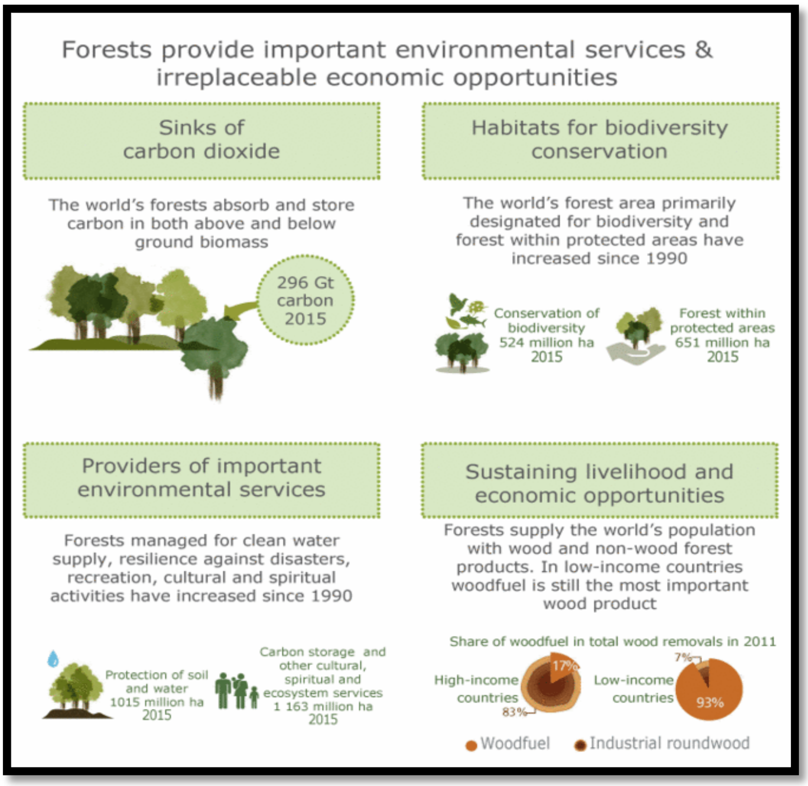


Fig.2.4 Forests and Ecosystem Services

There is a need for sustainable forest management due to the thrust of climate change. The implementation of forest-related climate protection and adaptation measures on the ground requires an integrated approach, supported by solid policy measures and appropriate legal and administrative frameworks. The concepts that guide global forest policy and practice are an integrated approach to forest management. At the national or subnational level, the implementation of sustainable forest management requires favorable policies, laws and institutions. Practices based on advanced science and traditional knowledge Sustainable forest management can be applied to all types of forests, regardless of the goals of forest management (such as production, protection, protection and reuse). In 2007, the United Nations General Assembly adopted an expression describing the concept of sustainable forest management and listing the elements involved.

Efforts worldwide to make progress towards sustainable forest management have provided a wealth of knowledge, experiences, best-practice guidance, tools, mechanisms and partnerships that can support efforts to meet the challenges posed by climate change. Using sustainable forest management as an overall framework helps ensure that adaptation and mitigation measures are carried out in synergy with other forest management objectives and take into account the economic, social and environmental value of forests. Mainstreaming climate change into forest policies and practices will allow for the identification and management of synergies and trade-offs with other forest management objectives.

Adaptive management

Adaptive management is a dynamic approach to forest management in which changing conditions are monitored and practices modified accordingly. It explicitly addresses complex and uncertain situations and is widely seen as part of an appropriate overall response to climate change, including in the forest sector.

Landscape approach

As integral parts of broader landscapes, forests and trees contribute to ensuring the stability and vitality of ecosystems and meeting societal needs. Integrated approaches to landscape management (addressed in module A3) can increase synergies among multiple land-use objectives. By considering the perspectives, needs and interests of all stakeholders, including local communities and individual land users, landscape approaches can be instrumental in developing sustainable strategies for land use and related livelihoods. Broad stakeholder dialogue is especially important when making changes to the way land is used and managed in the landscape. For example, addressing the drivers of deforestation, which are associated with factors well beyond the forests themselves, requires following a cross-sectoral landscape approach and reaching a consensus among multiple stakeholders. Some impacts of climate change (e.g. an increased risk of fire or pests) may require managers to look beyond their own management units and integrate their management approaches with those of other stakeholders living in similar landscapes. Adopting a landscape approach can help in identifying and implementing forest-based climate change adaptation and mitigation measures that lead to optimal economic, social and environmental outcomes.

Partnerships and participatory approaches

Given the many and diverse interests in forests, it is crucial that all stakeholders are involved in forest management. Partnerships and participatory approaches can operate at a range of levels, from the national to local level. They may involve state and local authorities, forest extension agencies, forest-dependent communities, non-governmental organizations, private-sector entities, research and academic organizations, and forest managers.

Indigenous knowledge System

Local and indigenous communities have managed forests and associated landscapes over centuries or even millennia. They have done this in ways that have sustained their livelihoods and cultures without jeopardizing the capacity of ecosystems to provide a continuous supply of goods and services. The knowledge, innovations and practices of these communities have evolved through experiences gained from their encounters with changes in environmental, economic, political and social conditions (Parrotta, Youn and Camacho, 2016). Typically, traditional knowledge is conveyed orally from generation to generation through stories, songs, folklore and proverbs, and through the direct training of youth by elders. Traditional knowledge, supported by and embodied in local languages, cultural values, beliefs, rituals, laws and governance systems, has created a diverse set of natural resource management practices that sustain food security, health and traditions (Berkes, 2008). Complex forest management practices based on traditional knowledge, including natural forest management, shifting cultivation and agroforestry systems, continue to meet the material and non-material needs of societies without putting the biodiversity and functional integrity of forests and associated ecosystems at risk. The speed of climate change depends on the geographic scale considered. The rate of change generally increases with distance from the equator. At the local level, the speed and direction of climate change depend on the terrain and distance from large swaths of water. People who rely on forests differ in their adaptability (ie identity) and adaptability to climate change. In order to cope with climate change, species must adapt to changing conditions or migrate to areas suitable for survival. Physical connection to suitable habitats The risks of species extinction and forest ecosystem changes vary by geography and time. Neither climate nor species respond linearly to changing conditions; they tend to respond violently when certain thresholds or critical points are reached.

The vulnerability of communities to climate change varies. The most vulnerable communities are those that are already fighting poverty and have limited job opportunities or earning income, and depend directly on rainfed agriculture or forests for their livelihoods. In forestry, adaptation includes changes in management practices and interventions to reduce the vulnerability of forests and forest communities to climate change-for specific adaptation measures in forestry, please refer to the Forest Manager's Climate Change Guide. Forests and adaptation to climate change are mainly related. Forests reduce the vulnerability of local communities and society as a whole to climate change by providing ecosystem services, thereby promoting adaptation. For example, the range of forest products tends to be more weather resistant than the range of traditional plants. When a natural disaster strikes or crops fail, the forest acts as a safety net and can provide food and income for the affected communities. Forests also provide ecosystems with services needed for livelihoods, food security, environmental sustainability, and national development. Climate change threatens the provision of these commodities and ecosystem services. The second link between forests and climate change adaptation involves the effects of climate change on forests and the measures needed to mitigate negative effects and maintain the functioning of forest ecosystems. The adaptation options for a particular forest depend on the expected impact of climate change, management objectives (which may change due to climate change), management history, and many other factors. Policies, laws and governance frameworks must be flexible enough to promote and support measures to adapt forests to climate change (ie adaptive management). See also chapter B85 on forest adaptation options. Genetic resources.

Biophysical impacts

Forest Area

The area covered by forests will change with climate change. Changes in forest types may also be due to changes in temperature and rainfall patterns. It is expected that the forests in the temperate zone will increase, while the forests in the northern and tropical regions will decrease. Due to natural climate change, similar changes have taken place in the past geological era, but in this era, it is difficult to distinguish climate change from other factors that affect the distribution of forest area. (Lucier et al., 2009) Plantation and natural regeneration have increased the forest area in China, the United States, many European countries, and some countries in Latin America and the Caribbean (such as Chile, Costa Rica, and Cuba). And Uruguay) (FAO, 2010). On the other hand, some countries in Africa, Asia and the Pacific, and Latin America continue to experience deforestation and forest degradation, mainly due to the conversion of forests to large and small crops and livestock. Deforestation in the northern forests of Siberia in the Russian Federation is mainly due to forest fires (FAO, 2009). Due to climate change, boreal forests are expected to migrate north. The area of temperate forests in the north is expected to increase, but the magnitude is greater than that of boreal forests, resulting in a decrease in the total area of boreal forests (Burton et al., 2010). The impacts of climate change, land-use transition and unsustainable land-use practices are expected to interact with changes in the amount of available water, which will be important factors for the survival and growth of many forest species, although the response to long-term drought varies from species to species and is the same. Between species (Lucier et al.Climate change will increase the risk of more frequent and violent fires, especially in areas with less rainfall or longer dry periods, such as boreal forests (Burton et al., 2010) and Mediterranean and subtropical forests. Areas (Fischlin et al., 2009) and areas where traditional slash-and-burn methods are used, such as in the Amazon (Aragão et al., 2008; Nepstad et al., 2008).

Health and Vitality Issues

Climate change has a major impact on the health and vitality of the world's forests. The health and vitality of forests depend on many factors (such as age, structure, composition, function, vitality, abnormal insect populations or diseases). It is important to understand that perceptions and interpretations of forest health and vitality are influenced by personal and cultural perspectives, land management goals, spatial and temporal scales, and the appearance of forests at specific points in time. (Helms, 1998). In some cases, a combination of carbon dioxide fertilization and a more favorable climate can be used to increase vitality; however, in most cases, higher temperatures will increase the number of insects, which is harmful to forest health (Lucier et al., 2009). Especially in forests where several tree species are dominant, or in forests where insect populations are sensitive to seasonal changes in temperature or humidity (Box B3.2).

Biodiversity

Most tree species have a climate zone where they grow best, are able to compete with other plant species, adapt to environmental changes, and respond to increased pests, diseases, and adverse environmental conditions and human impacts. Some species are better at adapting to changing conditions than others, leading to changes in forest composition rather than geographic changes in forest types (Breshears et al., 2008) (Box B3.3). Generally speaking, due to global warming, tree species may migrate to higher latitudes or higher altitudes (Rosenzweig et al., 2007; Breshears et al., 2008).

Productivity

The impact of climate change on forest productivity (that is, the ability of a particular forest stand to produce wood on land) varies according to geographic area, species, stand composition, tree age, and soil (especially their water storage capacity). The effects of carbon dioxide and nitrogen fertilizer and the interaction of these factors (Girardin et al., 2008; LeBauer, Treeseder, 2008; McMillan et al., 2008; Olinger et al., 2008; Phillips et al., 2008; Reich, Oleksyn , 2008; Saigusa et al., 2008; Clark et al., 2003). Some changes may be temporary, and after reaching the saturation level, the conditions will return to their previous state. Reduced availability usually reduces plant growth, 2008) and may be the cause of the performance degradation reported in the above study. Based on paleontological evidence, some authors believe that reduced productivity will not lead to forest degradation, which is often cited in the expected changes in the Amazon due to climate change (Mayle and Power, 2008). Natural disturbances usually reduce forest area and can also reduce productivity by destroying standing trees (Chakraborty et al., 2008; Jepsen et al., 2008; Kurz et al., 2008; Nepstad et al., 2008).

Soil and Water Protection

For a long time, people have believed that forests help protect water and soil; in some countries, this recognition has translated into programs that reward owners or provide other incentives for owners to provide these ecosystem services (Postel and Thompson, 2005). However, foresters and hydrologists are still discussing the impact of forests on water regulation (Kaimowitz, 2001; Innes et al., 2009). Climate change may make the role of forests in water resources management more important. Soil and water conservation is more important, but when total rainfall is low and large amounts of water are lost during the year, the ability to reduce rainy season runoff and increase dry season runoff does not matter if it is lost through evaporation and consumed by forests. Fog and clouds (horizontal rain), from which trees absorb water, can make a significant contribution to total precipitation (Stadtmüller, 1994). Changes in Amazon vegetation (Mayle and Power, 2008) indicate that in cloud forests, trees are often covered by fog, and higher temperatures will cause clouds to rise to the trees, thereby reducing the possibility of horizontal rainfall. Soil and land use are handled in modules B6 and B7.

Socio-economic impacts

Climate change can increase forest growth in some areas and reduce forest growth in other areas. The expected increase in global timber production may result in lower prices, thereby benefiting consumers. However, the impact of lower prices and regional differences on productivity has different effects on timber income and employment (OsmanElasha et al., 2009). In all continents except Australia, timber production can increase by up to 50%. However, it is expected that a large part of this increase will come from plantations with shorter and shorter crop rotations and therefore may be unevenly distributed across regions (OsmanElasha et al., 2009). In the South, where the fastest growth is expected, current plantation production is concentrated in Argentina, southern Brazil, Chile and Uruguay. Tropical rain forests in South America will reduce timber production in tropical regions. The extraction of non-timber forest products (NTFPs) has three main functions: 1) To meet part of the daily needs of people who depend on forests; 2) To obtain agricultural income; 3) To provide a safety net under adverse agricultural production conditions.Osman Elasa et al. (2009) suggested that climate change may affect the productivity of NTFP, and that more people looking for basic needs or alternative sources of income will increase the importance of NTFP. Continue your studies in areas where the frequency and intensity of high poverty and high dependence on NTFP, extreme weather events (such as droughts, storms, and floods) and other natural disturbances (such as pests and diseases and fires) and subsequent socio-economic impacts are expected to increase.

The impact of climate change on forest-related cultural and leisure activities is difficult to measure and has not been thoroughly investigated. Osman Elasha et al. (2009) reported a study of clearly defined recreational opportunities in forest landscapes. An example is mountainous areas, where skiing in low altitude areas may be affected by higher temperatures. The recreational value attributed to forests is usually local, and most countries lack reliable predictions of the local impact of climate change.

Vulnerabilities of forest-dependent poor

The expected intensification of extreme weather events such as heat waves, droughts and floods, as well as increased risks of fires, pests and diseases, will put additional pressure on large numbers of people who depend on forests. In order to meet the family's energy, nutrition and health needs, they are more susceptible to these pressures. In the case of food shortages, NPF can provide a safety net for rural and urban communities. Due to climate change, crop yield reductions may be more common. The role of forests in ensuring safety and increasing pressure on forest resources, especially during crises caused by extreme weather events. This will exacerbate poverty, lead to poor health and aggravate social conflict. Due to climate change, rope failures will increase, and diversification of livelihoods through forest products and services can improve the resilience of rural populations, especially in areas where forests have livelihood potential, such as NTFP production and ecotourism, which will no longer be implemented.

Impacts on human health

In many parts of the world, climate change scenarios herald more frequent forest fires and longer fire seasons, and fire intensity is expected to be higher, which may have serious effects on human health. Forest coverage and biodiversity will restrict access to forest food, medicines, other non-tropical forest plants and wood, which will also have direct effects on human health, such as reducing the supply of medicinal plants, and indirect effects such as reducing inventory resource. For example, if the local knowledge about medicinal plants is lost, the impact on human health can be felt for a long time. Changes in the global carbon cycle and its impact on atmospheric carbon dioxide concentration are of decisive significance in shaping the global climate. Forests play an important role as a sink and source of carbon dioxide, vegetation and soil Forests (see) contain about half of the world's carbon, and the earth's terrestrial ecosystem can absorb more carbon dioxide than it currently does. Forests absorb carbon dioxide through photosynthesis, store it as carbon, and release it through respiration, decomposition, and combustion. As carbon sinks increase with the growth rate of forests and their ability to continuously store carbon, young forests can absorb large amounts of carbon during their growth. Carbon content, but they are added to these pools more slowly. Forests are also a source of greenhouse gas emissions, mainly carbon dioxide. These emissions are related to deforestation and forest degradation and account for approximately 17% of global greenhouse gas emissions. Climate change and the increase in climate variability have direct and indirect impacts on forests. For example, there is a worrying synergy between poor logging, forest fragmentation, and increased drought caused by forest destruction, which makes many forests in the Amazon and Southeast Asia more vulnerable to fires. These changes have increased the vulnerability of forests to pressures that have existed for a long time but were previously far less threatening. If forests and related social systems cannot cope with the direct and indirect pressures associated with climate change, they will be considered endangered. The Reducing emissions from deforestation and forest degradation, as well as the role of nature protection, sustainable forest management, and increasing forest carbon storage are critical to global efforts to combat climate change. In the Paris Agreement on Climate Change (UNFCCC, 2015) in December 2015, countries agreed to protect and increase carbon sinks and carbon sinks, including forests. Therefore, countries disclosed that many of their nationally determined contributions to address climate change are: agriculture, forests And other land uses. In order to achieve relevant sustainable development goals and take necessary measures to address climate change, there is an increasing need to better understand the factors that drive the transition from forests to agriculture, and vice versa. Under four main categories: 1) Reduce emissions caused by deforestation; 2) Reduce emissions caused by forest degradation; 3) Increase forest carbon sinks; 4) Product replacement. Product substitution includes the vigorous use of wood instead of fossil fuels, and the use of wood fibers to replace materials such as cement, steel, and aluminum. These materials emit more greenhouse gases during the manufacturing process. There is an urgent need to take action in the forest to reduce human disturbance to the climate system; however, these measures will only begin to affect the global average surface temperature in a few decades. Adaptation measures in forests (see diagram) will take many years to ensure the availability of forest products and ecosystem services. Forestry can make an important contribution to reducing the impact of global climate change, but to take advantage of this potential requires coordinated actions between agriculture, animal husbandry and forestry. Mitigation measures for agriculture and animal husbandry can be found in modules B1 and B2. In recent international efforts to support and coordinate national REDD+ efforts, the use of forestry in agriculture has been recognized. This understanding reflects the huge potential for reducing greenhouse gas emissions from forestry and agroforestry compared with other mitigation programs related to agriculture. The overuse of forest products (such as wood and firewood) and the comparative economic benefits of deforestation in agriculture and animal husbandry (Cattaneo, 2008) Extensive literature on indirect or potential drivers of deforestation (eg Geist and Labin, 2002; Hosonuma Et al. 2012, Pacheco et al., 2010; La Bora et al., 2010; Cohen et al., 2014). In order to cope with deforestation and forest degradation, indirect development impacts outside the formal forestry sector must be considered, and management strategies must be coordinated at the landscape level (see B33.1). Many sustainable forestry practices have obvious advantages in reducing forest degradation in forest landscapes (Boscolo et al., 2009). These landscape management methods are important for mitigating climate change (see), but their widespread use may bring many financial, institutional and political constraints. There is an important relationship between the capacity of forests to store and fix carbon and changes in temperature and precipitation. On the one hand, the more carbon accumulated in the forest, the less carbon remains. Therefore, increasing forest carbon storage will help reduce the rate of global warming. This connection becomes important in the global climate debate. Many tropical countries are preparing to reduce forest-related emissions and increase forest carbon storage in order to obtain some international funds to reduce greenhouse gas emissions. Rick, the recognition of forest carbon storage in the mid-1990s led to innovative financing mechanisms for forest management, afforestation and protection (Sánchez Chávez, 2009), and increased efforts to measure the scale of existing natural forests. Plantations and their carbon content.On the other hand, it is expected that higher temperatures, longer dry seasons and higher atmospheric carbon dioxide concentrations will reduce the capacity of forests to store and bind carbon, and may turn forests into carbon sinks in carbon sources (Nepstad et al., 2008) ; Olinger et al.). Et al., 2008; Saigusa et al., 2008; Clark et al., 2003). Since the rate of carbon sequestration depends in part on forest productivity, all factors that affect productivity will also affect carbon sequestration. Increasing temperature will reduce carbon storage capacity; however, in temperate regions, the effect will vary with the seasons (Kenan et al., 2014).

Thakur Upadhyay, Prem L. Sankhayan, Birger Solberg University of Tromsø- Arctic University of Norway, Norwegian University of Life Sciences (NMBU), February 2005 Agriculture Ecosystems & Environment 105(3):449-465

Above workers reported Land-use changes and degradation of forests and soils in the Hindu Kush Himalayan region have important implications for CO2 emissions and global climatic change that calls for an interdisciplinary research to analyse the complexity of the problem. This paper represents an effort in this direction by reviewing the literature on land-use changes, forest/soil degradation and their effects on C sequestration in this region. The main objective of this study was to document knowledge on C sequestration as affected by land-use changes and forest/soil degradation. We found a very few attempts at studying the subject in its entirety, and a lack of reliable data on essential ecological parameters related to the dynamics of C sequestration in the region. Estimates of land-use changes, loss of soil due to erosion and soil organic carbon contents by dominant land-use categories have been documented from the available studies in the region. Some evidence exists to show that the land-use changes and forest/soil degradation affect C pools significantly. The net emissions of C due to land-use changes in Nepal were reported to be 6.9 × 106 to 42.1 × 106 Mg year−1 by earlier studies. In contrast to these findings, our own estimate for the year 1994 was 1.47 × 106 Mg year−1, representing C emissions from fuelwood consumption and loss of soil due to erosion less C fixation due to annual vegetation growth. Finally, an analytical framework is presented for investigating the dynamics of C sequestration. On the basis of review of past studies, there appeared to be a high potential for enhancing the C sequestration in the vegetation and soils of the Himalayan region through improved management of degraded lands. It is suggested that the complexity of dynamics of C sequestration caused by diverse bio-physical and socio-economic factors in the region needs ideally be analysed by following systems approach in the future research endeavours.

Proceedings of 5th International Conference on Environmental Aspects of Bangladesh [ICEAB 2014] Page | 16 Paper ID E06 Soil organic carbon dynamics for different land uses and soil management practices in Mymensingh Md. Asif Iqbal, Md. Shahadat Hossen* and Mst. Nasrin Islam Department of Environmental Science, Bangladesh Agricultural University, Mymensingh Corresponding e-mail: shah_envsc11@yahoo.com

Soil organic carbon (SOC) is an important part of regulating soil fertility and crop yields as well as the global carbon cycle. This study was conducted in Mimensingh, northern Bangladesh, at 24°45'14 north latitude and 90°24'11″ east longitude. The purpose of this study is to examine the impact of current land use and agricultural practices. July to October 2013 SOC accumulation during the period. Use different cultivated land (single, double and three), agroforestry, fallow land and meadow. Determine KOS. Soil organic carbon content varies with land use patterns and land management practices. In all land use patterns Among them, agriculture and forestry have the highest SOC, and fallow land has the lowest SOC. Organic carbon dynamics are severely regulated by organic Carbon dynamics and climate change mitigation are taken into consideration.

Allegra Mayer[1],*, Zeke Hausfather[2], Andrew D. Jones[3] and Whendee L. Silver[1] *Science Advances* 29 Aug 2018: Vol. 4, no. 8, eaaq0932 DOI: 10.1126/sciadv.aaq0932

The above article reviews the combination of removing carbon dioxide (CO_2) from the atmosphere and reducing emissions is necessary to keep global warming below the internationally agreed 2°C target. It is unknown whether the temperature has dropped significantly. We show that by 2100, storage of 0.68 Pg C/year within 85 years can reduce global temperature by 0.1°C, combined with a low emission trajectory [Representative Concentration Pathway (RCP) 2.6]). This value can be realized through existing agricultural management methods without reducing the area of food production. Existing agricultural climate protection methods can reduce the global temperature under RCP 2.6 by as much as 0.26°C, or reduce 25% of the remaining heat by 2°C.According to RCP 8, this value drops to 0.14°C. The results are sensitive to assumptions about the duration of carbon sequestration rates, which are hardly constrained by data. The results provide a basis for determining the potential role of organic carbon in agricultural soils for climate protection.

Chris Jones, Claire McConnell , Kevin Coleman , Peter Cox , Peter Falloon , David Jenkinson , David Powlson, 02 December 2004, https://doi.org/10.1111/j.1365-2486.2004.00885.x

Enhanced release of CO_2 to the atmosphere from soil organic carbon as a result of increased temperatures may lead to a positive feedback between climate change and the carbon cycle, resulting in much higher CO_2 levels and accelerated global warming. However, the magnitude of this effect is uncertain and critically dependent on how the decomposition of soil organic C (heterotrophic respiration) responds to changes in climate. Previous studies with the Hadley Centre's coupled climate–carbon cycle general circulation model (GCM) (HadCM3LC) used a simple, single pool soil carbon model to simulate the response. Here we present results from numerical simulations that use the more sophisticated ‘RothC’ multipool soil carbon model, driven with the same climate data.

2.8 Rationale of Locating Carbon Dynamics Studies Done Globally And Regionally

Zhongkui Luo [1], Wenting Feng [2], Yiqi Luo [3], Jeff Baldock [4], Enli Wang [1], Glob Chang Biol, 2017 Oct;23(10):4430-4439. doi: 10.1111/gcb.13767. Epub 2017 Jun 26, PMID: 28544252, DOI: 10.1111/gcb.13767.

As reported by the scholars that the dynamics of total organic carbon in soil (TOC) are determined by the complex interaction of climate, soil, and biological conditions; however, the relationship between SOC and these driving factors and their underlying interconnected networks is rarely quantified. In 90 field trials in 28 locations in different agricultural ecosystems in Australia's growing areas, we investigated the direct and indirect effects of climate, soil characteristics, carbon (C) input, and soil carbon storage (17 variables in total) on SOC. Fees Rate changes. (rC, Mg C ha1 year1). Among these variables, we found that the most influential variables in rC are the average carbon input and annual rainfall at the beginning of the experiment, as well as the total SOC stock. The relative influence of the number and abundance of herbaceous plants in the rotation system on rC accounted for 27%, followed by 25% of the climate (including precipitation and temperature), 24% of the soil area (including tank size and composition) and soil characteristics (such as cations). Exchange capacity, clay content, bulk density) 24% path analysis produces a network of relationships between climate, soil characteristics, carbon input, and soil carbon deposition to determine rC. If the effects of soil properties and carbon deposition are excluded, the direct correlation between rC and climate will be significantly weakened, and vice versa. These results show the relative importance of climate, soil properties, carbon input and carbon deposition and their complex regulatory relationships. SOC dynamics: Lack of understanding of the impact of changes in soil properties, carbon storage composition and carbon contribution (quantity and quality) on SOC dynamics may be one of the main sources of SOC uncertainty. Prediction based on the process-based SOC model.

Yong Zhou, Zhiqin Pei, Jiaqi Su, Jingli Zhang, Yuanrun Zheng, Jian Ni, Chunwang Xiao, Renzhong Wang, xPublished: August 10, 2012, https://doi.org/10.1371/journal.pone.0042927

Although semi-arid and arid regions account for about 40% of terrestrial surface of the Earth and contain approximately 10% of the global soil organic carbon stock, our understanding of soil organic carbon dynamics in these regions is limited. A field experiment was conducted to compare soil organic carbon dynamics between a perennial grass community dominated by *Cleistogenes squarrosa* and an adjacent shrub community co-dominated by *Reaumuria soongorica* and *Haloxylon ammodendron*, two typical plant life forms in arid ecosystems of saline-alkaline arid regions in northwestern China during the growing season 2010. We found that both fine root biomass and necromass in two life forms varied greatly during the growing season. Annual fine root production in the perennial grasses was 45.6% significantly higher than in the shrubs, and fine root turnover rates were 2.52 and 2.17 yr^{-1} for the perennial grasses and the shrubs, respectively. Floor mass was significantly higher in the perennial grasses than in the shrubs due to the decomposition rate of leaf litter in the perennial grasses was 61.8% lower than in the shrubs even though no significance was detected in litterfall production. Soil microbial biomass and activity demonstrated a strong seasonal variation with larger values in May and September and minimum values in the dry month of July. Observed higher soil organic carbon stocks in the perennial grasses (1.32 Kg C m^{-2}) than in the shrubs (1.12 Kg C m^{-2}) might be attributed to both greater inputs of poor quality litter that is relatively resistant to decay and the lower ability of microorganism to decompose these organic matter.

Sabina Dore, Danny L. Fry, Brandon M. Collins, Rodrigo Vargas, Robert A. York, Scott L. Stephens, Published: February 26, 2016 https://doi.org/10.1371/journal.pone.0150256

Forest ecosystems can act as sinks of carbon and thus mitigate anthropogenic carbon emissions. When forests are actively managed, treatments can alter forests carbon dynamics, reducing their sink strength and switching them from sinks to sources of carbon. These effects are generally characterized by fast temporal dynamics. Hence this study monitored for over a decade the impacts of management practices commonly used to reduce fire hazards on the carbon dynamics of mixed-conifer forests in the Sierra Nevada, California, USA. Soil CO_2 efflux, carbon pools (i.e. soil carbon, litter, fine roots, tree biomass), and radial tree growth were compared among un-manipulated controls, prescribed fire, thinning, thinning followed by fire, and two clear-cut harvested sites. Soil CO_2 efflux was reduced by both fire and harvesting (ca. 15%). Soil carbon content (upper 15 cm) was not significantly changed by harvest or fire treatments. Fine root biomass was reduced by clear-cut harvest (60–70 %) but not by fire, and the litter layer was reduced 80 % by clear-cut harvest and 40 % by fire. Thinning effects on tree growth and biomass were concentrated in the first year after treatments, whereas fire effects persisted over the seven-year post-treatment period. Over this period, tree radial growth was increased (25 %) by thinning and reduced (12 %) by fire. After seven years, tree biomass returned to pre-treatment levels in both fire and thinning treatments; however, biomass and productivity decreased 30 %-40 % compared to controls when thinning was combined with fire. The clear-cut treatment had the strongest impact, reducing ecosystem carbon stocks and delaying the capacity for carbon uptake. We conclude that post-treatment carbon dynamics and ecosystem recovery time varied with intensity and type of treatments. Consequently, management practices can be selected to minimize ecosystem carbon losses while increasing future carbon uptake, resilience to high severity fire, and climate related stresses.

María-Cristina Ordoñez, Juan Fernando Casanova Olayaeopoldo Galicia and Apolinar Figueroa, Instituto de Geografía, Universidad Nacional Autónoma de México, Circuito Exterior s/n, Ciudad Universitaria, México D. F. 04510, Mexico, *Agronomy* 2020, *10*(4), 507; https://doi.org/10.3390/agronomy10040507

Models can help to explain the main interactions, magnitudes, and velocity by which biological processes accumulate soil organic carbon (SOC) in pastures. An explanatory model using Insight Maker software was constructed for each soil under natural and cultivated pastures, using theoretical carbon models and data which were collected monthly in andisol sites. The model was calibrated and validated by comparing the modeled data to the field data until the smallest prediction error was reached. The indicators used were the mean absolute error (MAE), root-mean-square error (RMSE), mean absolute percentage error (MAPE) and the coefficient of determination (R^2). In natural pasture soil, the diversification of organic inputs consistently promoted the growth of microbial biomass and metabolic efficiency. In contrast, intensive management of cultivated pastures, involving the removal of plant cover, plowing and low input of organic matter, stressed the microbial community and increased the potential carbon loss through secondary mineralization and surface runoff. The application of modeling indicated that it is necessary to improve agronomic practices in cultivated pastures, to maintain soil cover and to increase the application of organic fertilizer by 1.5 times, in order to reduce stress on the microbial biomass, accumulate SOC, minimize organic matter mineralization and reduce C losses due to surface runoff. Therefore, improving agricultural management based on the understanding of soil processes will allow increasing the potential for SOC storage, while improving pasture sustainability.

1. GLOBEC (Global Ocean Ecosystems Dynamics: Northwest Atlantic program NASA Technical Reports Server (NTRS) 1991-01-01

The specific objective of the meeting was to plan an experiment in the Northwestern Atlantic to study the marine ecosystem and its role, together with that of climate and physical dynamics, in determining fisheries recruitment. The underlying focus of the GLOBEC initiative is to understand the marine ecosystem as it related to marine living resources and to understand how fluctuation in these resources are driven by climate change and exploitation. In this sense the goal is a solid scientific program to provide basic information concerning major fisheries stocks and the environment that sustains them. The plan is to attempt to reach this understanding through a multidisciplinary program that brings to bear new techniques as disparate as numerical fluid dynamic models of ocean circulation, molecular biology and modern acoustic imaging. The effort will also make use of the massive historical data sets on fisheries and the state of the climate

GEO-CAPE Coastal Ocean Ecosystem Dynamics White Paper

EPA Pesticide Factsheets

The Clean Water Act protects all navigable waters in the United States (CWA, 1988). The objective of the CWA is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." This Federal mandate authorizes states, tribes, and U.S. territories, with guidance and oversight from the U.S. Environmental Protection Agency (EPA), to develop and implement water quality standards to protect the human and aquatic life uses of the Nationâ€™s waterways. Water quality standards include designated uses, defined as the services that a water body supports such as drinking water, aquatic life, harvestable species, and recreation. These standards under the CWA Section 304 (a) are applicable within state waters, defined as less than 3 nautical miles from shore. Therefore, a majority of research by the EPA addresses near-shore coastal waters within 3 nautical miles, estuaries and lakes where applicable water quality regulation could be implemented. Policy makers and environmental managers and regional offices need tools enabling them to assess the sustainability of watershed ecosystems, and the services they provide, under current and future land use practices. The typical 1km resolution and current Case 1 algorithms of SeaWiFS, MODIS, and VIIRS provide limited assessments of near-shore coastal waters, estuaries and lakes. It has proven difficult to adequately resolve and derive products in smaller estuaries or waters in proximity.

Community driven processes and ecosystem functions in a high or rich CO_2 ocean: Some Examples

(J K, K, 2013) Disturbances are natural features of ecosystems that promote variability in the community and ultimately maintain diversity. Although it is recognized that global change will affect environmental disturbance regimes, our understanding of the community dynamics governing ecosystem recovery and the maintenance of functional diversity in future scenarios is very limited. Here, we use one of the few ecosystems naturally exposed to future scenarios of environmental change to examine disturbance and recovery dynamics. We examine the recovery patterns of marine species from a physical disturbance across different acidification regimes caused by volcanic CO2 vents. Plots of shallow rocky reef were cleared of all species in areas of ambient, low, and extreme low pH that correspond to near-future and extreme scenarios for ocean acidification. Our results illustrate how acidification decreases the variability of communities, resulting in homogenization and reduced functional diversity at a landscape scale. Whereas the recovery trajectories in ambient pH were highly variable and resulted in a diverse range of assemblages, recovery was more predictable with acidification and consistently resulted in very similar algal-dominated assemblages. Furthermore, low pH zones had fewer signs of biological disturbance (primarily sea urchin grazing) and increased recovery rates of the dominant taxa (primarily fleshy algae). Together, our results highlight how environmental change can cause ecosystem simplification via environmentally mediated changes in community dynamics in the near future, with cascading impacts on functional diversity and ecosystem function.

GLOBEC: Global Ocean Ecosystems Dynamics: A component of the US Global Change Research Program, NASA Technical Reports Server (NTRS) 1991-01-01

GLOBEC (GLOBal ocean ECosystems dynamics) is a research initiative proposed by the oceanographic and fisheries communities to address the question of how changes in global environment are expected to affect the abundance and production of animals in the sea. The approach to this problem is to develop a fundamental understanding of the mechanisms that determine both the abundance of key marine animal populations and their variances in space and time. The assumption is that the physical environment is a major contributor to patterns of abundance and production of marine animals, in large part because the planktonic life stages typical of most marine animals are intrinsically at the mercy of the fluid motions of the medium in which they live. Consequently, the authors reason that a logical approach to predicting the potential impact of a globally changing environment is to understand how the physical environment, both directly and indirectly, contributes to animal abundance and its variability in marine ecosystems. The plans for this coordinated study of of the potential impact of global change on ocean ecosystems dynamics are discussed.

1. The influence of oceanic basins on drought and ecosystem dynamics in Northeast Brazil, NASA Astrophysics Data System (ADS)

Santos Pereira, Marcos Paulo; Justino, Flavio; Mendes Malhado, Ana Claudia; Barbosa, Humberto; Marengo, JosÃ, 2014-12-01

The 2012 drought in Northeast Brazil was the harshest in decades, with potentially significant impacts on the vegetation of the unique semi-arid caatinga biome and on local livelihoods. Here, we use a coupled climate-vegetation model (CCM3-IBIS) to: (1) investigate the role of the Pacific and Atlantic oceans in the 2012 drought, and; (2) evaluate the response of the caatinga vegetation to the 2012 climate extreme. Our results indicate that anomalous sea surface temperatures (SSTs) in the Atlantic Ocean were the primary factor forcing the 2012 drought, with Pacific Ocean SST having a larger role in sustaining typical climatic conditions in the region. The drought strongly influenced net primary production in the caatinga, causing a reduction in annual net ecosystem exchange indicating a reduction in amount of CO2 released to the atmosphere.

2. Acidification in Ocean Ecosystem: Hypoxia and Impacted Marine Life

(Hannes, B. 2016) There is increasing recognition that low dissolved oxygen (DO) and low pH conditions co-occur in many coastal and open ocean environments.

Within temperate ecosystems, these conditions not only develop seasonally as temperatures rise and metabolic rates accelerate, but can also display strong diurnal variability, especially in shallow systems where photosynthetic rates ameliorate hypoxia and acidification by day. Despite the widespread, global co-occurrence of low pH and low DO and the likelihood that these conditions may negatively impact marine life, very few studies have actually assessed the extent to which the combination of both stressors elicits additive, synergistic or antagonistic effects in marine organisms. We review the evidence from published factorial experiments that used static and/or fluctuating pH and DO levels to examine different traits (e.g. survival, growth and metabolism), life stages and species across a broad taxonomic spectrum. Additive negative effects of combined low pH and low DO appear to be most common; however, synergistic negative effects have also been observed. Neither the occurrence nor the strength of these synergistic impacts is currently predictable, and therefore, the true threat of concurrent acidification and hypoxia to marine food webs and fisheries is still not fully understood. Addressing this knowledge gap will require an expansion of multi-stressor approaches in experimental and field studies, and the development of a predictive framework. In consideration of marine policy, we note that DO criteria in coastal waters have been developed without consideration of concurrent pH levels. Given the persistence of concurrent low pH-low DO conditions in estuaries and the increased mortality experienced by fish and bivalves under concurrent acidification and hypoxia compared with hypoxia alone, we conclude that such DO criteria may leave coastal fisheries more vulnerable to population reductions than previously anticipated. (Hunt, B. P. V.; et al., 2008) To date, little research has been carried out on pelagic gastropod molluscs (pteropods) in Southern Ocean ecosystems. However, recent predictions are that, due to acidification resulting from a business as usual approach to CO_2 emissions (IS92a), Southern Ocean surface waters may begin to become uninhabitable for aragonite shelled thecosome pteropods by 2050. To gain insight into the potential impact that this would have on Southern Ocean ecosystems, we have here synthesized available data on pteropod distributions and densities, assessed current knowledge of pteropod ecology, and highlighted knowledge gaps and directions for future research on this zooplankton group. Six species of pteropod are typical of the Southern Ocean south of the Sub-Tropical Convergence, including the four Thecosomes Limacina helicina antarctica, Limacina retroversa australis, Clio pyramidata, and Clio piatkowskii, and two Gymnosomes Clione limacina antarctica and Spongiobranchaea australis. Limacina retroversa australis dominated pteropod densities north of the Polar Front (PF), averaging 60 ind m -3 (max = 800 ind m -3) and 11% of total zooplankton at the Prince Edward Islands. South of the PF L. helicina antarctica predominated, averaging 165 ind m -3 (max = 2681 ind m -3) and up to >35% of total zooplankton at South Georgia, and up to 1397 ind m -3 and 63% of total zooplankton in the Ross Sea. Combined pteropods contributed <5% to total zooplankton in the Lazarev Sea, but 15% (max = 93%) to macrozooplankton in the East Antarctic. In addition to regional density distributions we have synthesized data on vertical distributions, seasonal cycles, and inter-annual density variation. Trophically, gymnosome are specialist predators on thecosomes, while thecosomes are considered predominantly herbivorous, capturing food with a mucous web. The ingestion rates of L. retroversa australis are in the upper range for sub-Antarctic mesozooplankton (31.2-4196.9 ng pig ind -1 d -1), while those of L.

Ecosystem overfishing in the ocean

(PubMed Coll, et al., 2008) Fisheries catches represent a net export of mass and energy that can no longer be used by trophic levels higher than those fished. Thus, exploitation implies a depletion of secondary production of higher trophic levels (here the production of mass and energy by herbivores and carnivores in the ecosystem) due to the removal of prey. The depletion of secondary production due to the export of biomass and energy through catches was recently formulated as a proxy for evaluating the ecosystem impacts of fishing-i.e., the level of ecosystem overfishing. Here we evaluate the historical and current risk of ecosystem overfishing at a global scale by quantifying the depletion of secondary production using the best available fisheries and ecological data (i.e., catch and primary production). Our results highlight an increasing trend in the number of unsustainable fisheries (i.e., an increase in the risk of ecosystem overfishing) from the 1950s to the 2000s, and illustrate the worldwide geographic expansion of overfishing. These results enable to assess when and where fishing became unsustainable at the ecosystem level. At present, total catch per capita from Large

Marine Ecosystems is at least twice the value estimated to ensure fishing at moderate sustainable levels.

Ecosystem Overfishing in the Ocean, PubMed Central Tudela, Sergi; Palomera, Isabel; Pranovi, Fabio, 2008-01-01

Fishery catches represent net exports of quality and energy, which can no longer be used for extraction of higher nutrient levels than catches. The degradation of by-products of biomass and energy exports has recently been formulated as a proxy for assessing the impact of fishing on the ecosystem, that is, the extent of ecosystem overfishing. We estimate the historical and current risks of overfishing in ecosystems worldwide by quantifying the decline in secondary production using the best available environmental and fishery data (ie, catches and primary production). Fishery catches represent net exports of quality and energy that can no longer be used for higher levels of nutrition and energy than catches. Fisheries from the 1950s to the 2000s (that is, the increased risk of overfishing in ecosystems), and an explanation of the global geographic extent of overfishing. These results provide an estimate of when and where fisheries are no longer sustainable at the ecosystem level. At present, the total per capita catch of large marine ecosystems is at least twice the estimated value, which guarantees a moderate and sustainable level of catch.

Dynamics of Oceanic Motions, DTIC Science & Technology, 1997-09-30

Ocean research is multiscale, interdisciplinary and generic. The methods are applicable to an arbitrary region of the coastal and deep ocean and across the dynamics. General objectives are to determine for the coastal and coupled deep ocean the multiscale processes which occur in straits and the eastern basin, extension and application of our balance of terms scheme (EVA) to multiscale and interdisciplinary fields with data.

Modeling Ocean Ecosystems: The PARADIGM Program, DTIC Science & Technology 2006-03-01

Biological reality: the wonderful com- 2. Nitrogen-fixing bacteria and archaea our concept of a species (e.g., Venter et plexity of ocean ecosystems will never be (diazotrophs), which convert atmo- al., 2004; Doney et al., 2004; DeLong and fully described with numerical models of spheric...applying ocean inventory of nitrogen nutrients. numerical models, we are confronted Specifying "Functional Groups" Some diazotrophs fix both CO_2 and with Ocean acidification causes ecosystem shifts via altered competitive interactions, NASA Astrophysics Data System (ADS), Kroeker, Kristy J.; Micheli, Fiorenza; Gambi, Maria Cristina 2013-02-01.

Ocean acidification represents a pervasive environmental change that is predicted to affect a wide range of species, yet our understanding of the emergent ecosystem impacts is very limited. Many studies report detrimental effects of acidification on single species in lab studies, especially those with calcareous shells or skeletons. Observational studies using naturally acidified ecosystems have shown profound shifts away from such calcareous species, and there has been an assumption that direct impacts of acidification on sensitive species drive most ecosystem responses. We tested an alternative hypothesis that species interactions attenuate or amplify the direct effects of acidification on individual species. Here, we show that altered competitive dynamics between calcareous species and fleshy seaweeds drive significant ecosystem shifts in acidified conditions. Although calcareous species recruited and grew at similar rates in ambient and low pH conditions during early successional stages, they were rapidly overgrown by fleshy seaweeds later in succession in low pH conditions. The altered competitive dynamics between calcareous species and fleshy seaweeds is probably the combined result of decreased growth rates of calcareous species, increased growth rates of fleshy seaweeds, and/or altered grazing rates. Phase shifts towards ecosystems dominated by fleshy seaweed are common in many marine ecosystems, and our results suggest that changes in the competitive balance between these groups represent a key leverage point through which the physiological responses of individual species to acidification could indirectly lead to profound ecosystem changes in an acidified ocean.

Ocean Dynamics: Case Study of Vietnam DRI, DTIC Science & Technology, 2014-09-30

To identify the phenomena involved in the cascade of energy from mesoscales to turbulent scales. In particular, we wish to quantify the...data from the profiler to the surface buoy. The WW Iridium telemetry system was tested on the WW moored over the continental shelf. Telemetry...2580 email: ajlucas@ucsd.edu Award: N00014-12-1-0635 LONG-TERM GOALS To gain a more complete understanding of ocean dynamical processes

Oceanic ecosystem dynamics during gigantic volcanic episodes: the Ontong Java and Manihiki Plateaus recorded by calcareous nano plankton. NASA Astrophysics Data System (ADS), Erba, E. 2010-12-01

Earth's volcanic activity introduces environmental stress that biota are forced to survive. There is a general consensus on the role of volcanogenic carbon dioxide increases, and implicit tectonic-igneous events, triggering major climate changes and profound variations in chemical, physical and trophic characteristics of the oceans through the Phanerozoic. Cretaceous geological records indicate conditions of excess atm CO_2 (up to 2000-3000 ppm) derived from construction of Large Igneous Provinces (LIPs). In such high CO_2 world□ and greenhouse conditions, the deep ocean became depleted of oxygen promoting the accumulation and burial of massive amounts of organic matter; such episodes are recognized as Oceanic Anoxic Events (OAEs) and their geological records merit careful examination of how the Earth system, and Life in particular, can overcome extreme experiments of global change. The Early Aptian (Ëœ 120 million years ago) OAE1a is a complex example of volcanic CO_2 -induced environmental stress. There is a general consensus on the causes of this case-history, namely excess CO_2 derived from the construction of the Ontong Java-Manihiki LIP. Multi- and inter-disciplinary studies of the OAE1a have pointed out C, O, Os, Sr isotopic anomalies, a biocalcification crisis in pelagic and neritic settings, enhanced fertility and primary productivity, as well as ocean acidification. Available cyclochronology allows high-resolution dating of biotic and environmental fluctuations, providing the precision necessary for understanding the role of volcanogenic CO_2 on nannoplankton biocalcification, adaptations, evolutionary innovation and/or extinctions. The reconstructed sequence of volcanogenic CO_2 pulses, and perhaps some clathrate melting, triggered a climate change to supergreenhouse conditions, anoxia and ocean acidification. The demise of heavily calcified nannoconids and reduced calcite paleofluxes marks beginning of the pre-OAE1a calcification crisis. Ephemeral coccolith

Impacts of the Nutrient Inputs from Riverine on the Dynamic and Community Structure of Fungal-like Protists in the Coastal Ocean Ecosystems, NASA Astrophysics Data System (ADS), Duan, Y.; Wang, G.; Xie, N. 2016-02-01

The coastal ocean connects terrestrial (e.g., rivers and estuaries) with oceanic ecosystems and is considered as a major component of global carbon cycles and budgets. The coastal waters are featured with a high biodiversity and high primary production. Because of the excessive primary production, a large fraction of primary organic matter becomes available to consumers as detritus in the coastal waters. Bacterioplankton have long been known to play a key role in the degradation of this detritus, and export and storage of organic matter in the coastal ecosystems. However, the primary and secondary production and the carbon biogeochemical processes in the ecosystems are largely regulated by nutrient inputs from riverine and other anthropogenic activities through heterotrophic microbial communities. Thraustochytrids, commonly known as fungal-like protists, are unicellular heterotrophic protists and are recently acknowledged to play a significant role in ocean carbon cycling. Their abundance exceeds that of bacterioplankton in the most time of the year in the coastal waters of China. Also, their abundance and diversity are largely regulated by nutrients inputs from riverine and other anthropogenic activities. Our findings support that thraustochytrids are a dominant heterotrophic microbial group in the coastal waters. Evidently, thraustochytrids are an import, but neglected, component in microbial carbon biogeochemical processes of the coastal ocean.

Hydrologic dynamics and ecosystem structure.PubMed, RodrÃguez-Iturbe, I 2003-01-01

Eco-hydrology is the science that studies the mutual interaction between the hydrological cycle and ecosystems. Such an interaction is especially intense in water-controlled ecosystems, where water may be a limiting factor, not only because of its scarcity, but also because of its intermittent and unpredictable appearance. Hydrologic dynamics is shown to be a crucial factor for ecological patterns and processes. The probabilistic structure of soil moisture in time and space is presented as the key linkage between soil, climate and vegetation dynamics. Nutrient cycles, vegetation coexistence and plant response to environmental conditions are all intimately linked to the stochastic fluctuation of the hydrologic inputs driving an ecosystem.

Deep time ocean hypoxia: The impact on Jurassic marine ecosystems, NASA Astrophysics Data System (ADS), Caswell, B. A.; Frid, C. L. J., 2016-02-01

In order to understand how the environment will change over the next 100-1000 years and how this will impact the biosphere we need long-term data from a range of scenarios. This long-term perspective can be achieved by looking at periods of comparable environmental change in Earth history. Two past periods of ocean deoxygenation, 150 and 183 million years ago, are compared: (1) a period of global climate change, analogous to that occurring today, and (2) a period of regional hypoxia associated with changing circulation and nutrient supply. Palaeoecological changes in populations, communities, and seafloor functioning were investigated using data spanning millions of years at high resolution (100s-1000s years). Large shifts in biodiversity, body-size and the population-size of the dominant benthic taxa occurred in response to ocean anoxia. Ecological changes spanned multiple trophic levels and suggest that changes in primary productivity impacted macrobenthos and their pelagic predators resulting in biogeographic range shifts. Quantitative analyses of changes in biological traits and core ecosystem functions show changes in nutrient regeneration, food web dynamics, and benthic-pelagic coupling. During ocean deoxygenation Jurassic ecosystems showed functional resilience and redundancy, but ultimately functioning collapsed. Quantification of the relationships between ecological change and various proxies for palaeoenvironmental change show that both hypoxia and primary productivity were important drivers. Environmental thresholds for local ecosystem change are identified. The patterns of Jurassic ecosystem change share many similarities with present-day hypoxic systems. Critically, the recovery from global anoxia was very slow and connectivity, with potential sources of new recruits, was an important contributor to ecosystem recovery. This emphasises the risks of relying on patterns of short-term and small-scale resilience when managing modern marine systems.

ONR Ocean Wave Dynamics Workshop NASA Astrophysics Data System (ADS)

In anticipation of the start (in Fiscal Year 1988) of a new Office of Naval Research (ONR) Accelerated Research Initiative (ARI) on Ocean Surface Wave Dynamics, a workshop was held August 5-7, 1986, at Woods Hole, Mass., to discuss new ideas and directions of research. This new ARI on Ocean Surface Wave Dynamics is a 5-year effort that is organized by the ONR Physical Oceanography Program in cooperation with the ONR Fluid Mechanics Program and the Physical Oceanography Branch at the Naval Ocean Research and Development Activity (NORDA). The central theme is improvement of our understanding of the basic physics and dynamics of surface wave phenomena, with emphasis on the following areas: precise air-sea coupling mechanisms, dynamics of nonlinear wave-wave interaction under realistic environmental conditions, wave breaking and dissipation of energy, interaction between surface waves and upper ocean boundary layer dynamics, and surface statistical and boundary layer coherent structures.

2.9 Global Warming and Incessant Threat of Climate Change Impacts Particularly at The Global Forums and National Initiatives In India Before And After Paris Agreement

The strategy for soil protection and its implementation report emphasize the importance of healthy soil in both climate change mitigation and adaptation. The Paris Agreement highlights the critical role of the land use sector in climate action. Following suit, a new EU regulation on land use, land use change and forestry requires that Member States, at the minimum, fully offset the sector’s greenhouse gas emissions from 2021 to 2030. The implementation of the new regulation requires reporting and monitoring, which the EEA will support. The EEA also continues to develop knowledge about the environmental issues associated with land use and forestry and related land management practices, including by using Earth observation data from the Copernicus Land Monitoring Service. Many of the EEA’s assessments, indicators and data on soil, land, ecosystems, agriculture, forestry, green infrastructure and other topics also have strong links to climate change. A lot remains unknown, but the better we understand the dynamics between soil, land and the climate, the better are our chances of designing and implementing sustainable solutions. To date, the effort to manage climate change has been a matter of high level diplomatic negotiations involving states and international organizations with a loud, but largely excluded fringe of NGOs, business groups, and minor political actors. The logic for this is that global climate change affects us all, but individual countries can manage only the activities that take place within their borders; to confront a global problem, we need a global solution. As the United Nations history of these negotiations begins: “Climate change is a global challenge and requires a global solution. Greenhouse gas emissions have the same impact on the atmosphere whether they originate in Washington, London or Beijing. Consequently, action by one country to reduce emissions will do little to slow global warming unless other countries act as well. Ultimately, an effective strategy will require commitments and action by all the major emitting countries

To date, the effort to manage climate change has been a matter of high level diplomatic negotiations involving states and international organizations with a loud, but largely excluded fringe of NGOs, business groups, and minor political actors. The logic for this is that global climate change affects us all, but individual countries can manage only the activities that take place within their borders; to confront a global problem, we need a global solution. As the United Nations history of these negotiations begins: “Climate change is a global challenge and requires a global solution. Greenhouse gas emissions have the same impact on the atmosphere whether they originate in Washington, London or Beijing. Consequently, action by one country to reduce emissions will do little to slow global warming unless other countries act as well. Ultimately, an effective strategy will require commitments and action by all the major emitting countries.” The global effort to manage climate change has been organized through what is called the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC was launched at the 1992 Rio Earth Summit to achieve GHG concentrations “at a level that would prevent dangerous anthropogenic interference with the climate system”. It also set voluntary GHG emissions reductions that countries did not meet. With the failure of the Rio initiatives, the then 191 signatories to the UNFCCC agreed to meet in Kyoto in 1997 to establish a more stringent regime. The resulting Kyoto Protocol created a global trading system for carbon credits and binding GHG reductions for ratifying countries. (The US did not sign; China and India were exempt as developing countries) the well acclaimed Conferences of the Parties (COPs) were held almost annually thereafter in places such as The Hague, Cancun and Doha without much progress being made.

(Following the failure of the 2012 Doha meeting and its declaration, the unrenewed Kyoto carbon trading system got collapsed.)

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, Green house 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.

Importance of soil to mitigate Climate Change-

Soil can play on important role in climate change mitigation by storing carbon and decreasing greenhouse gas emissions in the atmosphere. According to FAO (2015) healthy soils provides the largest store of carbon. Carbon sequestration occurs when carbon from the atmosphere is absorbed and stored in the soil. Soil holds three times more carbon in natural climate solutions (NCS) shows that soil carbon makes up 25% of the total potential of Natural Climate Solutions. The Study also shows that soil carbon makes up 47% of the climate mitigation potential of agriculture. Climate Change is the defining issue of our time and we are at dating moment. Through Carbon Cycle, Atmospheric carbon stored in soil or reservoir, by the process of photosynthesis.

2.10 Soil and Seasonality of Lucknow

Lucknow has a humid subtropical climate wit cool, dry winters form mid November to February and dry, hot summer from late March to June. The rainy Season is from July to mid-September. In winter, the maximum temperature is around

25^0C and minimum is 3^0C to 7^0C range. fog is quite common from mid- December to late January. Summers are extremely hot with temperature ranging from 40^0C to 45^0C. Increasing urbanization due to expansion of Lucknow city creating shortage of cultivable land

2.10.1 Soil types reported in Lucknow in acreage:

1. **Land Soil-** Medium Textured, good aeration, poor water holding capacity, low in organic matter, non- sticky etc. (Area in Hactare- 17304).
2. **Sandy Loam-**Coarse textured, poor water holding capacity, low in organic matter, good aeration, poor nutrients retaining capacity etc. (22970).
3. **Silty Loam-** Medium Textured, good aeration, low in organic matter, good aeration, hold plant nutrients well etc. (99301).
4. **Silt loam-** Medium Textured, less aeration, good aeration, low in organic matter, good aeration, holds plant nutrients well (23835).
5. **Silty day loam-** Medium textured, moderate aeration, high moisture and nutrients retaining capacity, soil particles sticky when wet, dried out slowly and become cloddy, moderate aeration etc. (18352).
6. **Clay Loam-**Fine textured, moderate aeration, high moisture and nutrients retaining capacity, soil particles sticky when wet, dries out slowly and become cloddy, moderate aeration etc.(87251).
7. **Silty clay-** Medium textured moderate aeration, high moisture, and nutrients retaining capacity, soil particles are sticky when wet, dries out slowly and becomes more or less moist with moderate aeration etc. (4526)
8. **Total Area-** 199715

CHAPTER-3

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

3.1 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
- Interrelational Statistical Analysis using standard tools
- Observations and illustrations

3.2 Rationale

In this study an attempt has been made 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.

3.3 Collection of Soil Samples

The soil samples were taken from an agricultural field with PVC pipes. It were collected from August to September and December to February in the years 2016, 2017 and 2018. These soil samples were scooped underneath from earth surface (0-30 cm deep) thus were randomly selected from farmland near Lucknow town in triplicate and analyzed separately.

Walkley-Black Method (Walkley and Black, 1934) and Gerhardt Kjeldhal Method (Misra, 1968)

After the soil was first identified, further experiments were carried out. In this study, the total oxidizable organic carbon (SOC) was determined using the Walkley Black method (Walkley and Black, 1934). The total nitrogen is determined according to the method of Gerhard Kjeldahl (Misra, 1968), which consists of three steps digestion, distillation and titration. As described by (Chan et al., 2001) a modified Walkley-Black Method was used to calculate the SOC levels of different groups.

The total SOC share is estimated to be 12.0, 18.0, and 24.0 N. H2SO4 or total SOC is divided into four different groups based on its oxidation stability.

The organic carbon in the soil is oxidized by 12.0 N H_2SO_4, which is described as a very unstable reservoir (Reservoir I). The unstable reservoir (Reservoir II) is calculated from the difference between 18.0 N H_2SO_4 and 12.0 N H_2SO_4, oxidizable SOC and the difference between 24.0 N H_2SO_4, and 18.0 N. H_2SO_4, oxidizable SOC belongs to the third group. The difference between the total SOC and the SOC oxidized with H_2SO_4 and 24.0 N is called the refractory pond (Pool IV). Therefore, it involves mixing a solution of 1 N. dichromate and H2SO4 in different ratios.

A variety of analysis methods were used to compare and analyze the physical and chemical properties of the soil, and the pH value and electrical conductivity (EC) of the soil were analyzed with a pH meter and electrical conductivity, respectively.

Phosphate – P and total element – N were determined by Olsen's bicarbonate of soda technique (Mackereth, 1963) and Micro-kjeldahl distillation assembly (Misra, 1968), respectively. Available metal K+ was calculable with the assistance of a Flame photometer. Exchangeable ion flux was calculated as follows: ESP = (exchangeable sodium concentration (cmol/kg)/cation exchange capability (cmol/kg)×100.

Ten soil samples (0–5cm depth) were taken randomly during August/September and December and February in 2015, 2016 and 2017 from the agricultural fields near and around Luck now city, Its geographic sketch is attached in two different maps for the purpose of location (Please see map of UP, India and

Lucknow). After initial soil identification other experiments were performed and analyzed individually.

In the investigations oxidizable organic carbon (OC) was determined by using Walkley-Black method. In the next analysis soil samples were air dried and passed through < 2 mm sieve and used for the laboratory analysis.

Available K was calculated with the assistance of a Flame photometer. Exchangeable metallic element was calculated as follows: psychic phenomena = (exchangeable sodium concentration (cmol/kg)/cation exchange capability (cmol/kg) ×100.

Therefore, here a solution in which 1 N dichromate and H_2SO_4 are mixed in different ratios. Various methods, such as soil pH value and electrical conductivity (EC), were used to compare the physical and chemical properties of sodium soil and the influence of organic additives in sodium soil. These methods are determined by pH value.

Phosphate-P and total nitrogen-N were measured using Olsen's sodium bicarbonate method (Mackereth, 1963) and Microkjeldahl distillation unit (Misra, 1968), respectively. Use a flame photometer to evaluate the effective potassium K +.

In a table or graph, the percentage of exchangeable sodium is calculated as follows: ESP = (Exchangeable sodium concentration (cmol / kg) / cation exchange capacity (cmol / kg) × 100 Titration data (wet decomposition method) are reported together with other parameters.

The sampling for soil was done in selected sites in urban areas of Lucknow around Hazratganj Chauk.

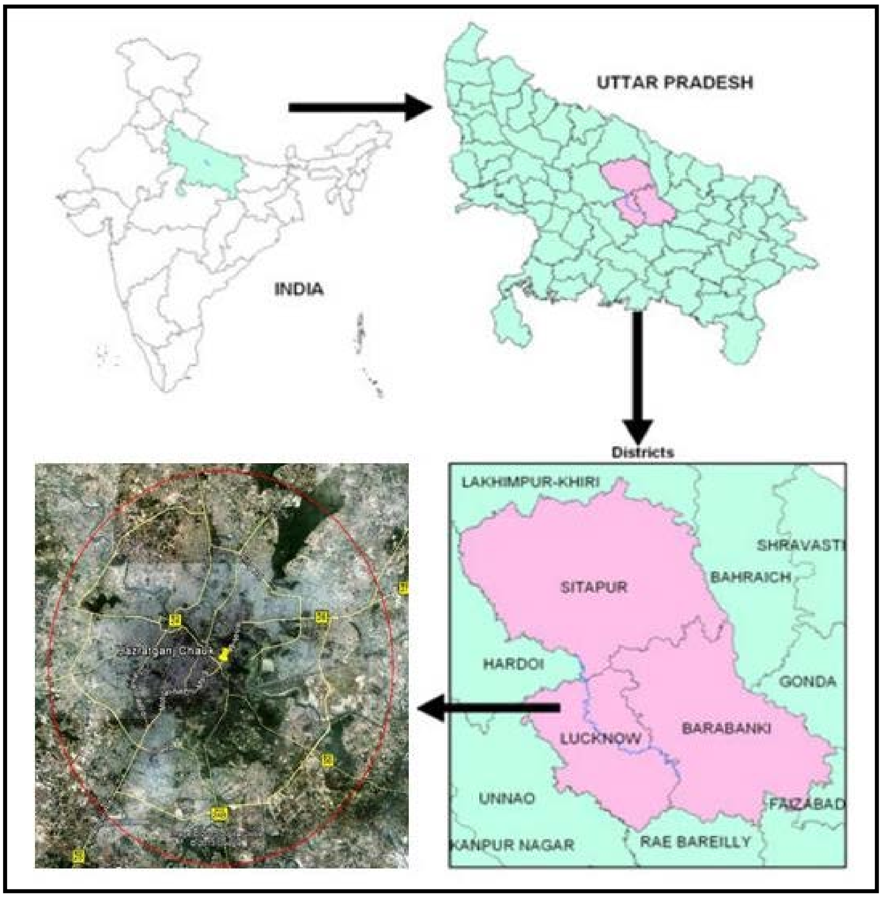


Fig. 3.1: Soil Sampling Sites

Fig. 3.2: Agricultural Farm Land

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

The plate count technique is one of the most routinely used procedures for enumeration of viable cells by this method**. This method is based on the principle that when a material containing bacterium is cultured, every viable bacterium develops into a visible colony on a nutrient agar medium.** The numbers of colonies, therefore, are the same as the number of organism contained in the sample. In this procedure a small measured volume (or weight) is mixed with a large volume of sterile water or saline called the diluent or dilution blank. Dilutions are usually made in multiples of ten. A single dilution is calculated as follows:

Dilution = Volume of Sample / Total Volume of Sample and the Dilution Factor

Serial dilutions are prepared by transferring a known volume of the dilution to second dilution blank and so on. Once diluted, the specified volume of the dilution sample (1ml or 0.1ml) from various dilutions is added to sterile petri plates (in triplicate for each dilution) to which molten and cooled (45-500C) suitable agar medium is added. The colonies are counted on a Quebec colony counter. The number of organisms developed on the plates after an incubation period of 24-48 hours per ml is obtained by multiplying the number of colonies obtained per plate by the dilution factor, which is the reciprocal of the dilution. To facilitate calculations, the dilution is written in exponential notation.

$$\textbf{number of cells/ml} = \frac{\textit{number of colonies}}{\textit{amount plated} \times \textit{dilution}}$$

Requirements-

- Soil Samples
- 9ml dilution blanks (10)
- Sterile petri plates (10)
- Sterile 1ml pipette (10)
- Nutrient agar medium (200ml)
- Colony counter

Nutrient Agar Composition (pH 7.0)

- Peptone : 5.0g
- Beef extract : 3.0g
- NaCl : 5.0g
- Nutrient agar : 15.0g
- Distilled water : 1000.0ml

Finally, the samples were analysed using FTIR, SEM and EDS techniques to correlate advanced structural dynamics using standard operating procedures (SOP) as detailed.

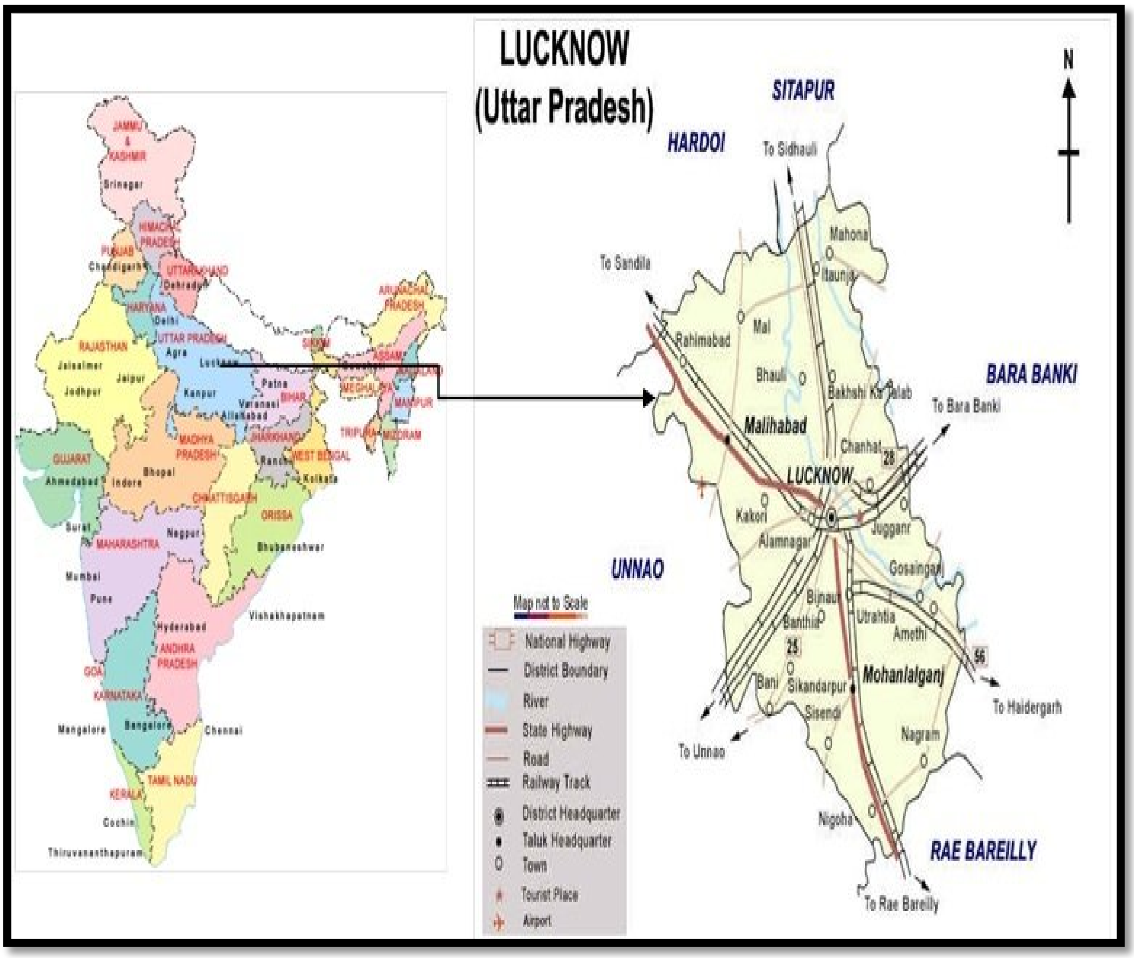


Fig.3.3 Location Map of Study Area (Lucknow, U.P.)

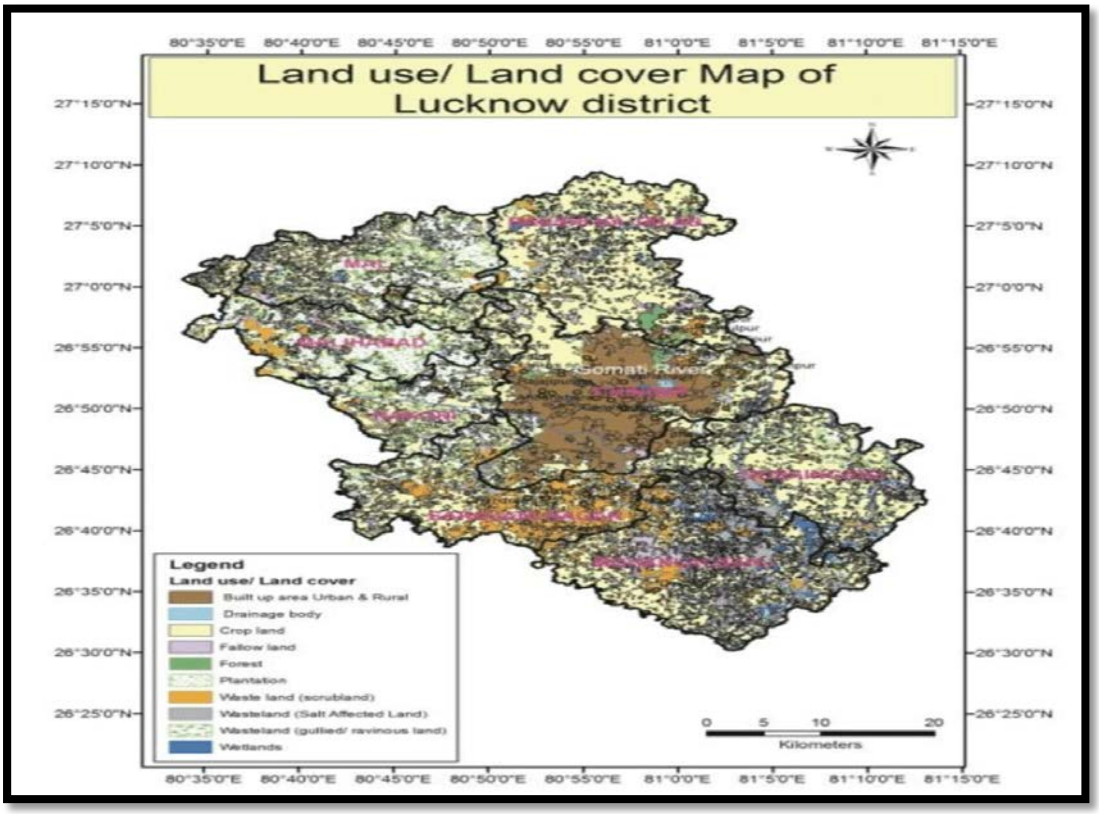


Fig.3.4 Land use and Land Cover Map of Lucknow (Lucknow, U.P.)

3.5 FTIR Spectroscopy

This technique is used to obtain an infrared spectrum of absorption or emission of a solid, liquid and gas. FTIR is used to collect high spectral resolution data over a wide range, usually between 5000 and 400 cm−1 for mid-IR region wavelength, and between 10,000 and 4000 cm−1 for near-IR region wavelength. An FTIR spectrometer simultaneously collects high-resolution spectral data over a wide spectral range. This confers a significant advantage over a dispersive spectrometer, which measures intensity over a narrow range of wavelengths at a time.

FTIR Sample Preparation

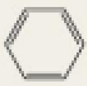
- Soil sample were collected and dried for 4 to 5 hrs in oven at 40-50°C to remove moisture content.
- 1 mg of soil sample was mixed with 100 mg of potassium bromide (KBr) using an agate mortar and pestle.

- The KBr based pellet was compressed into a thin disk using a hydraulic press (CAP–15T) by establishing ten tons pressure.
- Die set was disassembled and pellet was fixed in sample holder.
- The disks were fixed in a FTIR spectrometer (Thermo-Nicolet 6700) and analysed in the spectral region 4000-400 cm-1 against KBr background.

Fig 3.5 FTIR Spectroscopy

Table 3.1 Standard Infra Red Frequency Stretching Limits

Important IR Stretching Frequencies

Type of bond	Wavenumber (cm^{-1})	Intensity
C≡N	2260–2220	medium
C≡C	2260–2100	medium to weak
C=C	1680–1600	medium
C=N	1650–1550	medium
	~1600 and ~1500–1430	strong to weak
C=O	1780–1650	strong
C—O	1250–1050	strong
C—N	1230–1020	medium
O—H (alcohol)	3650–3200	strong, broad
O—H (carboxylic acid)	3300–2500	strong, very broad
N—H	3500–3300	medium, broad
C—H	3300–2700	medium

3.6 SEM And EDS Analysis

Scanning Electron Ficroscopy (SEM) is an established method for high-resolution imaging of surfaces. The SEM uses electrons for imaging, much as a light microscope uses visible light. The advantages of SEM over light microscopy include much higher magnification (>100,000X) and greater depth of field up to 100 times that of light microscopy (Xiong et al., 2017). Energy Dispersive X-ray Spectroscopy (EDS) allow for targeted analysis of sample surfaces. The EDS technique detects x-rays emitted from the sample during bombardment by an electron beam to characterize the elemental composition of the analyzed volume (Liao et al., 2020).

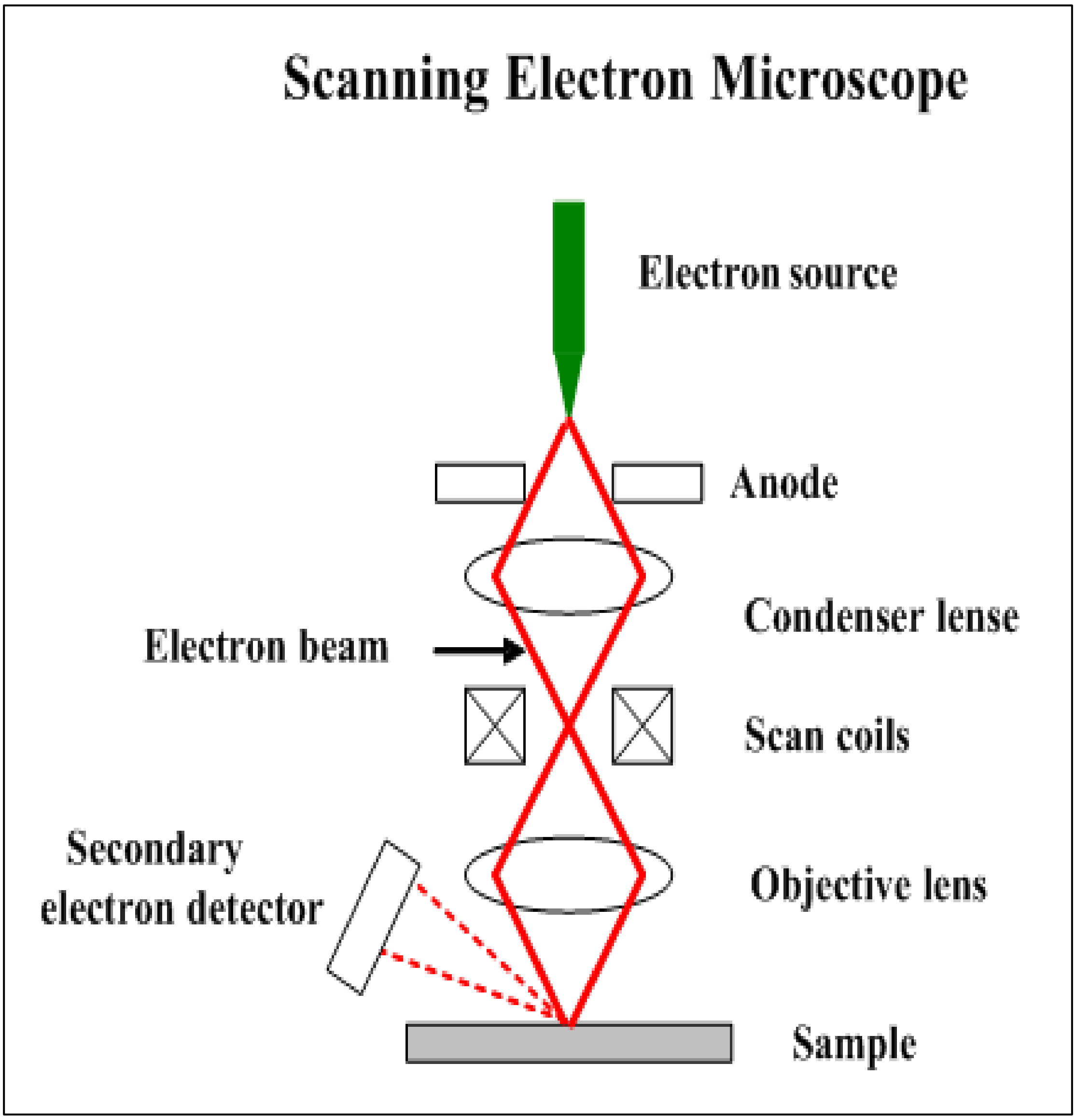


Fig.3.6 Diagramatic Sketch of SEM

SEM Sample Preparation:

- Soil sample were collected and dried for 4 to 5 hrs in oven at 40-50°C to remove moisture content.
- The Soil samples were mounted on the aluminium stubs using carbon adhesive tape.
- The samples were sputter-coated with palladium coater (Auto Fine Coater JFC- 1600 JEOL, Japan).
- The samples were viewed using a scanning electron microscope (JEOL 6490 LV) by applying different accelerating voltage.

CHAPTER-4

RESULTS AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Soil Analysis

Soil Organic Carbon (SOC) is composed of recalcitrant and labile carbon pools hence; labile and recalcitrant fractions were analyzed by using different concentrations of sulfuric 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 (See Graph 1 and Table 1). 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(See Fig 4.1). Secondly oxidizable fraction is labile carbon which very rapidly responds to changes that are taking place in soil and surrounding environment.

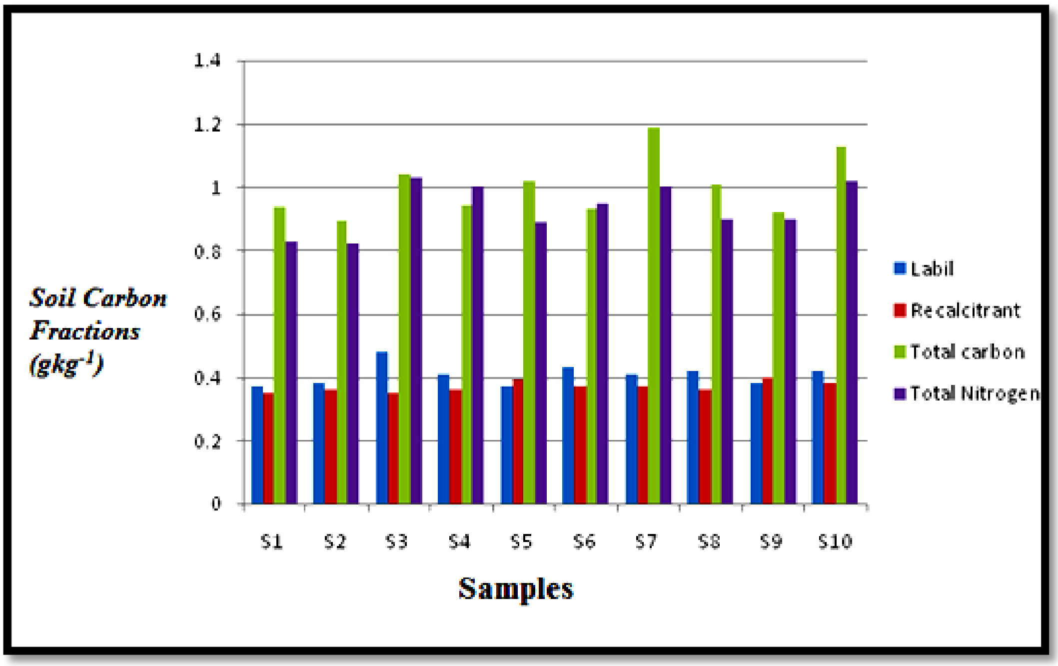


Fig.4.1 Soil Carbon Analysis

Table 4.1 Soil Pool Analysis Data

Samples	Soil organic C Pools ($g\ kg^{-1}$)					
	Very labile (Pool I)	Labile (Pool II)	Labil (Pool I + Pool II)	Recalcitrant	Total carbon	Total nitrogen ($g\ kg^{-1}$)
S1	0.18	0.19	0.37	0.35	0.938	0.83
S2	0.2	0.18	0.38	0.36	0.892	0.82
S3	0.25	0.23	0.48	0.35	1.04	1.03
S4	0.2	0.21	0.41	0.36	0.940	1
S5	0.16	0.21	0.37	0.39	1.02	0.89
S6	0.23	0.2	0.43	0.37	0.934	0.95
S7	0.22	0.19	0.41	0.37	1.19	1
S8	0.23	0.19	0.42	0.36	1.01	0.9
S9	0.21	0.17	0.38	0.4	0.923	0.9
S10	0.24	0.18	0.42	0.38	1.13	1.02

Estimation of SOC by the modified Walkley–Black method

The different pools of SOC was estimated by the modified Walkley–Black method as described by Chan *et al*. (2001), by using 12.0, 18.0 and 24.0N H_2SO_4, respectively. Total SOC was divided into four different pools according to their order of stability against oxidation. Soil organic carbon, oxidized by 12.0 N H_2SO_4, was termed very labile pool (pool I), labile pool (pool II) was calculated by taking difference in SOC oxidizable by 18.0 N H_2SO_4 and that by 12.0 N H_2SO_4, the difference in SOC oxidizable by 24.0 N H_2SO_4, and that by 18.0 N H_2SO_4, was pool III. The difference between total SOC and SOC oxidizable by 24.0 N H_2SO_4, was termed refractory pool (pool IV). Pool I and II together known as the labile pool, which ranged from 3.6 to 4.5 g kg -1 and pool III and IV constitute together the recalcitrant/refractory pool, which ranged from 3.2 to 3.8 g kg^{-1} (See Fig 4.2 and Table 4.1).

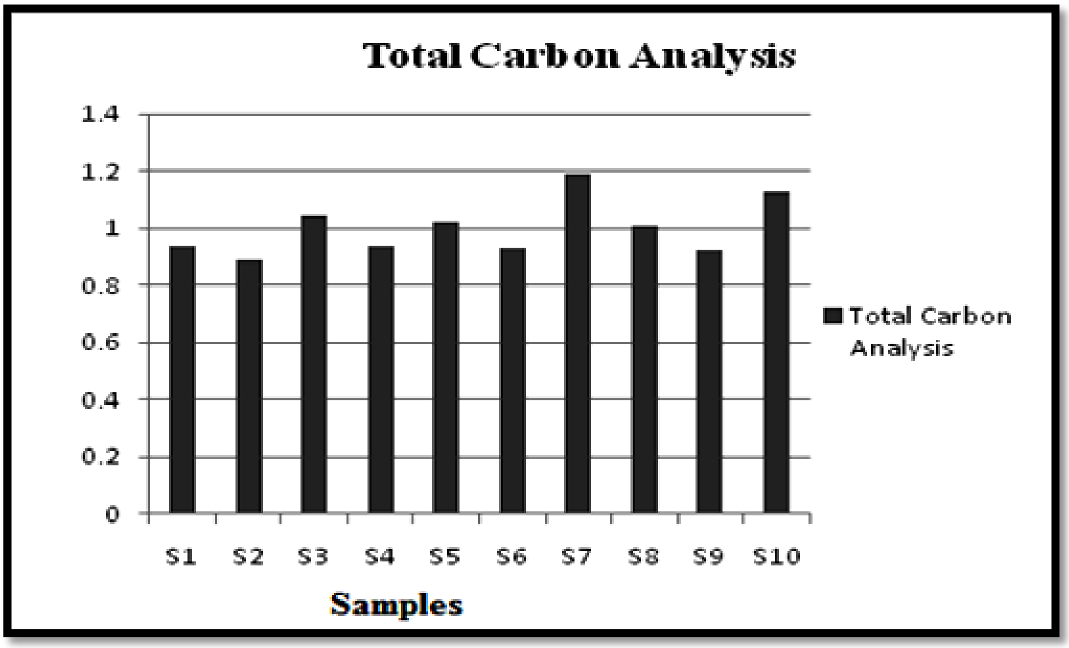


Fig 4.2: Total Carbon Analysis

The comparative analysis of Physic-Chemical properties of Sodic soil as influenced by organic amendments

The highest decrease in soil pH, EC and ESP were observed in FYM and VC (T8) treated plots. The soil nutrients N, P, K and SOC contents were significantly higher in organically amendments sodic soils than soils amended with chemical fertilizers (T3; NPK amended soil) and control soil. The highest soil nutrients were observed in FYM and VC treated plots (T8). The increased values were N (2.62 % - 33.2 %), P (3.69 % – 78.3 %), K (2.72 % - 29.5 %) and OC % (16 %-152 %) in comparison to pre harvest values. Various physico-chemical properties of used organic amendments such as FYM and VC were also analyzed (Table 2). It further indicates that, organically amended soil have a potential to reduce the sodicity and enhance the fertility. Further FYM and VC in 2:1 can act as boosting element to improve soil structure by facilitating the growth of microbial population and in turn carbon assimilation. Composition of total SOC determines the soil quality. Agricultural practices affect the soil organic pool as well as composition of SOC. TOC ranged between 8.9 -11.9 g/kg, SOC ranged between 7.4-9.19 g/kg, TN ranged from 0.82-1.12 g/Kg. The difference between total SOC and SOC oxidizable by 24.0N H_2SO_4, was termed refractory pool (pool IV). Pool I and II together known as the labile pool, which ranged from 3.6 to 4.5 g kg -1 and pool III and IV constitute together the recalcitrant/refractory pool, which ranged from 3.2 to 3.8 g kg -1.

Table 4.2 Physico-chemical properties of sodic soil as influenced by organic amendments in sodic soil. Values are in means and range. Values in parenthesis represent % increase (+) or decrease (-) with respect to pre-harvest values.

Properties	pH	Ec (dSm^{-1})	N (kgha^{-1})	P (kgha^{-1})	K (kgha^{-1})	OC (%)	ESP
Pre harvest	9.04	1.05	268	21.7	184	0.25	78.5
T1	9.03 (-0.11)	0.95 (-9.5)	264(-1.49)	22.5 (+3.69)	182.6 (-0.76)	0.24 (-4.0)	75.7 (-3.56)
	9.01-9.06	0.95-0.96	257-272	21.2 -23.8	174-185	0.23-0.25	74.3-77.2
T2	9.03 (-0.11)	0.94 (-10.4)	275 (+2.61)	24.4 (+12.4)	189 (+2.72)	0.29(+16)	81.3 (+3.56)
	9.00-9.05	0.90-0.95	264-283	23.3-25.7	167-196	0.23-0.33	78.4-83.2
T3	8.64 (-4.42)	0.75 (-28.5)	317(+18.2)	33.6 (+54.8)	205.3 (+11.5)	0.53(+112)	63.3 (-19.3)
	8.62-8.66	0.70-0.79	311-324	25.5-39.7	188-218	0.51-0.55	61.3-66.3
T4	8.64 (-4.42)	0.71 (-32.3)	322 (+20.1)	35.3 (+62.6)	214.6 (+16.6)	0.55 (+120)	66.4(-15.4)
	8.62-8.68	0.70-0.73	315-327	27.4-42.8	187-233	0.54-0.56	63.4-68.5
T5	8.72 (-3.50)	0.77 (-26.6)	294 (+9.70)	30.6 (+41.0)	196.3 (+6.68)	0.43 (+72)	74.4(-5.22)
	8.71-8.74	0.77-0.78	291-298	23.7-34.6	178-216	0.42-0.44	71.6-77.4
T6	8.55 (-5.42)	0.65 (-38.0)	351 (+30.9)	36.8 (+69.5)	225 (+22.2)	0.56 (+124)	54.1 (-30.1)
	8.55-8.66	0.64-0.66	343-359	27.4-39.3	199-140	0.55-0.58	51.6-57.3
T7	8.53 (-5.64)	0.64 (-39.0)	353 (+31.7)	38.1 (+75.5)	231.6 (+25.8)	0.64 (+156)	47.68 (-39.3)
	8.52-8.55	0.63-0.65	346-357	26.8-49.4	195-258	0.62-0.65	44.8-50.6
T8	8.50 (-5.97)	0.61 (-41.9)	357 (+33.2)	38.7 (+78.3)	238.3 (+29.5)	0.63 (+152)	40.8 (-48.0)
	8.50-8.51	0.60-0.62	344-363	28.6-46.4	197-248	0.61-0.64	38.5-52.6

T1=control; T2=NPK; T3=FYM (farm yard manure); T4=VC (Vermicompost); T5=NPK+VC;

T6=FYM+VC (1:1); T7=FYM+VC (1:2); T8 =FYM+VC (2:1)

4.2 Soil Parameters

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. (Table 4.3 - 4.4), (Fig 4.3).

Table 4.3 Soil Amendments and their abbreviations

S.No	Abbreviations	Soil amendments
1.	**S1**	control
2.	**S2**	NPK
3.	**S3**	compost
4.	**S4**	VC
5.	**S5**	NPK+compost
6.	**S6**	NPK + compost (1:2)
7.	**S7**	NPK+VC
8.	**S8**	NPK + VC (1:2)
9.	**S9**	NPK + compost +VC
10.	**S10**	VC+compost 1:1

Table 4. 4 Variations in pH at Sites (n=3 ± SD)

S.No	SAMPLE	DECEMBER	FEBRUARY	MEAN
1.	**S1**	8.47±6.00	8.52±6.04	8.49±6.02
2.	**S2**	8.25±5.85	8.36±5.92	8.3±5.89
3.	**S3**	8.17±5.79	8.14±5.77	8.15±5.78
4.	**S4**	8.04±5.70	8.12±5.75	8.08±5.73
5.	**S5**	7.85±5.56	8.16±5.78	8±5.67
6.	**S6**	7.82±5.54	8.13±5.76	7.97±5.65
7.	**S7**	7.77±5.51	8.14±5.77	7.95±5.64
8.	**S8**	7.63±5.41	8.05±5.70	7.84±5.56
9.	**S9**	7.58±5.37	7.88±5.58	7.73±5.48
10.	**S10**	7.53±5.34	7.84±5.56	7.68±5.45

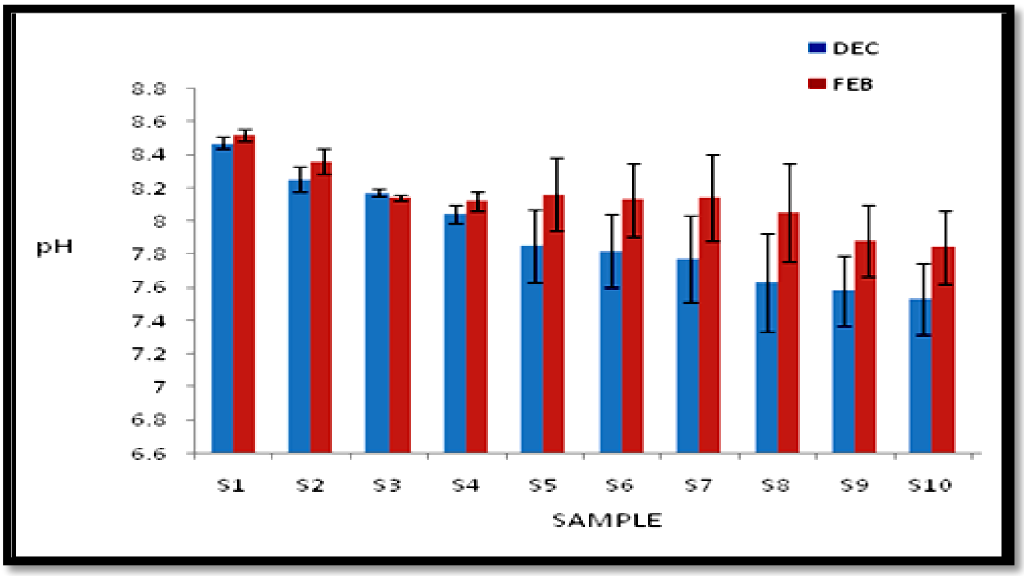


Fig 4.3: Variation in pH

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 (Table 4.5), (Fig 4.4).

Table 4.5 Variations in Electrical Conductivity (µS/cm^2) at sites (n=3±SD)

S. No	Sample	DECEMBER	FEBRUARY	MEAN
1.	S1	236±167.35	224±158.86	230±163.12
2.	S2	217±153.9	218±154.60	217.5±154.25
3.	S3	198±140.42	211±149.64	204.5±145.03
4.	S4	179±126.95	186±131.91	182.5±129.43
5.	S5	168±119.14	166±117.73	167±118.43
6.	S6	153±108.51	154±109.21	153.5±108.86
7.	S7	142±100.70	147±104.25	144.5±102.48
8.	S8	134±95.03	138±97.87	136±96.45
9.	S9	144±102.12	125±88.65	134.5±95.39
10.	S10	139±98.58	121±85.81	130±92.19

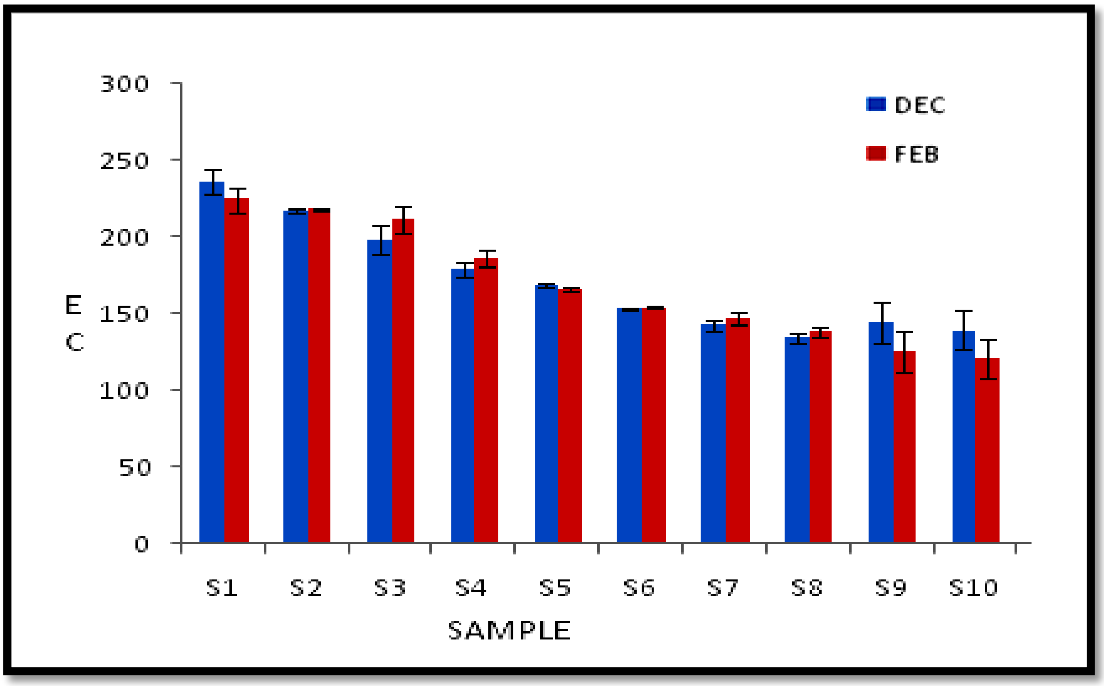


Fig 4.4: Variation in EC

3. 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 (Table 4.6), (Fig 4.5).

Table 4.6 Variation in Total Organic Carbon (%)

S. No	Sample	DECEMBER	FEBRUARY	MEAN
1.	**S1**	7.24±5.13	6.44 ±4.56	6.84±4.85
2.	**S2**	6.44±4.56	7.24±5.13	6.84±4.85
3.	**S3**	9.66±6.85	8.86±6.28	9.26±6.56
4.	**S4**	8.86±6.28	9.66±6.85	9.26±6.56
5.	**S5**	10.13±7.18	9.76±6.92	9.94±7.05
6.	**S6**	9.76±6.92	10.13±7.18	9.94±7.05
7.	**S7**	10.25±7.26	9.46±6.70	9.85±6.98
8.	**S8**	9.46±6.70	10.25±7.26	9.85±6.98
9.	**S9**	11.16±7.91	10.95±7.76	11.05±7.84
10.	**S10**	10.95±7.76	11.16±7.91	11.05±7.84

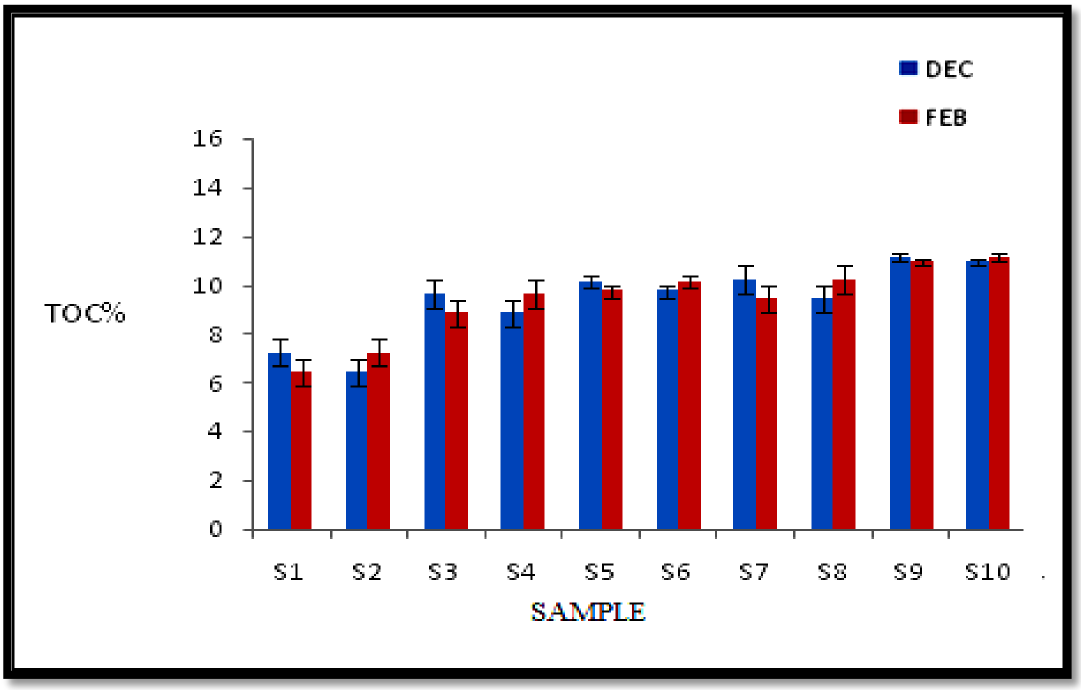


Fig 4.5: Variation in Total Organic Carbon (%)

4) 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 (Table 4.6), (Fig 4.6).

Table 4.6 Showing CFU Count of Bacteria

S. No	Sample	DEC	FEB
1.	**S1**	1600000	1900000
2.	**S2**	3600000	4200000
3.	**S3**	4800000	5400000
4.	**S4**	5800000	6600000
5.	**S5**	6500000	7400000
6.	**S6**	7200000	8000000
7.	**S7**	7000000	7700000
8.	**S8**	11500000	12200000
9.	**S9**	13700000	14600000
10.	**S10**	14500000	15800000

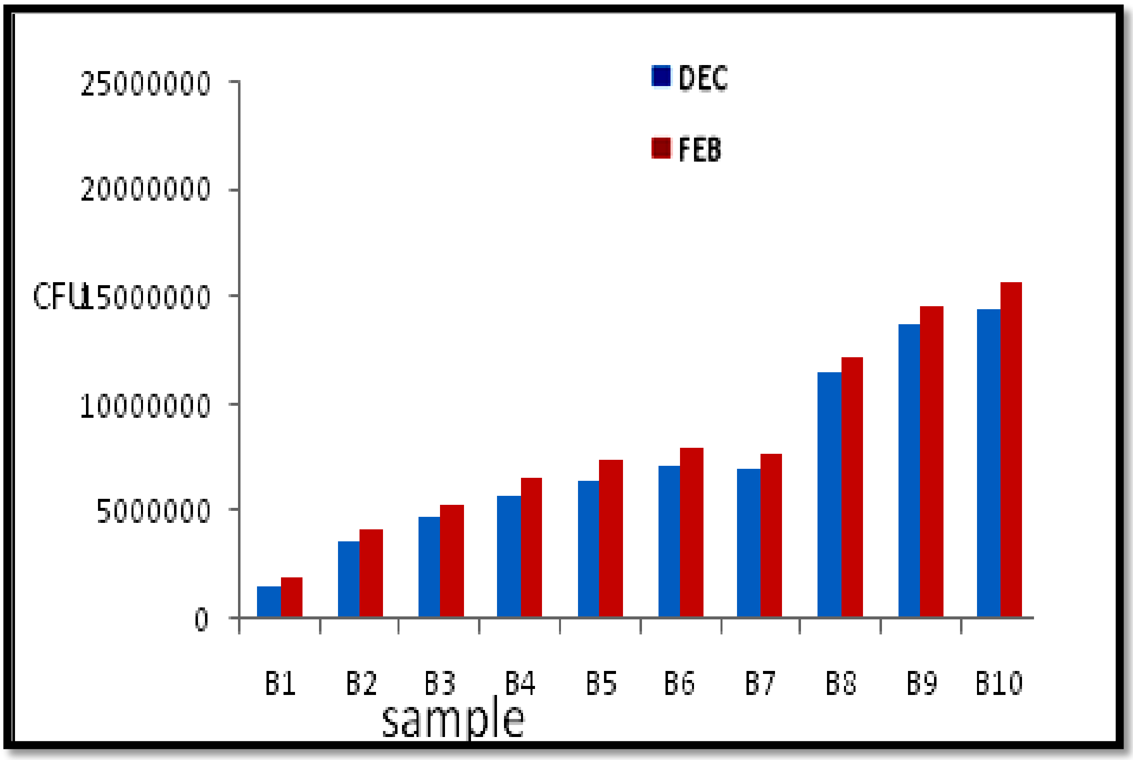


Fig 4.6: CFU count of bacteria

5) 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 (Table 4.7), (Fig 4.7).

Table 4.7 Showing Variations in CFU Count of Fungi

S. No	S. No	DEC	FEB
1.	**S1**	700	1000
2.	**S2**	7200	8000
3.	**S3**	11500	12000
4.	**S4**	13300	14000
5.	**S5**	21400	22000
6.	**S6**	34200	35000
7.	**S7**	23400	24000
8.	**S8**	43200	44000
9.	**S9**	46000	51000
10.	**S10**	70800	71600

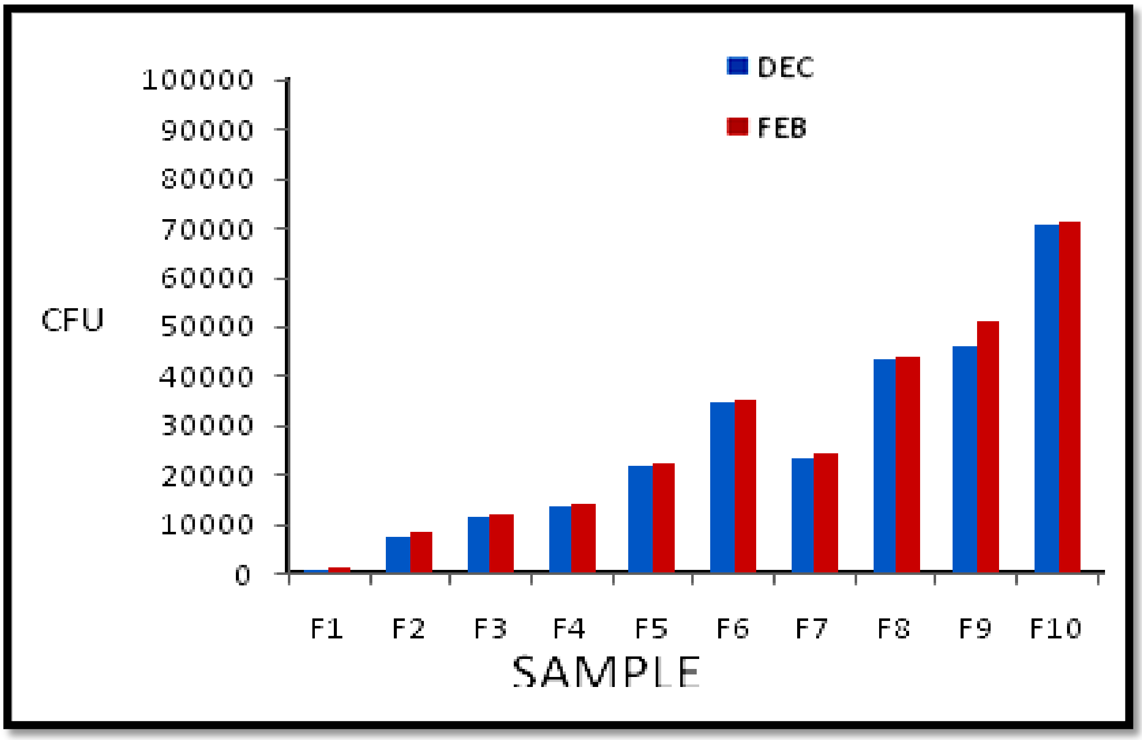


Fig 4.7 Variations in CFU Count of Fungi

6) 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 (Table 4.8), (Fig 4.8).

Table 4.8 Showing Variations in Nitrate

S. No	Sample	DECEMBER	FEBRUARY	MEAN
1.	**S1**	3.98±2.82	3.22±2.28	3.6±2.55
2.	**S2**	5.01±3.55	4.25±3.01	4.63±3.28
3.	**S3**	6.1±4.32	5.34±3.78	5.72±4.05
4.	**S4**	6.21±4.40	5.45±3.86	5.83±4.13
5.	**S5**	6.44±4.56	5.68±4.02	6.06±4.29
6.	**S6**	6.6±4.68	5.84±4.14	6.22±4.41
7.	**S7**	6.91±4.90	6.15±4.36	6.53±4.63
8.	**S8**	7.19±5.09	6.43±4.56	6.81±4.82
9.	**S9**	7.51±5.32	6.75±4.78	7.13±5.05
10.	**S10**	9.34±6.62	8.58±6.08	8.96±6.35

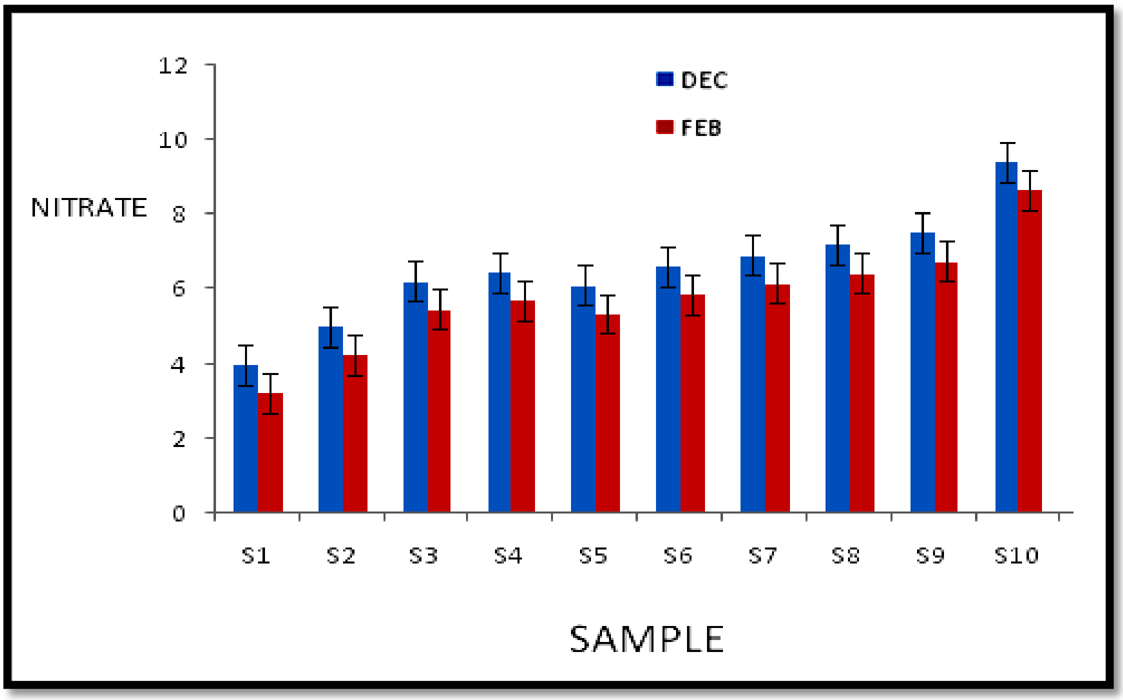


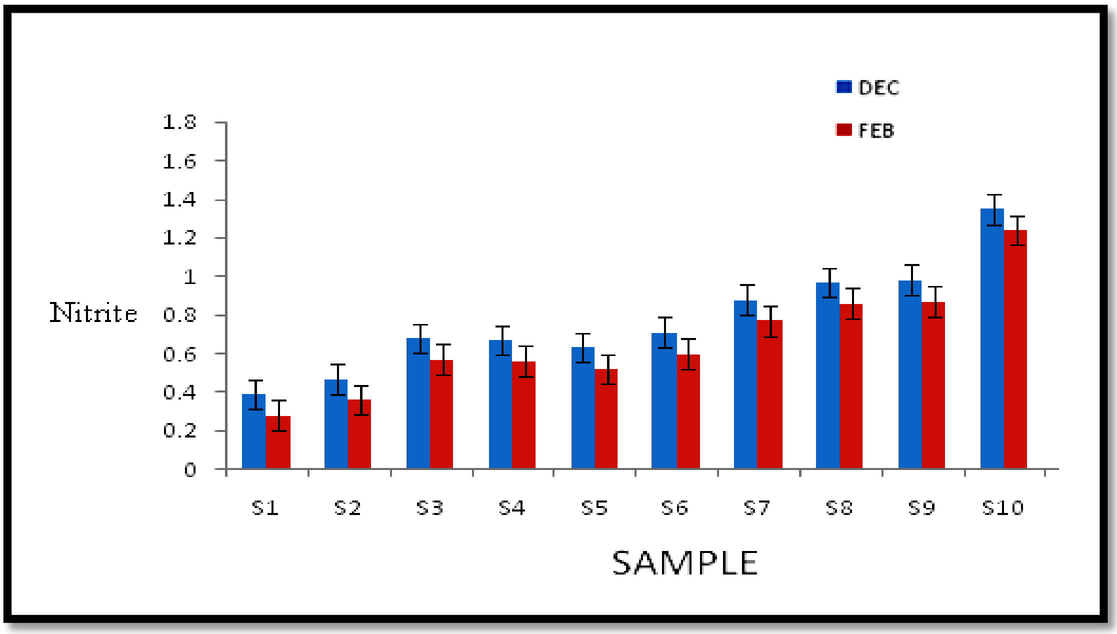
Fig 4.8 Variations in Nitrate

7) 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 (Table 4.9), (Fig 4.9).

Table 4.9 Showing Variations in Nitrite

S. No	Sample	DECEMBER	FEBRUARY	MEAN
1.	**S1**	0.39±0.27	0.28±0.19	0.335±0.23
2.	**S2**	0.47±0.33	0.36±0.25	0.415±0.29
3.	**S3**	0.68±0.48	0.57±0.40	0.625±0.44
4.	**S4**	0.67±0.47	0.56±0.39	0.615±0.43
5.	**S5**	0.63±0.44	0.52±0.36	0.575±0.40
6.	**S6**	0.71±0.50	0.6±0.42	0.655±0.46
7.	**S7**	0.88±0.62	0.77±0.54	0.825±0.58
8.	**S8**	0.97±0.68	0.86±0.60	0.915±0.64
9.	**S9**	0.98±0.69	0.87±0.61	0.925±0.65
10.	**S10**	1.35±0.95	1.24±0.87	1.295±0.91



Graph 4.9 Variations in Nitrite

8) 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 (Table 4.10), (Fig 4.10).

Table 4.10 Showing Variations in Phosphate

S. No	Sample	DECEMBER	FEBRUARY	MEAN
1.	**S1**	0.17±0.12	0.17±0.25	0.265±0.18
2.	**S2**	0.36±0.25	0.36±0.12	0.265±0.18
3.	**S3**	0.50±0.36	0.57±0.40	0.545±0.38
4.	**S4**	0.57±0.40	0.52±0.36	0.545±0.38
5.	**S5**	0.54±0.38	0.6±0.42	0.57±0.40
6.	**S6**	0.6±0.42	0.54±0.38	0.57±0.56
7.	**S7**	0.74±0.52	0.86±0.60	0.8±0.56
8.	**S8**	0.86±0.60	0.74±0.52	0.8±0.76
9.	**S9**	1.01±0.71	1.14±0.80	1.075±0.76
10.	**S10**	1.14±0.80	1.01±0.71	1.075±0.76

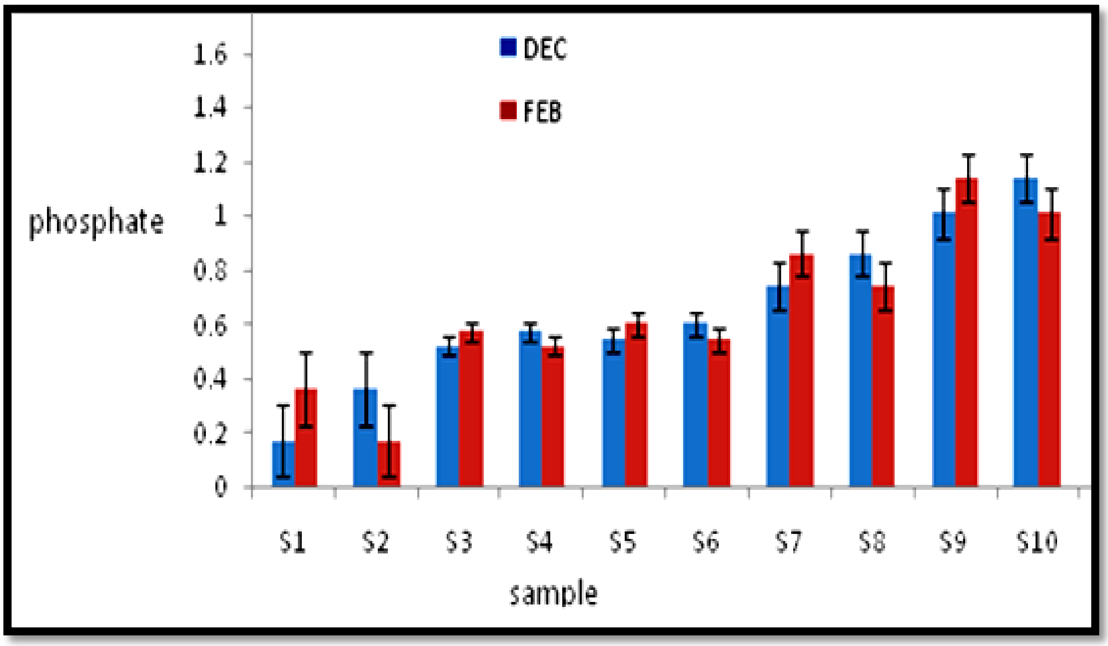


Fig 4.10 Variation in Phosphate

The highest decrease in soil pH, EC and Exchangeable Sodium Percentage (ESP) were observed in FYM and VC (T8) treated plots respectively. The soil nutrients N, P, K and SOC contents were higher in organically amendments sodic soils than soils amended with chemical fertilizers (T3; NPK amended soil) and control soil. The highest soil nutrients were observed in FYM and VC treated plots (T8). The increased values were N (2.62%-33.2%), P (3.69 %-78.3%), K (2.72%-29.5%) and OC% (16%-152%) in comparison to pre harvest values. Various physic-chemical properties of used organic amendments such as FYM and VC were also analyzed and given in Table 4.2. It further indicates that organically amended soil have a potential to reduce the sodicity and enhance fertility. Further FYM and VC IN 2:1 can act as boosting element to improve soil structure by facilitating the growth of microbial population and in turn carbon assimilation.

Table 4.11 Correlation B/W Soil Parameters

Correlations

		pH	EC	TOC	Nitrite	Nitrate	Phosphate	CFUB	CFUF
pH	Pearson Correlation	1	-.939**	-.968**	-.944**	-.966**	-.974**	-.969**	-.939**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000	.000
	N	12	12	12	12	12	12	12	12
EC	Pearson Correlation	-.939**	1	.902**	.981**	.966**	.979**	.976**	.990**
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.000	.000
	N	12	12	12	12	12	12	12	12
TOC	Pearson Correlation	-.968**	.902**	1	.891**	.937**	.923**	.928**	.904**
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.000	.000
	N	12	12	12	12	12	12	12	12
Nitrite	Pearson Correlation	-.944**	.981**	.891**	1	.983**	.984**	.961**	.971**
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.000	.000
	N	12	12	12	12	12	12	12	12
Nitrate	Pearson Correlation	-.966**	.966**	.937**	.983**	1	.972**	.950**	.958**
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000	.000
	N	12	12	12	12	12	12	12	12
Phosphate	Pearson Correlation	-.974**	.979**	.923**	.984**	.972**	1	.986**	.973**
	Sig. (2-tailed)	.000	.000	.000	.000	.000		.000	.000
	N	12	12	12	12	12	12	12	12
CFUB	Pearson Correlation	-.969**	.976**	.928**	.961**	.950**	.986**	1	.982**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000		.000
	N	12	12	12	12	12	12	12	12
CFUF	Pearson Correlation	-.939**	.990**	.904**	.971**	.958**	.973**	.982**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	
	N	12	12	12	12	12	12	12	12

**. Correlation is significant at the 0.01 level (2-tailed).

Table.4.12 Soil Fractional Analysis

Sample	Soil Organic Pools (g kg^{-1})					
	Very Labile (Pool -I)	Labile (Pool II)	Labile (Pool I + Pool III)	Labile (Pool III)	Labile (Pool IV)	Total Nitrogen (g kg^{-1})
S1	0.18	0.19	0.37	0.35	0.938	0.83
S2	0.2	0.18	0.38	0.36	0.892	0.82
S3	0.25	0.23	0.48	0.35	1.04	1.03
S4	0.2	0.21	0.41	0.36	0.940	1
S5	0.16	0.21	0.37	0.39	1.02	0.89
S6	0.23	0.2	0.43	0.37	0.934	0.95
S7	0.22	0.19	0.41	0.37	1.19	1.12
S8	0.23	0.19	0.42	0.36	1.01	0.9
S9	0.21	0.17	0.38	0.4	0.923	0.9
S10	0.24	0.18	0.42	0.38	1.13	1.02

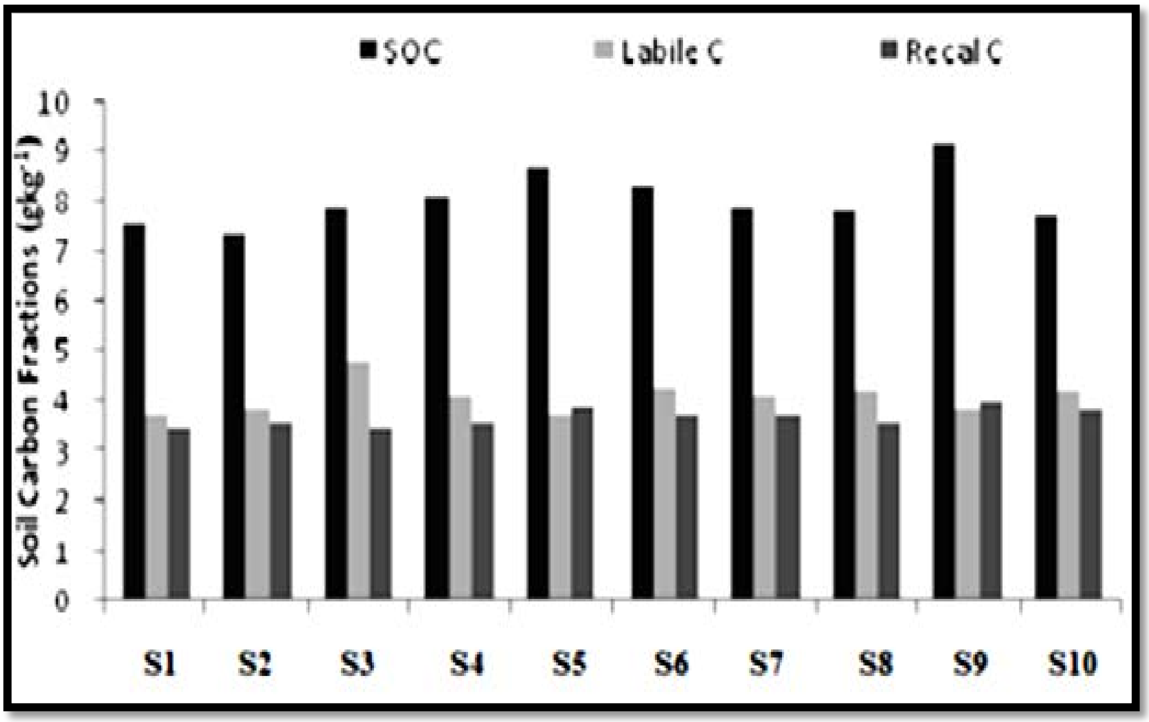


Fig 4.11: Soil Carbon Fractions

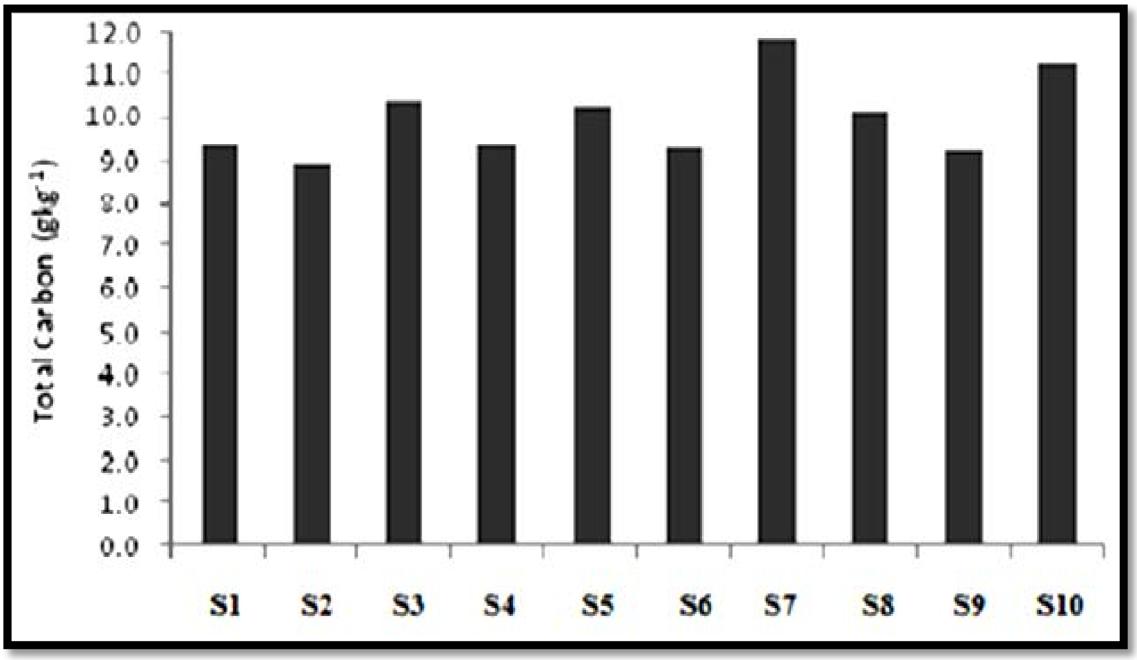


Fig 4.12: Total Carbon Analysis

Table 4.13 The comparatice Analysis of physico-chemical properties of sodic soil as influenced by organic amendments

Table 2. Chemical properties of sodic soil as influenced by organic amendments in sodic soil. Values are in means and range. Values in parenthesis represent % increase (+) or decrease (-) with respect to pre-harvest values.

Pre harvest	9.04	1.05	21.7	184
T1	9.03 (-0.11)	0.95 (-9.5)	22.5 (+3.69)	182.6 (-0.76)
	9.01-9.06	0.95-0.96	21.2 -23.8	174-185
T2	9.03 (-0.11)	0.94 (-10.4)	24.4 (+12.4)	189 (+2.72)
	9.00-9.05	0.90-0.95	23.3-25.7	167-196
T3	8.64 (-4.42)	0.75 (-28.5)	33.6 (+54.8)	205.3 (+11.5)
	8.62-8.66	0.70-0.79	25.5-39.7	188-218
T4	8.64 (-4.42)	0.71 (-32.3)	35.3 (+62.6)	214.6 (+16.6)
	8.62-8.68	0.70-0.73	27.4-42.8	187-233
T5	8.72 (-3.50)	0.77 (-26.6)	30.6 (+41.0)	196.3 (+6.68)
	8.71-8.74	0.77-0.78	23.7-34.6	178-216
T6	8.55 (-5.42)	0.65 (-38.0)	36.8 (+69.5)	225 (+22.2)
	8.55-8.66	0.64-0.66	27.4-39.3	199-140
T7	8.53 (-5.64)	0.64 (-39.0)	38.1 (+75.5)	231.6 (+25.8)
	8.52-8.55	0.63-0.65	26.8-49.4	195-258
T8	8.50 (-5.97)	0.61 (-41.9)	38.7 (+78.3)	238.3 (+29.5)
	8.50-8.51	0.60-0.62	28.6-46.4	197-248

T1=control; T2=NPK; T3=FYM (farm yard manure); T4=VC (Vermicompost); T5=NPK+VC; T6=FYM+VC (1:1); T7=FYM+VC (1:2); T8 =FYM+VC (2:1)

4.3 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 (Please see Table 4.14 to 4.29 for details).

Table 4.14

Sample ID	Season	$d^{13}C$	$d^{15}N$	C %	N %	C / N
Sample 1	**Monsoon**	-26.0	3.1	2.3	0.18	15.3
Sample 1	**Monsoon**	-26.1	4.8	3.1	0.24	14.8
Sample 1	**Monsoon**	-25.6	3.8	2.8	0.22	14.4
Sample 1	**Monsoon**	-25.9	4.3	3.0	0.23	15.1
Sample 1	**Monsoon**	-27.5	2.5	2.0	0.15	15.6
Sample 1	**Monsoon**	-25.3	2.6	2.7	0.21	14.8

Table 4.15

Sample ID	Season	$d^{13}C$	$d^{15}N$	C %	N %	C / N
Sample 2	**Summer**	-20.7	4.7	2.3	0.19	13.8
Sample 2	**Summer**	-25.4	3.7	3.2	0.29	13.1
Sample 2	**Summer**	-24.4	4.4	2.3	0.20	13.4
Sample 2	**Summer**	-25.0	4.5	3.1	0.27	13.3
Sample 2	**Summer**	-26.5	3.7	3.8	0.29	15.3
Sample 2	**Summer**	-25.4	4.0	5.0	0.36	16.2

Table 4.16

Sample ID	Season	$d^{13}C$	$d^{15}N$	C %	N %	C / N
Sample 3	**Winter**	-27.5	4.7	3.1	0.27	13.7
Sample 3	**Winter**	-25.5	4.1	3.9	0.31	14.4
Sample 3	**Winter**	-24.4	4.8	3.2	0.28	13.3
Sample 3	**Winter**	-26.5	3.1	4.8	0.36	15.7
Sample 3	**Winter**	-27.0	4.2	4.9	0.33	17.4
Sample 3	**Winter**	-26.7	2.7	3.9	0.30	15.4

Table 4.17

Sample ID	Season	$d^{13}C$	$d^{15}N$	C %	N %	C / N
Sample 4	**Summer**	-22.9	5.9	2.6	0.3	9.4
Sample 4	**Summer**	-23.2	5.4	3.0	0.4	9.8
Sample 4	**Summer**	-23.3	3.8	2.7	0.3	10.2
Sample 4	**Summer**	-23.8	6.3	3.0	0.4	9.9
Sample 4	**Summer**	-24.8	2.2	3.2	0.4	10.1
Sample 4	**Summer**	-23.6	6.2	3.7	0.4	10.9

Table 4.18

Sample ID	Season	$d^{13}C$	$d^{15}N$	C %	N %	C / N
Sample 5	**Monsoon**	-25.3	7.2	2.8	0.3	10.3
Sample 5	**Monsoon**	-23.7	6.5	2.6	0.3	10.3
Sample 5	**Monsoon**	-23.2	7.9	2.6	0.3	10.4
Sample 5	**Monsoon**	-23.8	5.2	3.0	0.3	10.9
Sample 5	**Monsoon**	-26.1	5.4	4.2	0.4	11.6
Sample 5	**Monsoon**	-24.6	5.6	2.9	0.3	10.6

Table 4.19

Sample ID	Season	$d^{13}C$	$d^{15}N$	C %	N %	C / N
Sample 6	**Winter**	-23.5	7.6	3.4	0.4	10.6
Sample 6	**Winter**	-24.1	2.8	3.2	0.3	10.9
Sample 6	**Winter**	-23.1	8.6	3.3	0.4	10.5
Sample 6	**Winter**	-29.8	3.4	4.3	0.5	10.9
Sample 6	**Winter**	-25.6	3.8	5.0	0.5	11.2
Sample 6	**Winter**	-23.6	7.3	4.4	0.5	10.9

Table 4.20

Sample ID	Season	$d^{13}C$	$d^{15}N$	C %	N %	C / N
Sample 7	**Summer**	-22.4	5.7	2.8	0.3	12.6
Sample 7	**Summer**	-22.4	5.2	3.2	0.3	12.9
Sample 7	**Summer**	-24.5	4.7	2.8	0.3	12.8
Sample 7	**Summer**	-23.0	5.1	3.3	0.3	11.7
Sample 7	**Summer**	-26.1	5.4	4.0	0.3	14.7
Sample 7	**Summer**	-26.0	6.6	5.1	0.4	16.9

Table 4.21

Sample ID	Season	$d^{13}C$	$d^{15}N$	C %	N %	C / N
Sample 8	Monsoon	-22.2	6.2	2.8	0.3	12.6
Sample 8	Monsoon	-26.5	5.2	3.5	0.3	13.5
Sample 8	Monsoon	-23.5	4.9	3.2	0.3	12.5
Sample 8	Monsoon	-23.4	5.8	4.0	0.3	14.0
Sample 8	Monsoon	-26.1	5.9	5.2	0.4	15.1
Sample 8	Monsoon	-24.9	7.3	4.1	0.3	15.4

Table 4.22

Sample ID	Season	$d^{13}C$	$d^{15}N$	C %	N %	C / N
Sample 9	Winter	-24.0	5.8	3.1	0.3	12.6
Sample 9	Winter	-23.1	5.2	3.5	0.3	13.2
Sample 9	Winter	-22.4	6.2	3.1	0.3	11.2
Sample 9	Winter	-24.8	5.1	4.5	0.3	15.2
Sample 9	Winter	-27.4	6.0	6.4	0.5	15.8
Sample 9	Winter	-26.6	5.5	5.5	0.4	17.1

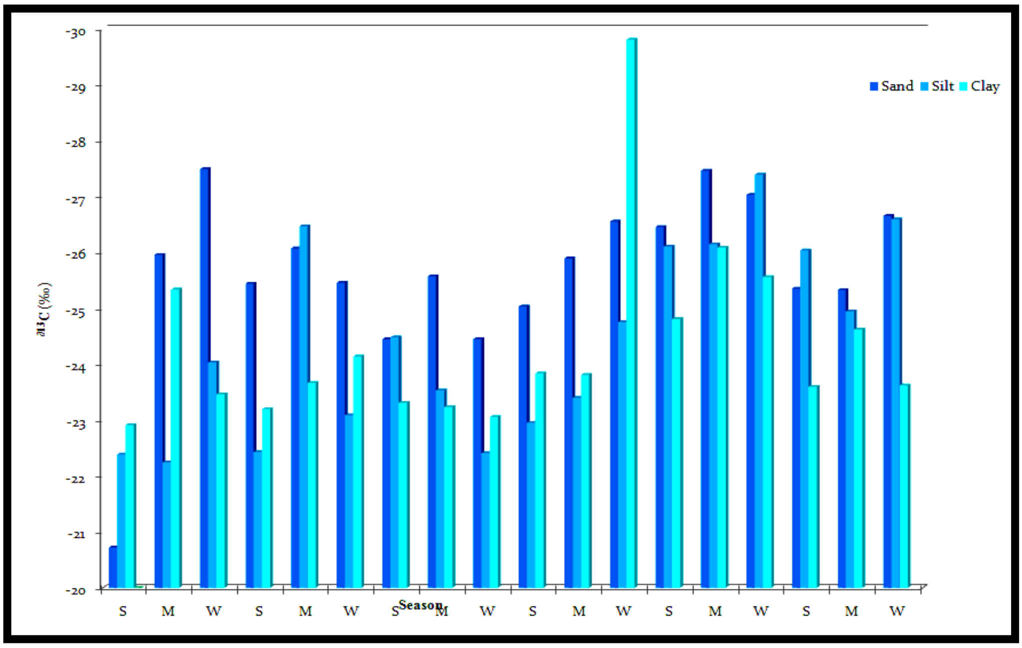


Fig 4.13

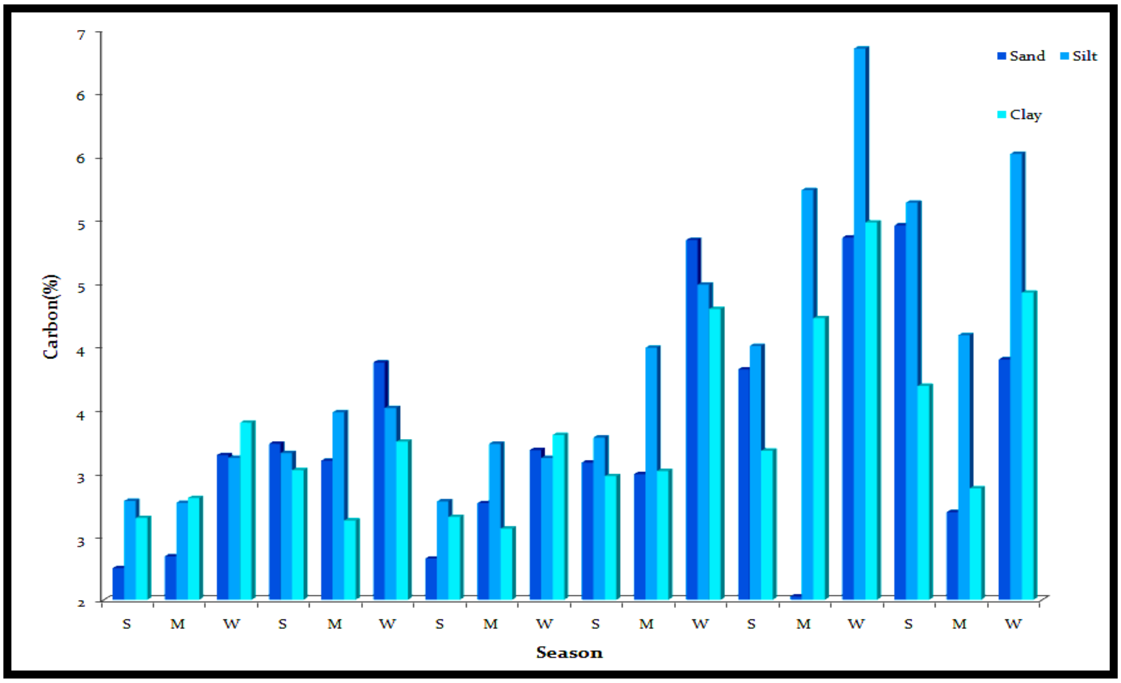


Fig 4.14

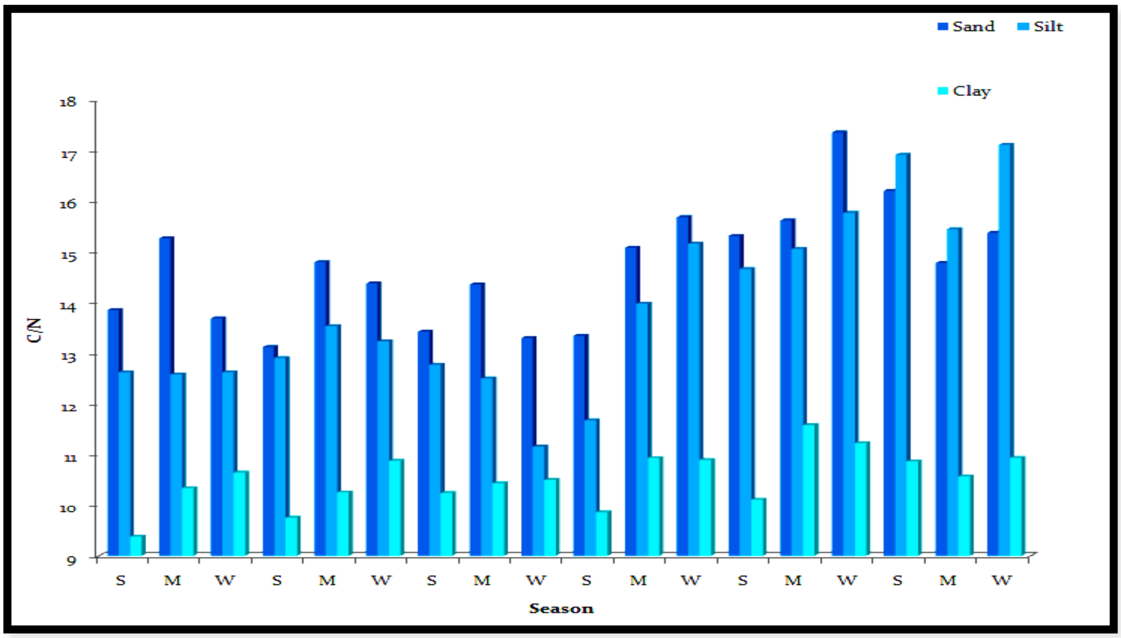


Fig 4.15

Table 4.23 Percentage of Nitrogen with Season

S	0.19	0.3	0.3
S	0.29	0.3	0.4
S	0.20	0.3	0.3
S	0.27	0.3	0.4
S	0.29	0.3	0.4
S	0.36	0.4	0.4
M	0.18	0.3	0.3
M	0.24	0.3	0.3
M	0.22	0.3	0.3
M	0.23	0.3	0.3
M	0.15	0.4	0.4
M	0.21	0.3	0.3
W	0.3	0.27	0.4
W	0.3	0.31	0.3
W	0.3	0.28	0.4
W	0.3	0.36	0.5
W	0.5	0.33	0.5
W	0.4	0.30	0.5

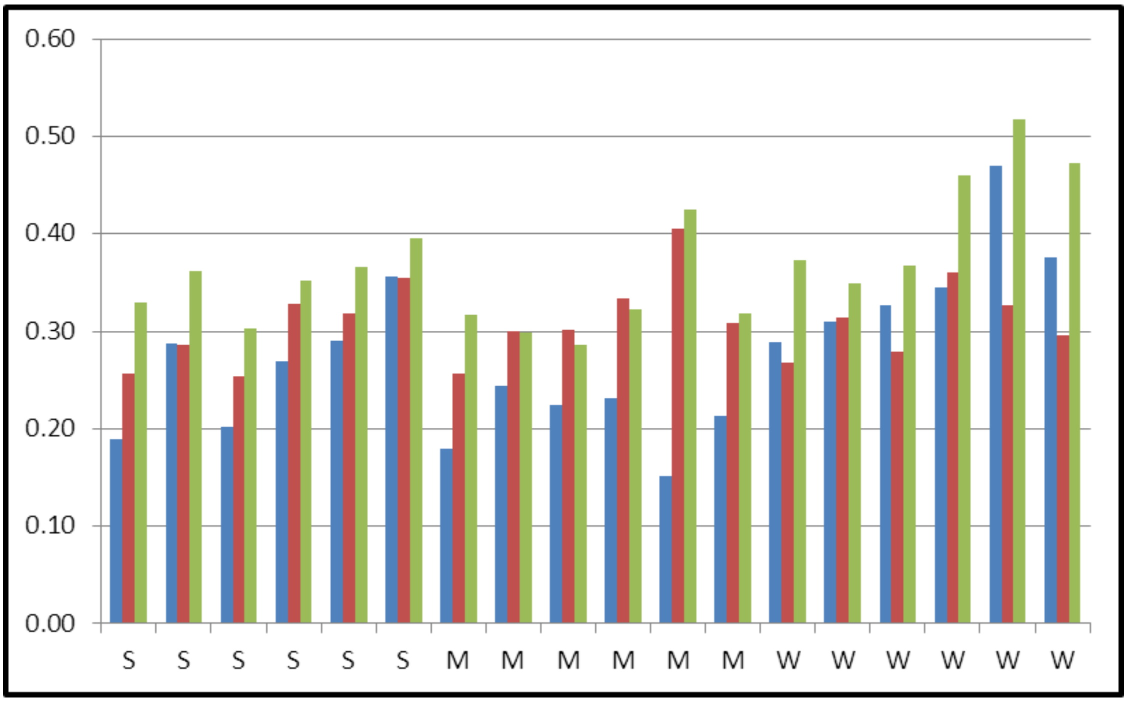


Fig 4.16 Percentage of Nitrogen with Season

Table 4.24 Derivatization of Nitrogen with Season (d15N)

S	4.7	5.7	5.9
S	3.7	5.2	5.4
S	4.4	4.7	3.8
S	4.5	5.1	6.3
S	3.7	5.4	2.2
S	4.0	6.6	6.2
M	3.1	0.3	7.2
M	4.8	0.3	6.5
M	3.8	0.3	7.9
M	4.3	0.3	5.2
M	2.5	0.4	5.4
M	2.6	0.3	5.6
W	4.7	5.8	7.6
W	4.1	5.2	2.8
W	4.8	6.2	8.6
W	3.1	5.1	3.4
W	4.2	6.0	3.8
W	2.7	5.5	7.3

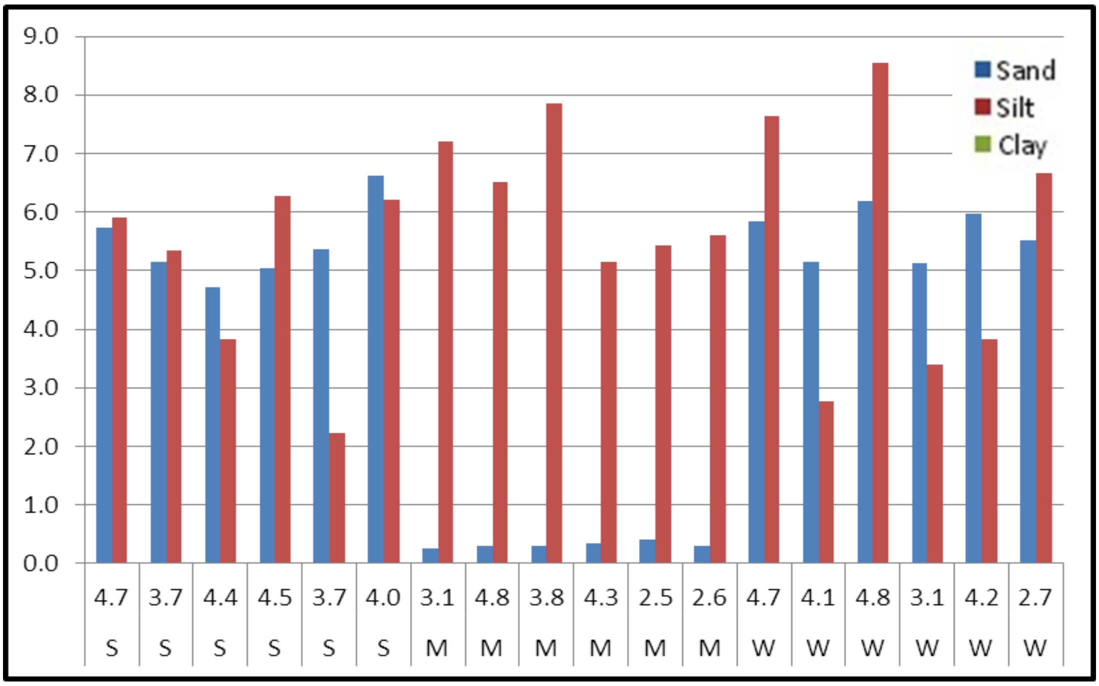


Fig 4.17 Derivatization of Nitrogen with Season (d15N)

Table 4.25 Percentage of Carbon with Season

S	2.3	2.8	2.6
S	3.2	3.2	3.0
S	2.3	2.8	2.7
S	3.1	3.3	3.0
S	3.8	4.0	3.2
S	5.0	5.1	3.7
M	2.3	2.8	2.8
M	3.1	3.5	2.6
M	2.8	3.2	2.6
M	3.0	4.0	3.0
M	2.0	5.2	4.2
M	2.7	4.1	2.9
W	3.1	3.1	3.4
W	3.9	3.5	3.2
W	3.2	3.1	3.3
W	4.8	4.5	4.3
W	4.9	6.4	5.0
W	3.9	5.5	4.4

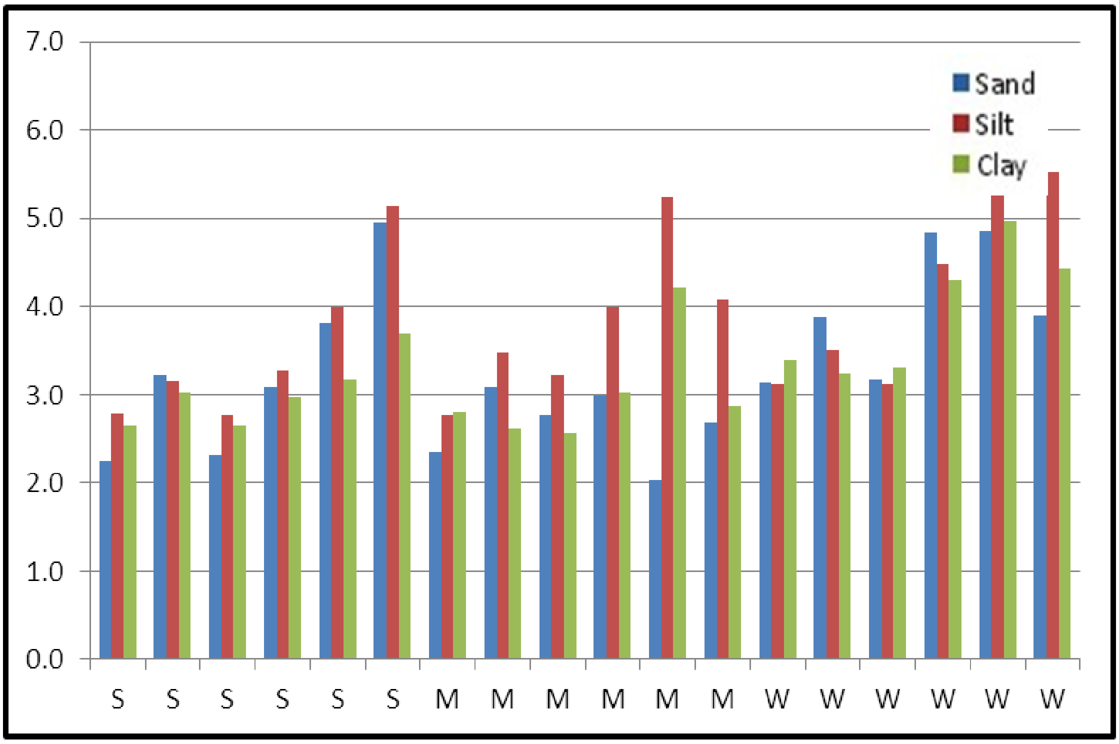


Fig 4.18 Percentage of Carbon with Season

Table 4.26 Derivatization of Carbon with Season (d13C)

S	-20.7	-22.4	-22.9
M	-26.0	-22.2	-25.3
W	-27.5	-24.0	-23.5
S	-25.4	-22.4	-23.2
M	-26.1	-26.5	-23.7
W	-25.5	-23.1	-24.1
S	-24.4	-24.5	-23.3
M	-25.6	-23.5	-23.2
W	-24.4	-22.4	-23.1
S	-25.0	-23.0	-23.8
M	-25.9	-23.4	-23.8
W	-26.5	-24.8	-29.8
S	-26.5	-26.1	-24.8
M	-27.5	-26.1	-26.1
W	-27.0	-27.4	-25.6
S	-25.4	-26.0	-23.6
M	-25.3	-24.9	-24.6
W	-26.7	-26.6	-23.6

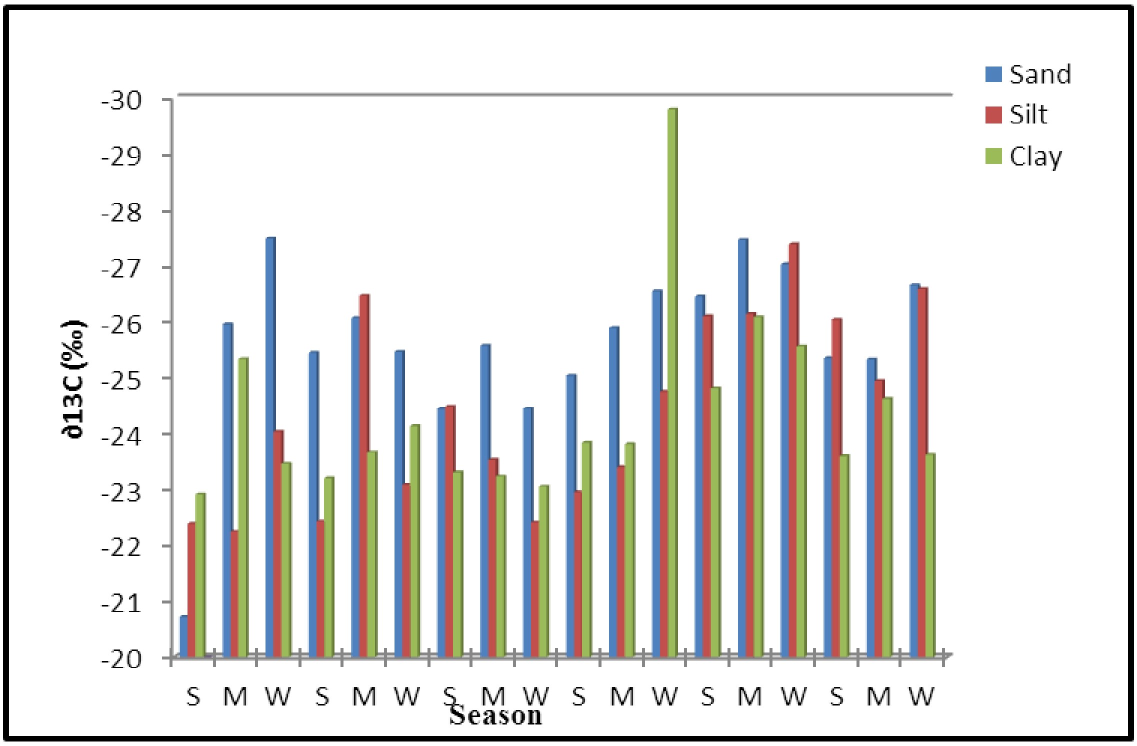


Fig. 4.19 Derivatization of Carbon with Season (d13C)

Table 4.27 Carbon and Nitrogen (C/N) with Season

S	13.8	12.6	9.4
M	15.3	12.6	10.3
W	13.7	12.6	10.6
S	13.1	12.9	9.8
M	14.8	13.5	10.3
W	14.4	13.2	10.9
S	13.4	12.8	10.2
M	14.4	12.5	10.4
W	13.3	11.2	10.5
S	13.3	11.7	9.9
M	15.1	14.0	10.9
W	15.7	15.2	10.9
S	15.3	14.7	10.1
M	15.6	15.1	11.6
W	17.4	15.8	11.2
S	16.2	16.9	10.9
M	14.8	15.4	10.6
W	15.4	17.1	10.9

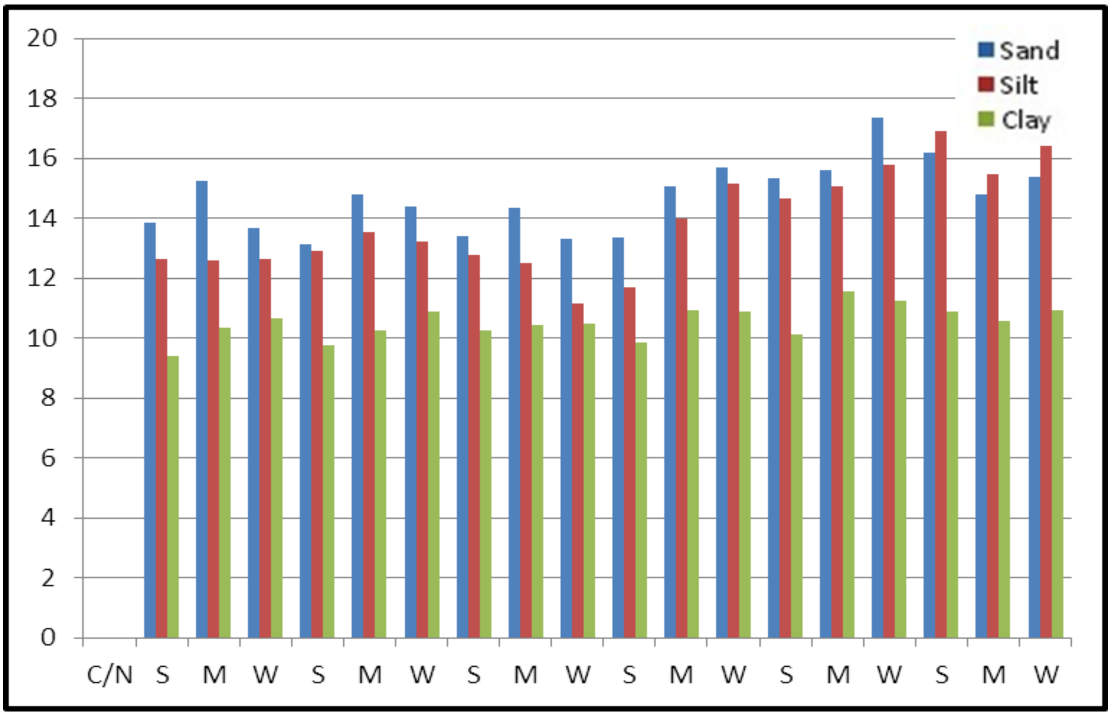


Fig 4.20 Carbon and Nitrogen (C/N) with Season

4.4 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.

4.5 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 in further elaborated in Table Nos 20 and 21.

Table 4.28 FTIR Analyses of Soil Samples

FunctionalGroup	Site1	Site2	Site3	Site4	Site5	Site6	Site7	Site8	Site9	Site10
OH in alcohols andphenols	3623.5	3629.6	3621.0	3619.1	3621.5	3621.3	3622.5	3622.9	3621.8	3621.6
$-NH_2$ inaromatic amines, primary amines and amides	-	-	3433.2	3433.8	3435.0	3430.0	-	-	-	3433.8
N-H in primaryamides	1627.1	-	1622.0	1644.6	1621.6	1622.8	1645.1	1619.7	1621.2	1621.6
C-N in primaryamides	1434.8	1441.8	-	1428.7	1433.0	1437.4	1435.4	1429.3	1436.2	-
Si-O-Siinsiloxanes	1019.1	1015.0	1020.3	1027.1	1012.8	1017.1	1013.0	1023.8	1020.1	1026.1
C-S in sulfonyl chlorides	771.6	770.0	775.0	774.1	773.9	775.6	775.2	775.1	774.8	774.8
C-C-CHO in aldehydes	688.5	689.1	690.2	690.1	690.0	690.5	690.4	689.7	690.3	690.3
NO_2 in nitrocompounds	521.3	522.9	522.3	526.8	-	-	523.9	524.7	524.3	523.7
C-N-C in amines	467.4	467.3	467.3	467.3	466.8	469.3	467.4	467.4	467.8	466.9

Table 4.29 Analyses and Interpretation of FTIR Species in Samples

Stretching FrequencyRange (cm^{-1})		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
3650-3600	**OH**	+	+	+	+	+	+	+	+	+	+
3520-3320	**-NH2**	+	+	+	-	+	+	-	+	-	+
1640-1580	**N-H**	-	-	+	+	+	+	-	-	-	+
1440-1400	**C-N**	+	+	-	-	+	+	+	+	-	-
1055-915	**Si-O-Si**	+	+	+	+	+	+	+	+	+	+
775-650	**C-S**	+	+	+	+	+	+	+	+	+	+
695-635	**C-C-CHO**	+	+	+	+	+	+	+	+	+	+
530-470	**NO2**	+	+	+	+	-	-	+	+	+	+
520-430	**C-N-C**	+	+	+	+	+	+	+	+	+	+

4.6 Discussion

It is established that soil is a complex of living, changing and dynamic component of earth crust. A thorough understanding of the mineralogy of soil is very important because of their low cost, abundance in most continents of the world, high sorption properties and potential for ion exchange. Soil is one form of nature and its versatile world 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. 1 gram of soil has over 50,000 as well as bacteria, algae, fungi, Earthworms and Nematodes. Given this preface experimentations have indicated that labile organic carbon has been proved to be sensitive indicators of changes in SOC pool due to changes in agricultural management practices (Ghosh *et al*., 2013). The soil organic carbon pool and the total amount of labile carbon fraction has direct control over physiochemical and biological properties of the soil system and also influences self-organization capacity of soil (Addiscott, 1995; Blair and Crocker, 2000;). In 1995 in a report the Carbon liability was defined as the ratio of labile C to non-labile C (Blair *et al*., 1995). Changes in labile C pools occur within a short period (one to two years) and this pool (LOC) can be used to assess land management effects. Walkley Black C (WBC) or oxidizable soil organic C mostly represents the entire labile C pool and some portion of long-lived C pools, which takes longer to change, due to land management effects (Six *et al*., 1999). Hence, several workers reported that the KMnO4- oxidizable SOC or LOC is a more sensitive SOC indicator compared with total SOC or WBC (Moharana *et al*., 2012; Liu *et al*., 2014). This fraction of carbon is a crucial part of global carbon cycle. In the present analysis it is indicative of its complex dynamics. In the other observation of organic amendment the pH may reduce primarily due to high production of CO2 and organic acids in soil followed by solubilisations of CaCO3 and even neutralization of sodicity is reported (Shiamma *et al*., 2012). 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. 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. 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. Moreover the 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. It is reiterated that quantification of soil carbon (C) cycling which is influenced by management practices is also necessary for determining carbon sequestration dynamics as hypothesized is justified.

CHAPTER-5

CONCLUSIONS

CHAPTER-5

CONCLUSIONS

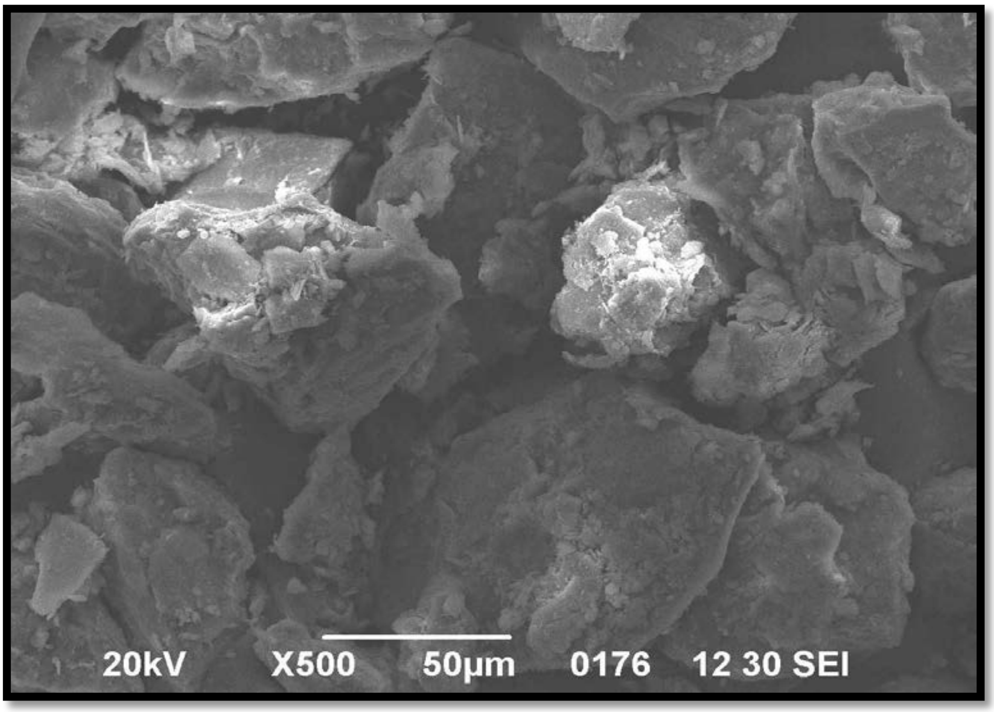
Soil acts as a major sink to atmospheric carbon, thus plays a key role in global carbon cycle. Soil organic carbon (SOC) is composed of recalcitrant and labile carbon pools. Recalcitrant pool of carbon (that includes humin and humic substances) is resistant to microbial degradation due to its complex 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.

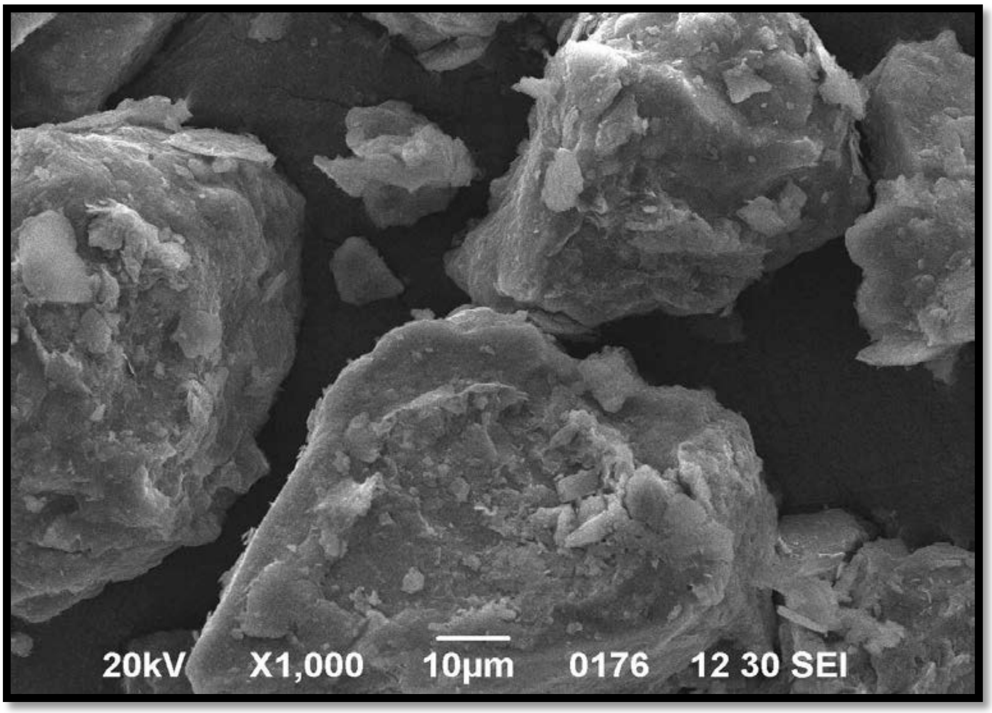
Our analysis of samples revealed its types as sandy, clay and loam soil with pH 8.3 to 9.6. Electrical conductivity (EC), Phosphate (P) Potassium (K) are ranged between 0.60-0.96 (dSm-1), 21.2-46.4 (kg ha-1) and 167-258 (kg ha-1) respectively. Oxidizable- organic carbon (OC) was determined by using Walkley - Black Method (modified). Total organic carbon (TOC) ranged between 8.9 -11.9 g/kg, SOC ranged between 7.4-9.19 g/kg, Total nitrogen (TN) ranged from 0.82-1.12 g/Kg. (TOC) ranged between 8.9 -11.9 g/kg, SOC ranged between 7.4-9.19 g/kg, The difference between total SOC and SOC oxidizable by 24.0N H2SO4 was termed refractory pool (pool IV). Pool I and II together known as the labile pool, which ranged from 3.6 to 4.5 g kg -1 and pool III ranged from 3.2 to 3.8 g kg -1. Analyses using FTIR, SEM and EDS revealed complexity in the nature of functional groups, Textural dimensions and elemental details.

Finally 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. In this way soil carbon cycling as demonstrated in the experiments provides a crucial linkage of its interrelationship with other functions in the given ecosystem as hypothesised is justified.

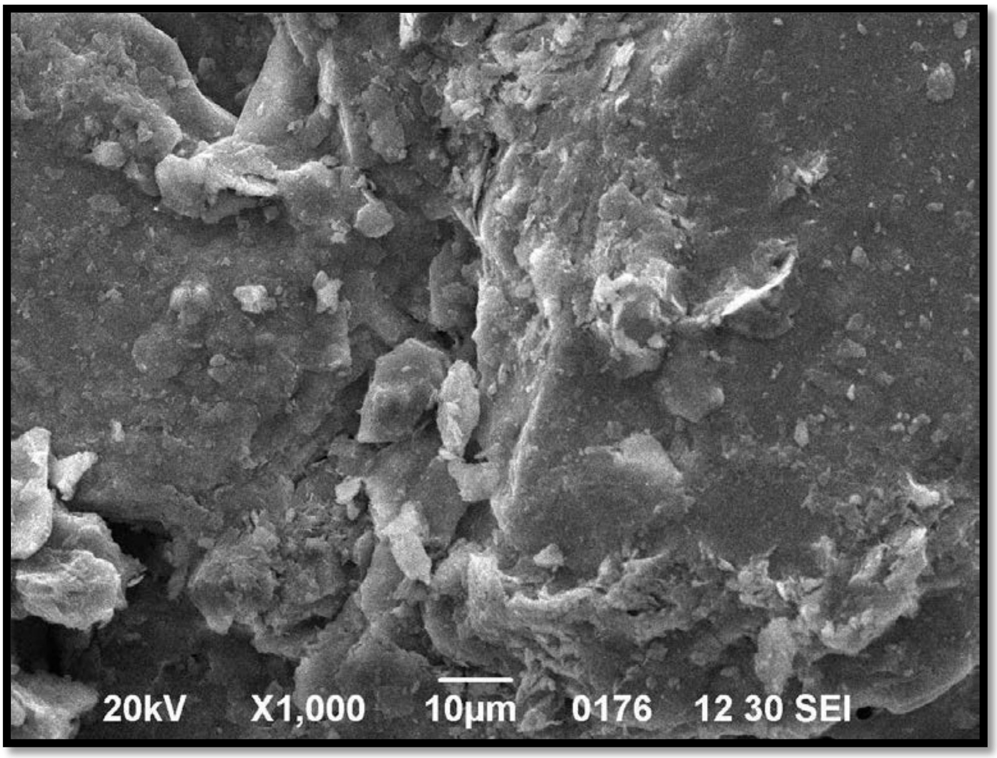
PHOTOGRAPHS

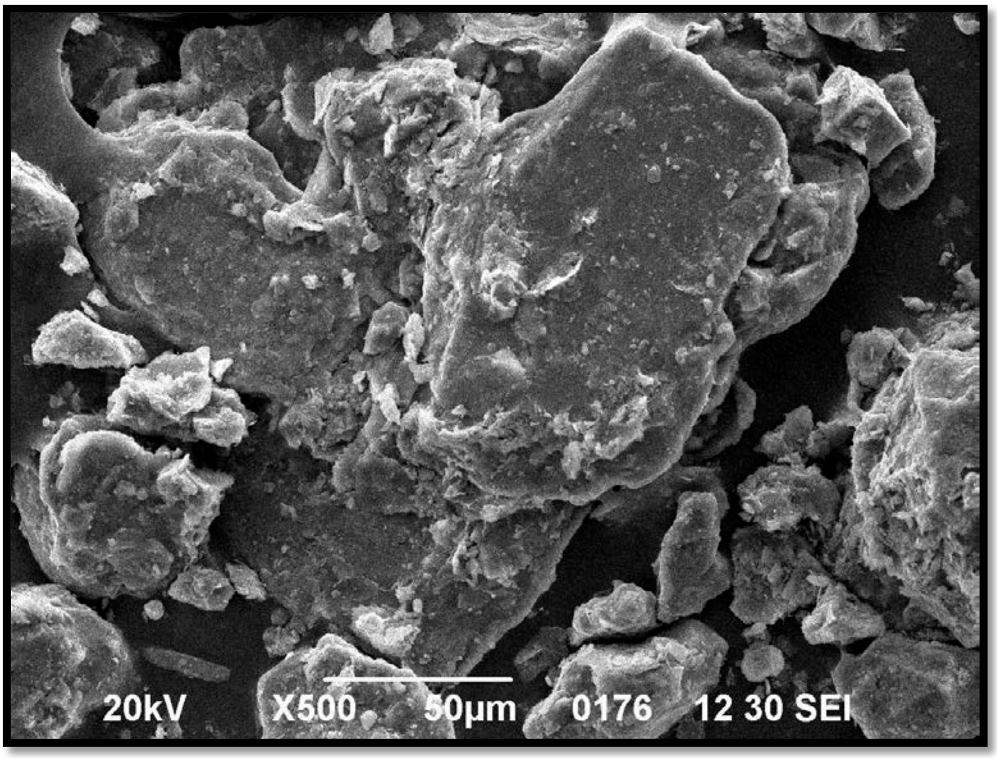
SCANNING ELECTRON MICROSCOPY (SEM) OF SOIL SAMPLES



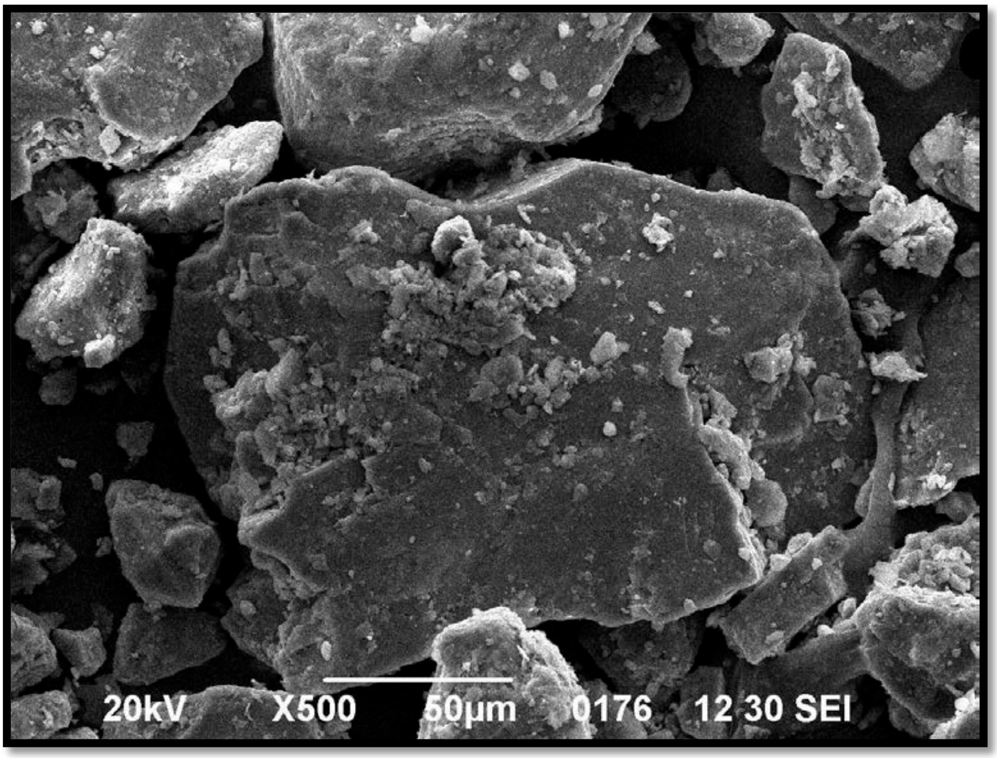


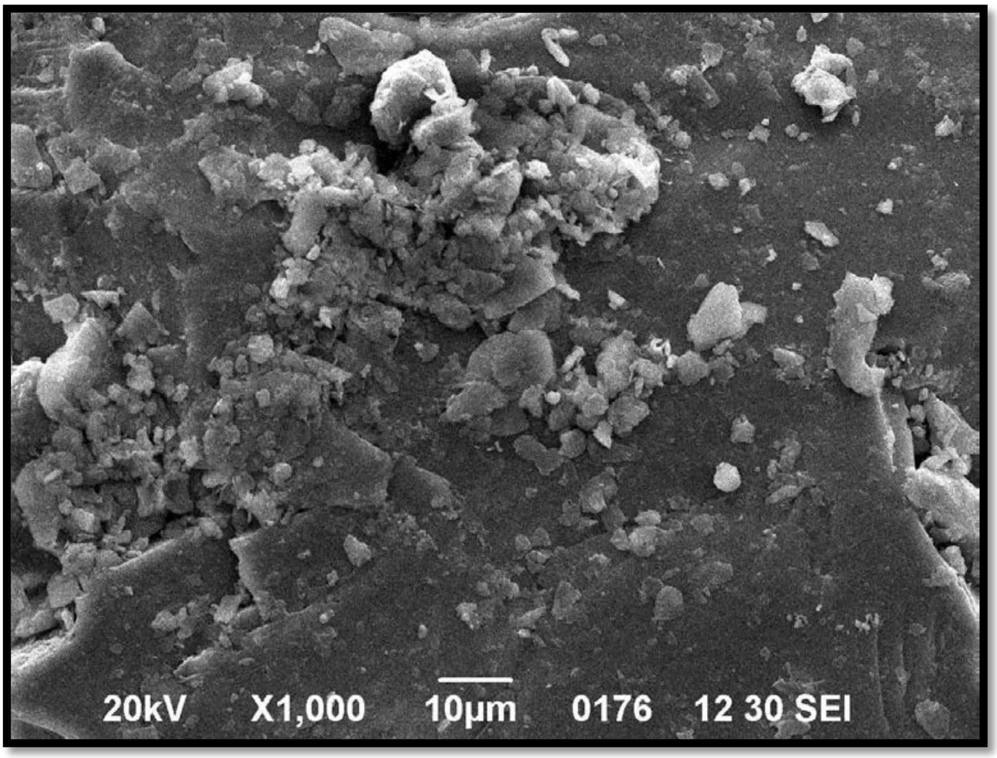
Photograph 1: Scanning Electron Microscopic Analysis of Soil Sample No 1



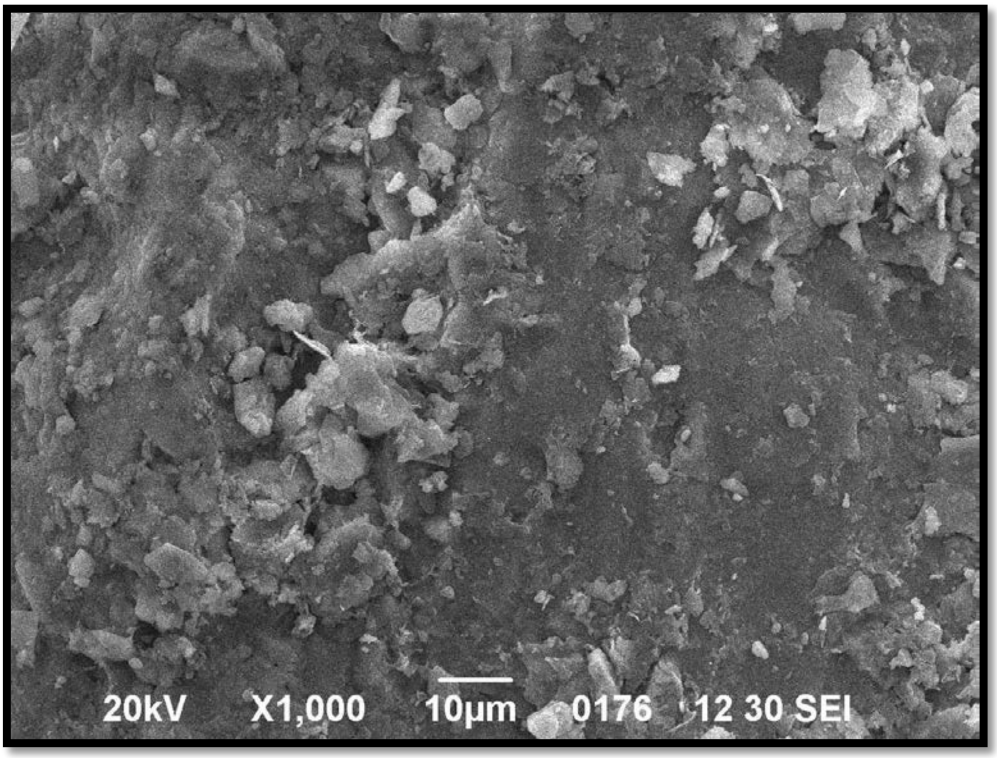


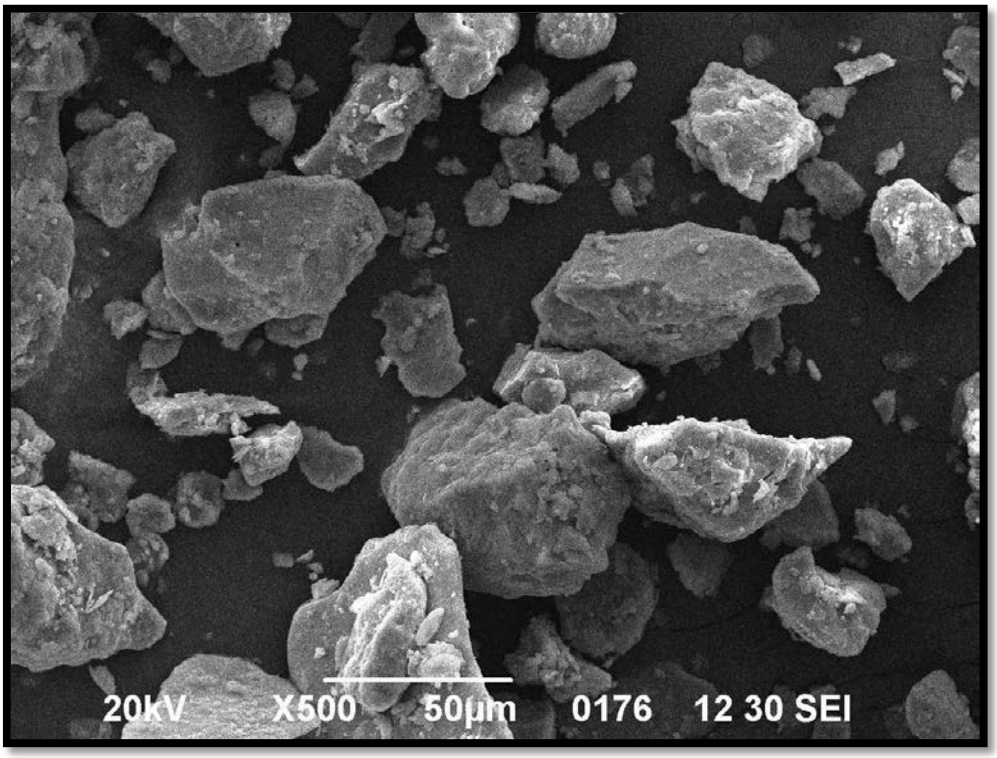
Photograph 2: Scanning Electron Microscopy of Soil Sample No 2



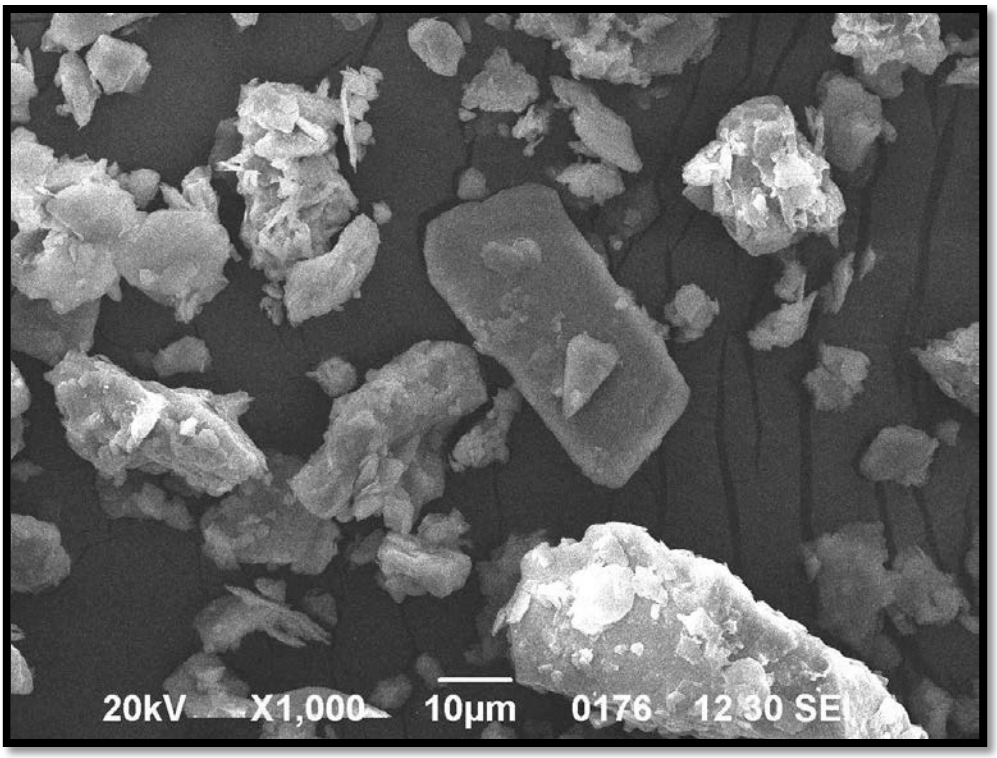


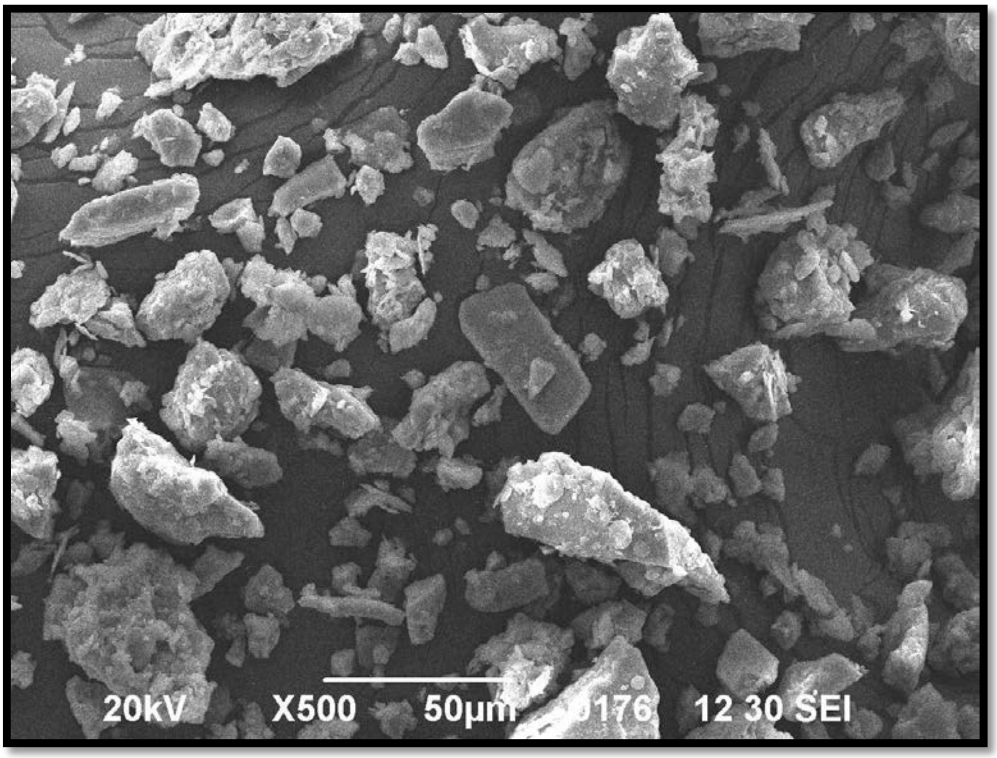
Photograph 3: Scanning Electron Microscopy of Soil Sample No 3



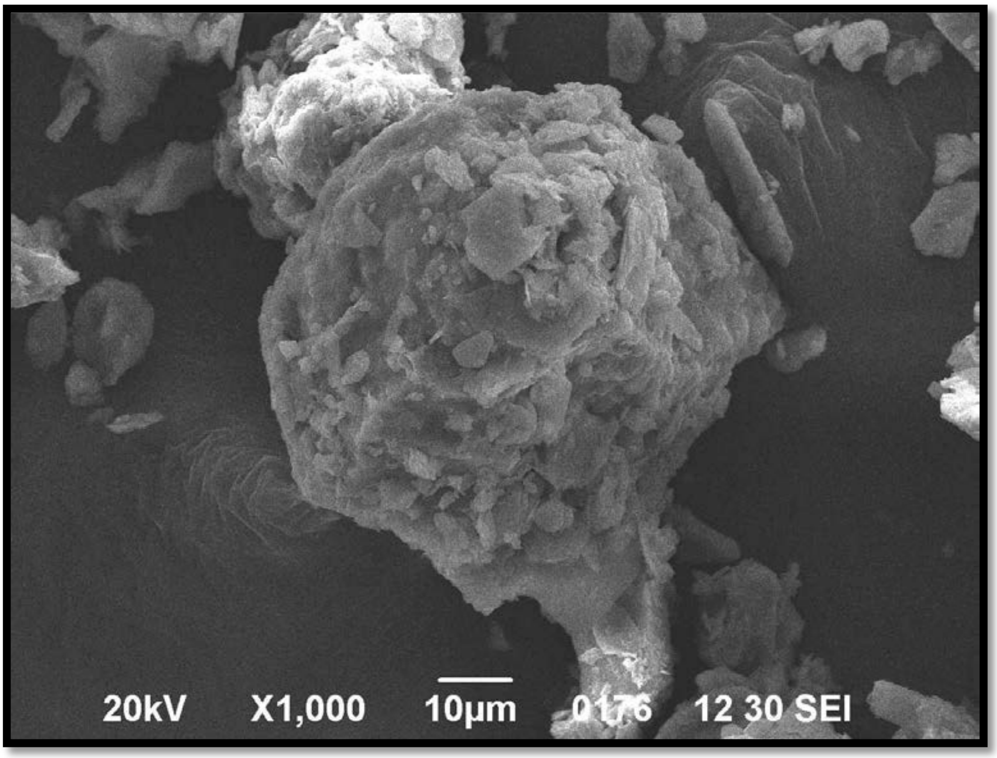


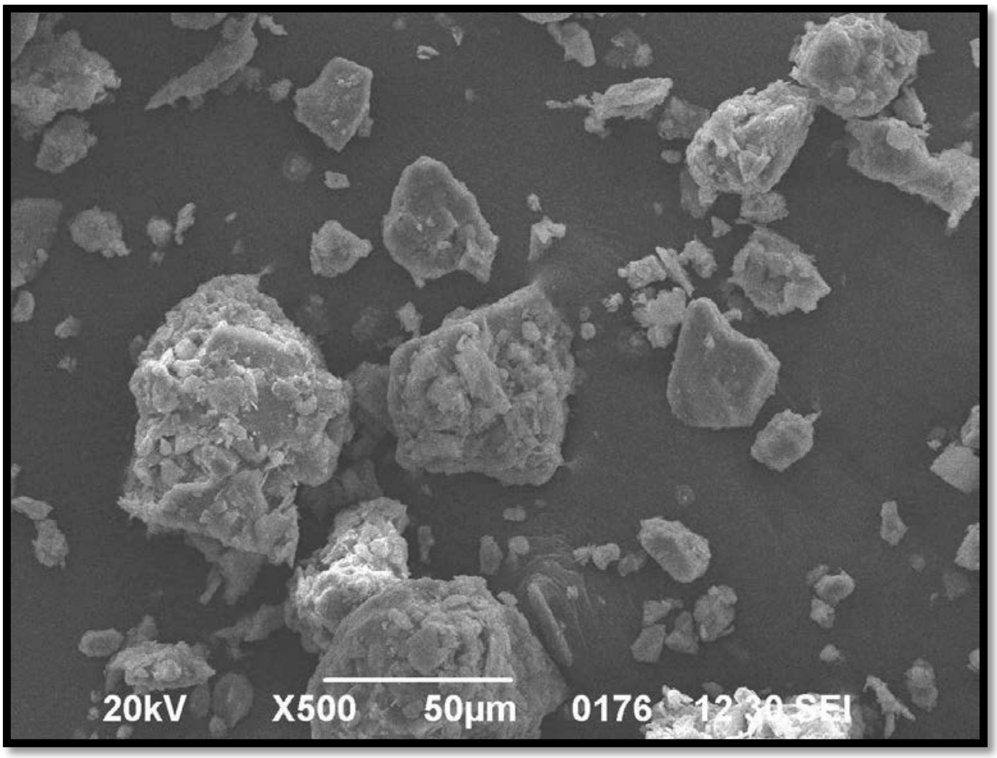
Photograph 4: Scanning Electron Microscopy of Soil Sample No 4



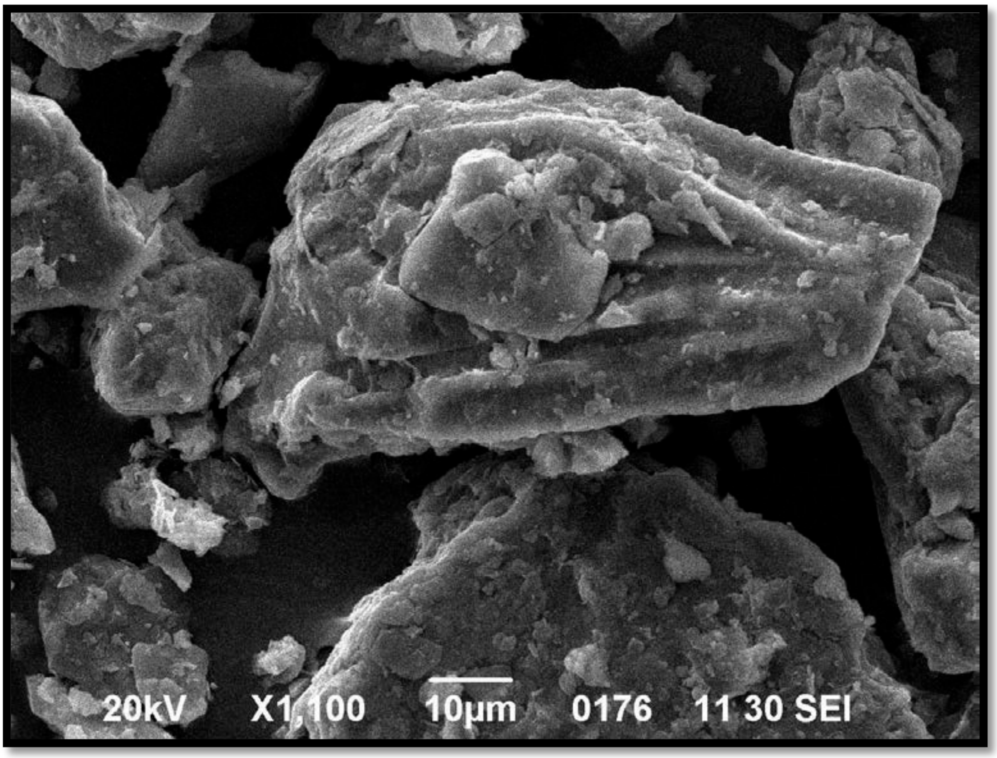


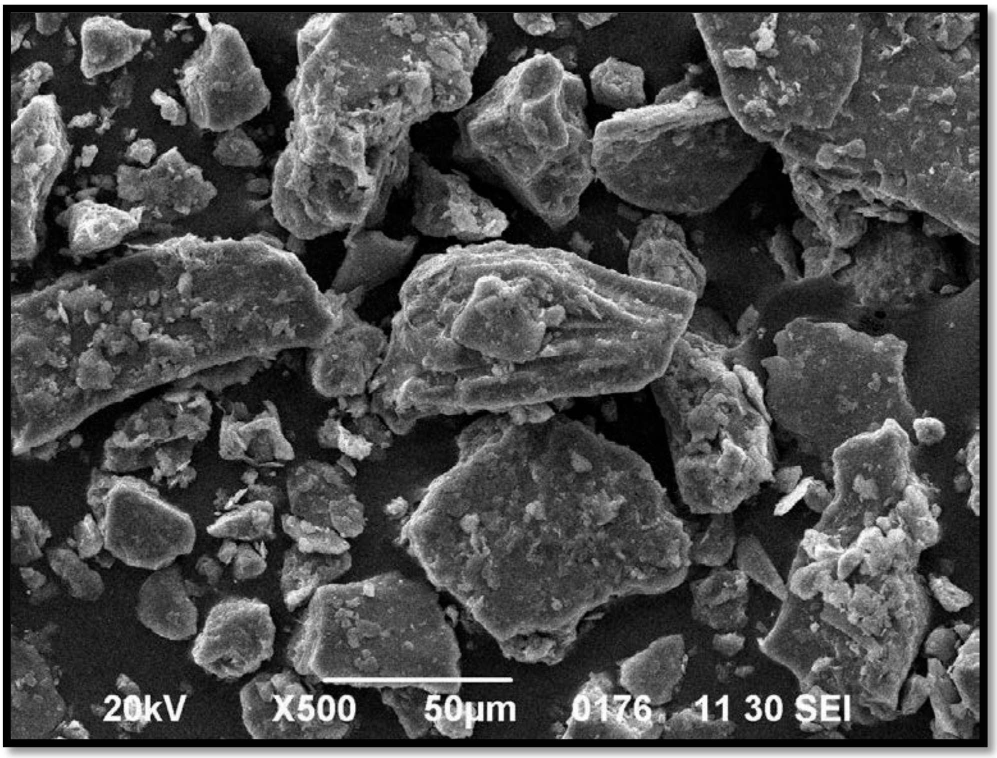
Photograph 5: Scanning Electron Microscopy of Soil Sample No 5



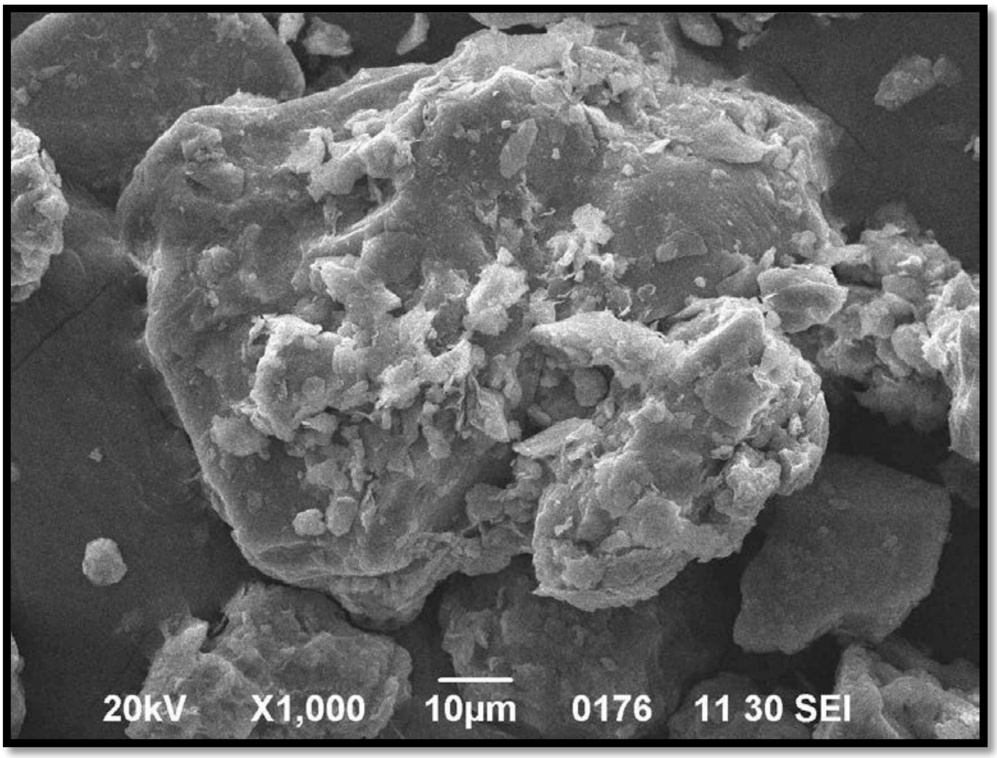


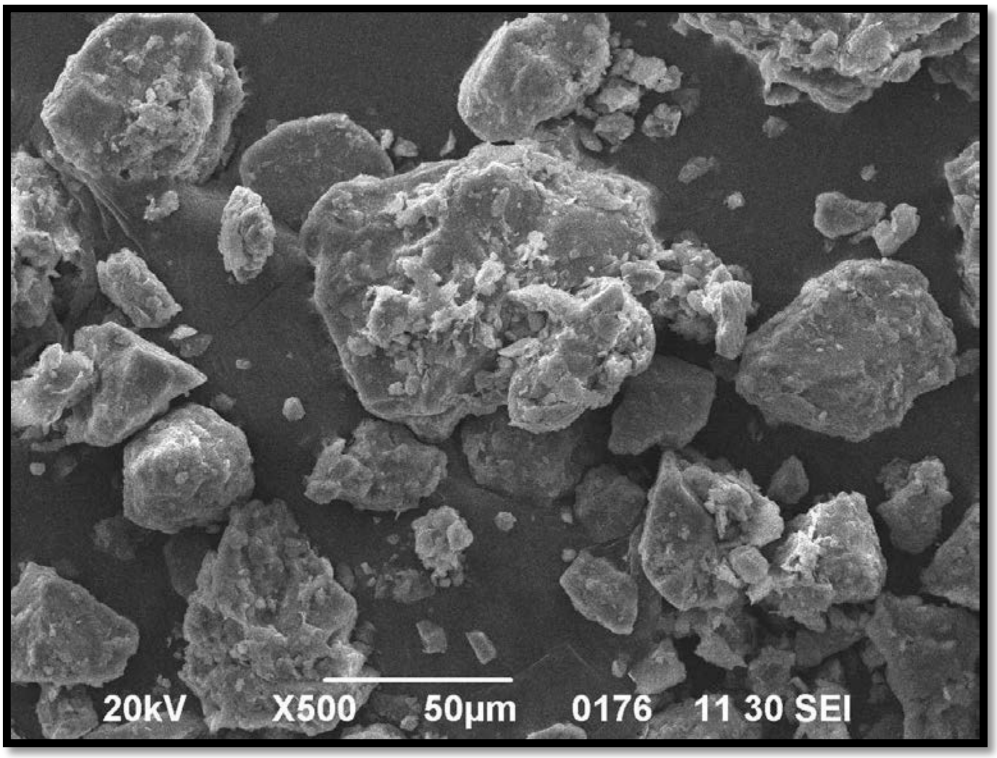
Photograph 6: Scanning Electron Microscopy of Soil Sample No 6



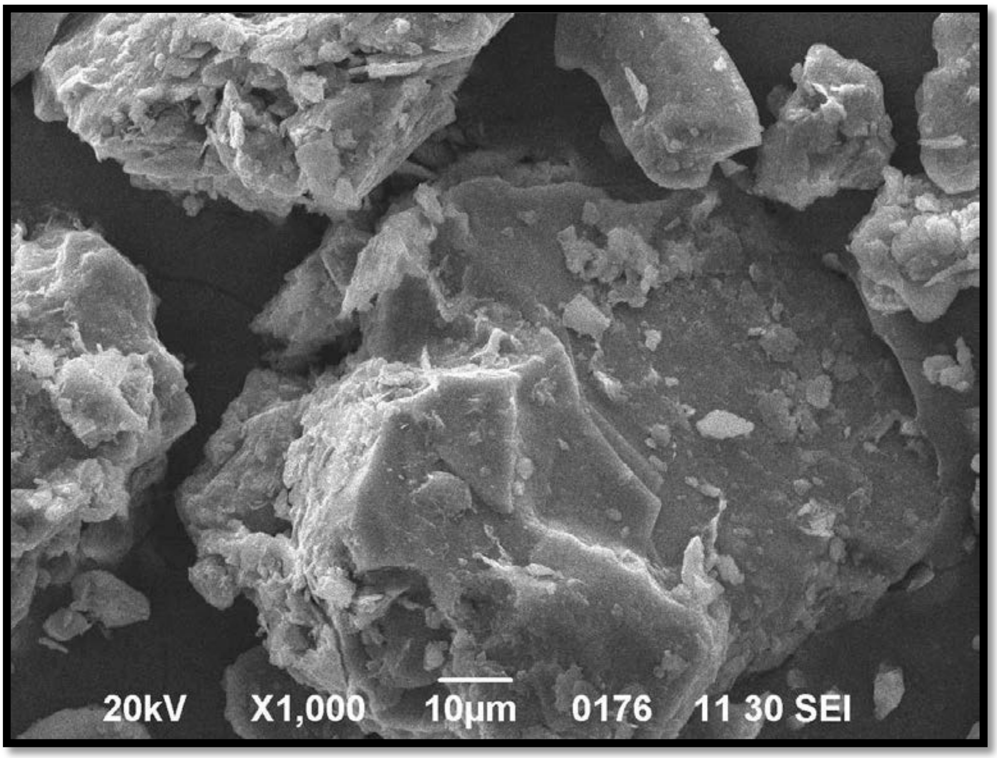


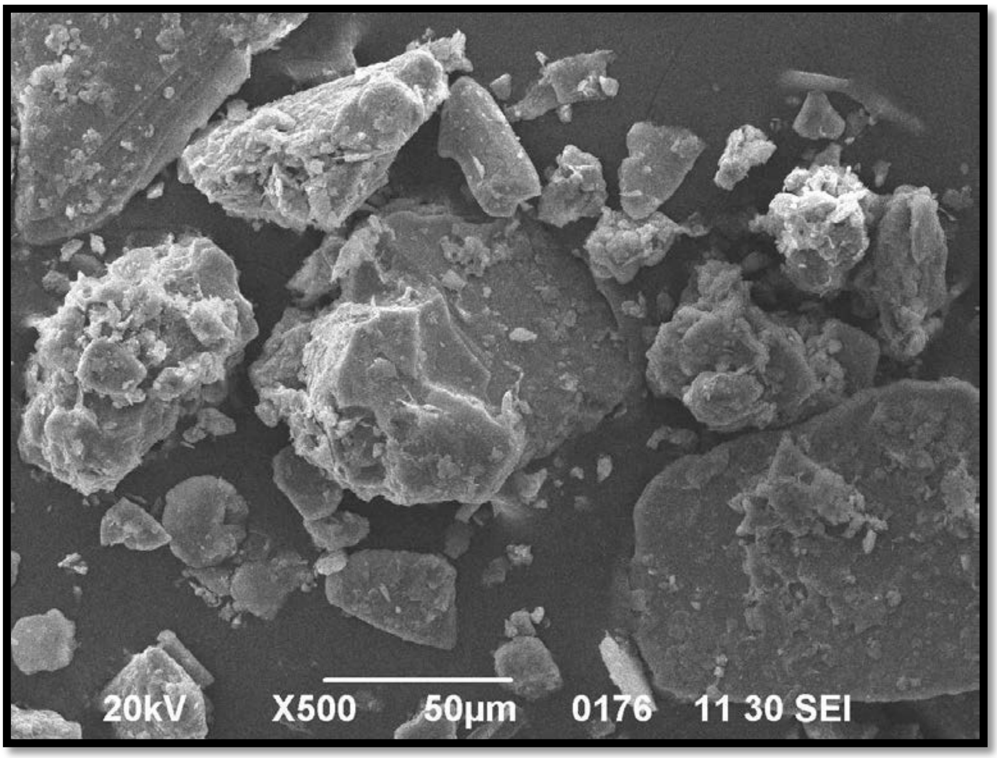
Photograph 7: Scanning Electron Microscopy of Soil Sample No 7



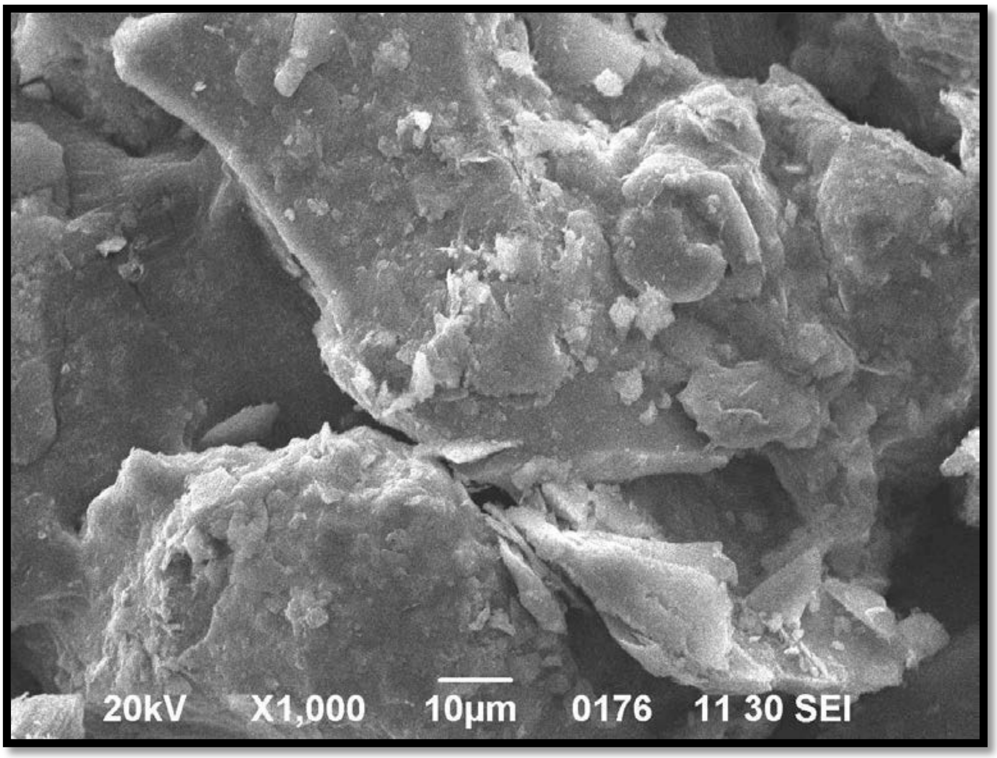


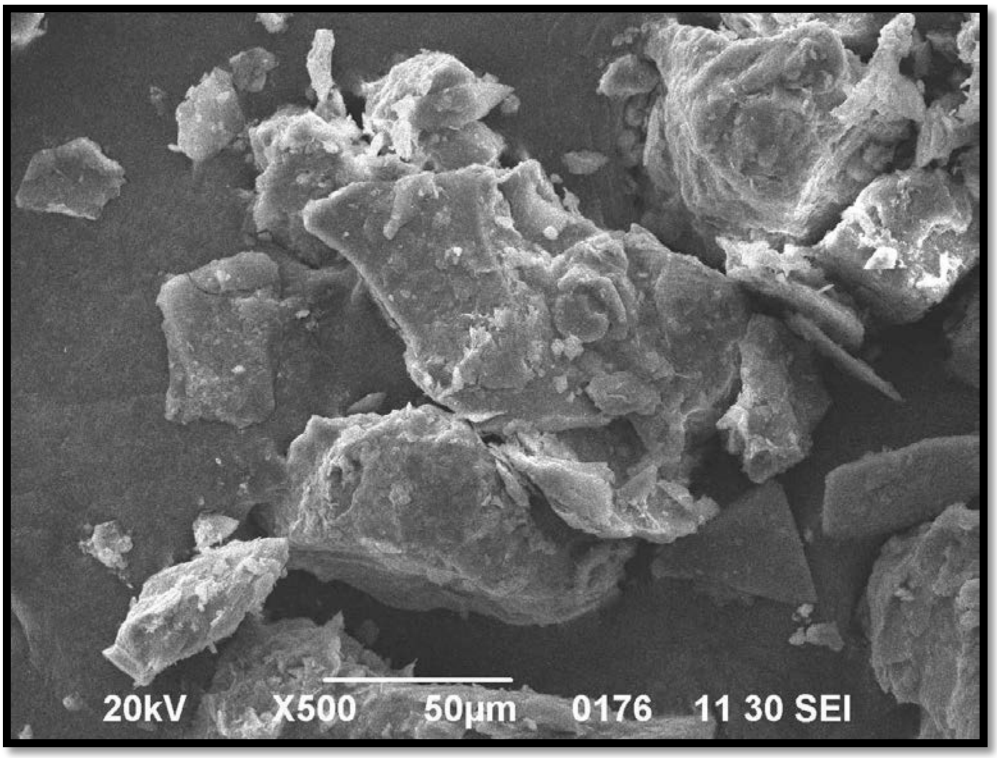
Photograph 8: Scanning Electron Microscopy of Soil Sample No 8





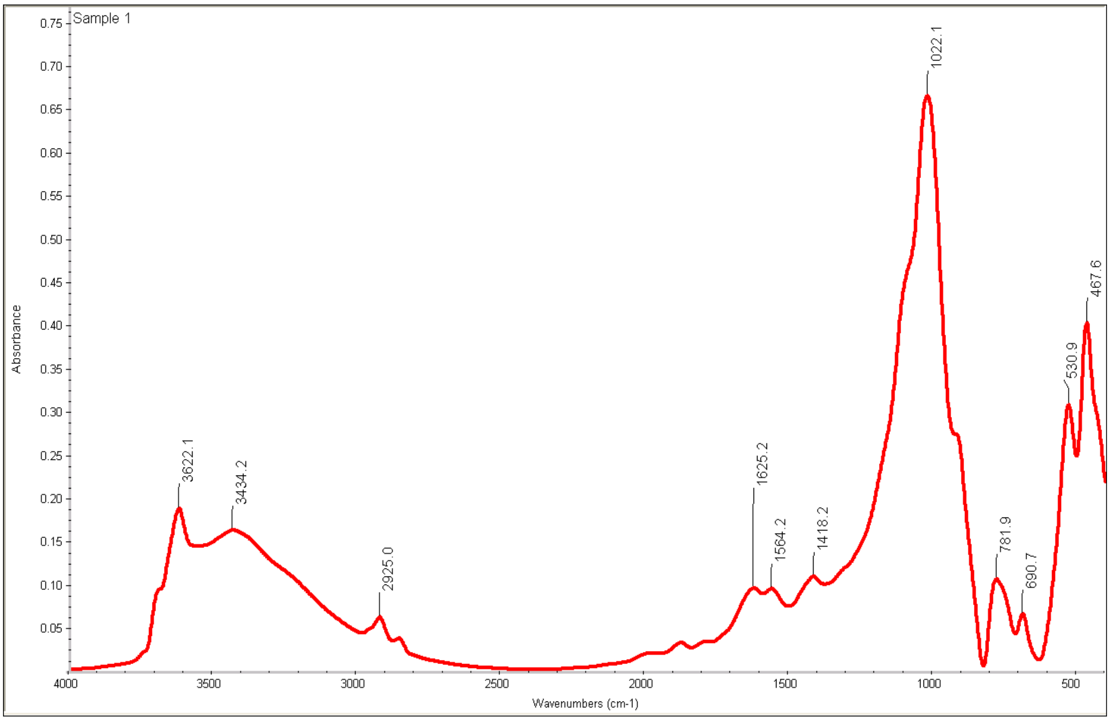
Photograph 9: Scanning Electron Microscopy of Soil Sample No 9



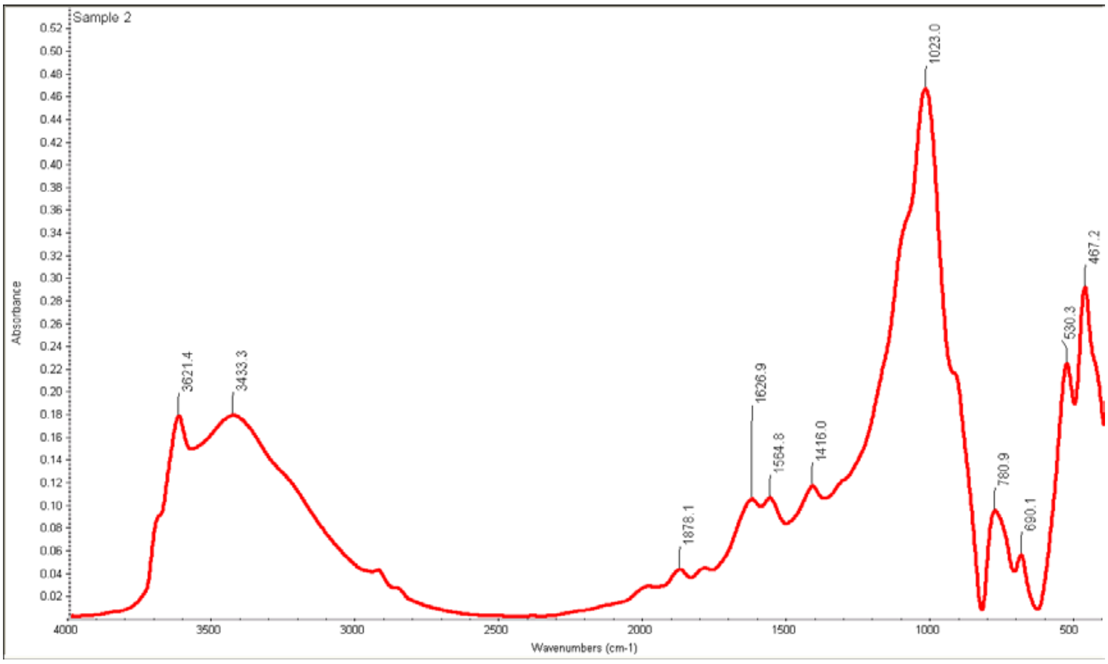


Photograph 10: Scanning Electron Microscopy of Soil Sample No 10

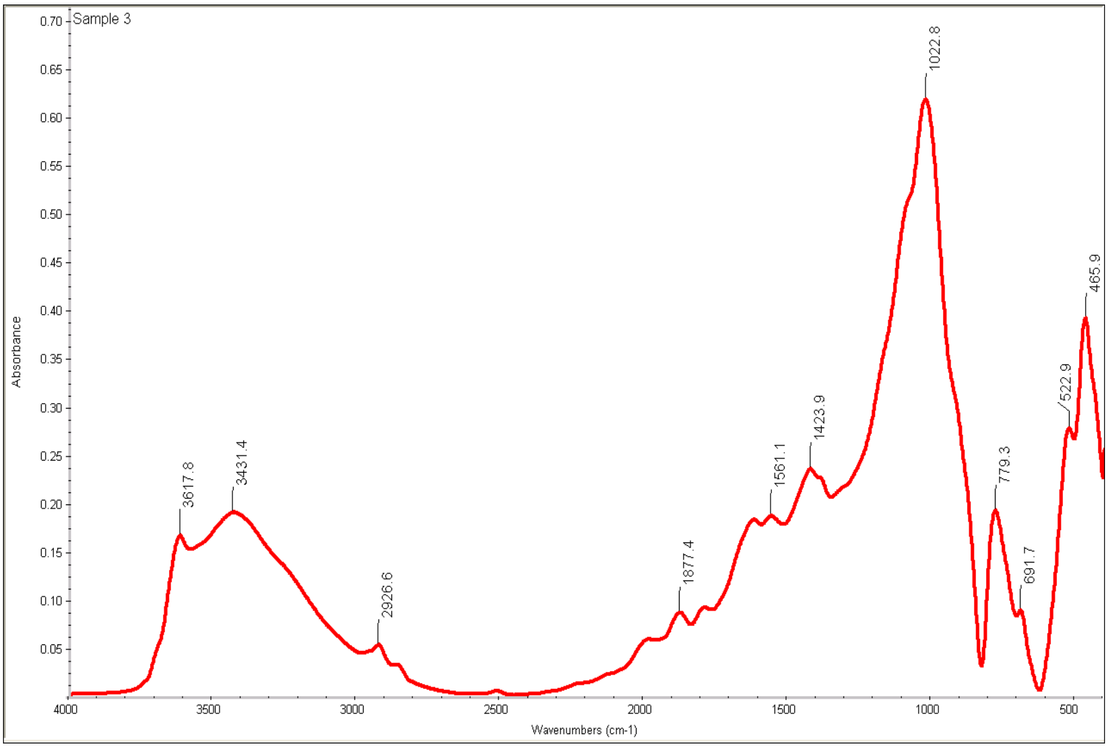
FTIR SPECTRUM



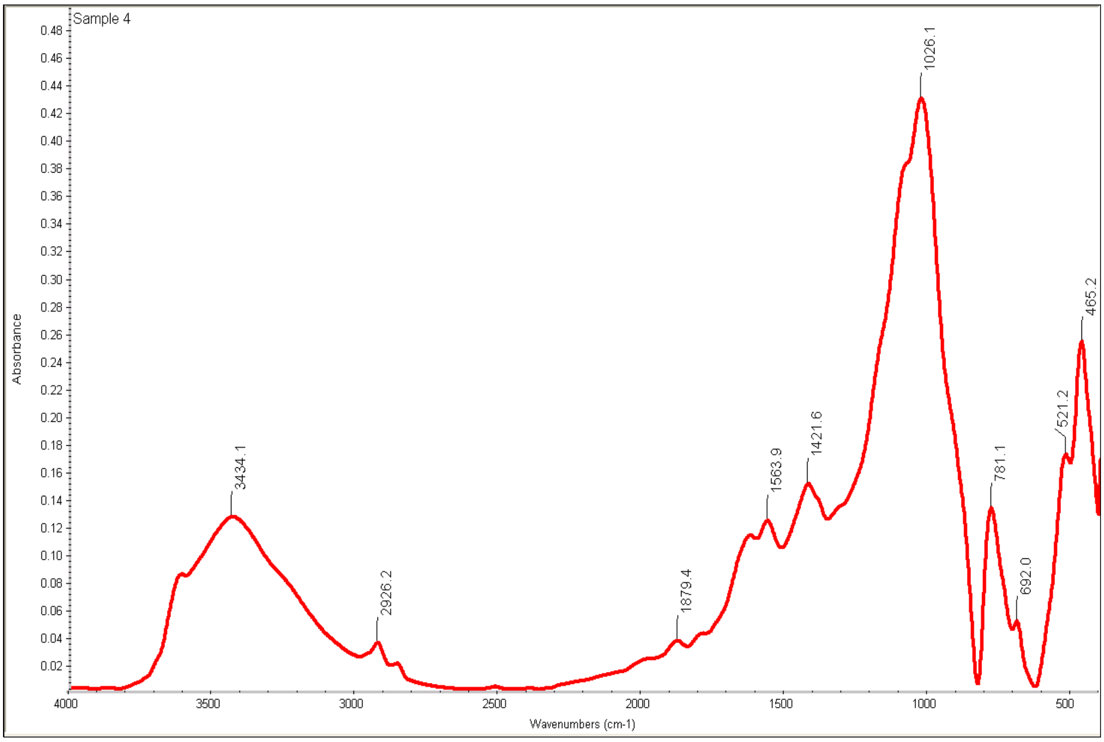
Photograph 11: FTIR Spectrum of Sample No. 1



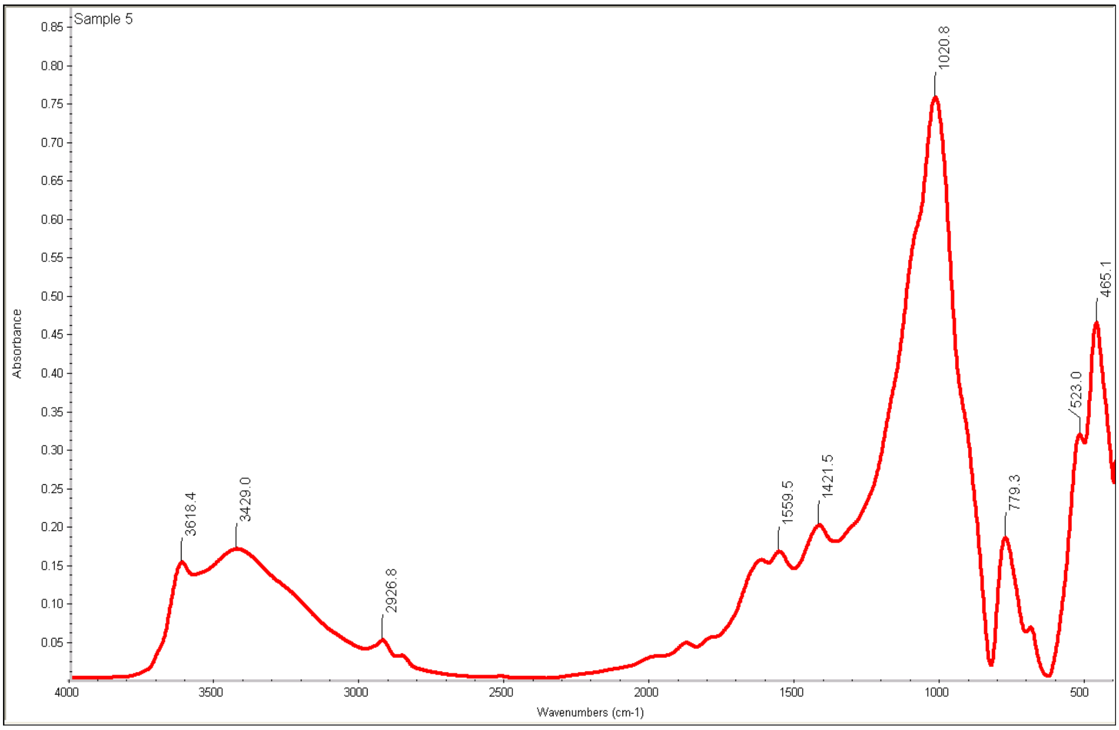
Photograph 12: FTIR Spectrum of Sample No. 2



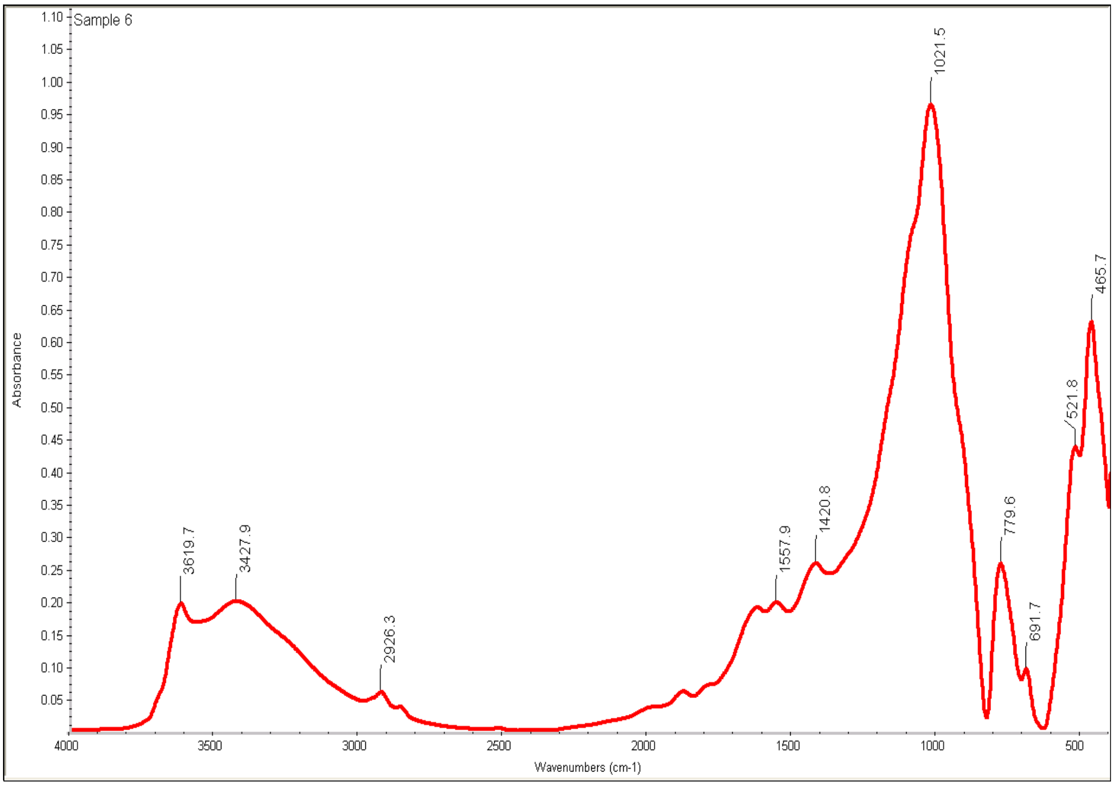
Photograph 13: FTIR Spectrum of Sample No. 3



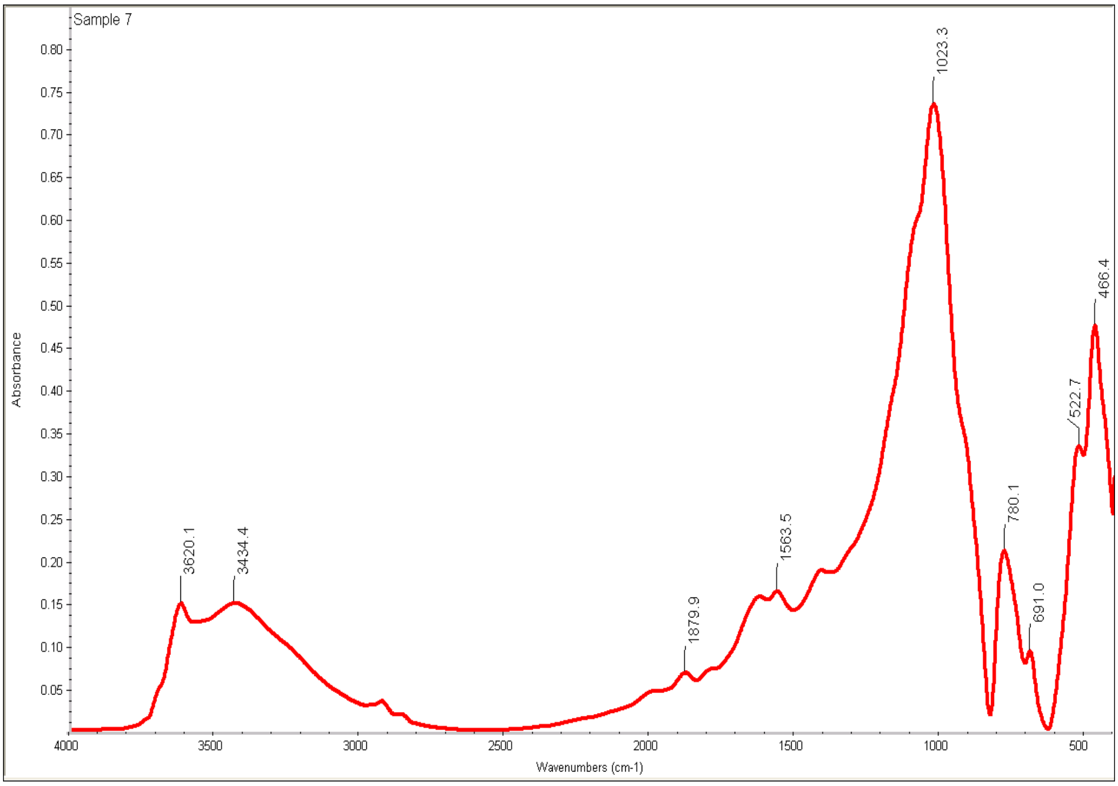
Photograph 14: FTIR Spectrum of Sample No. 4



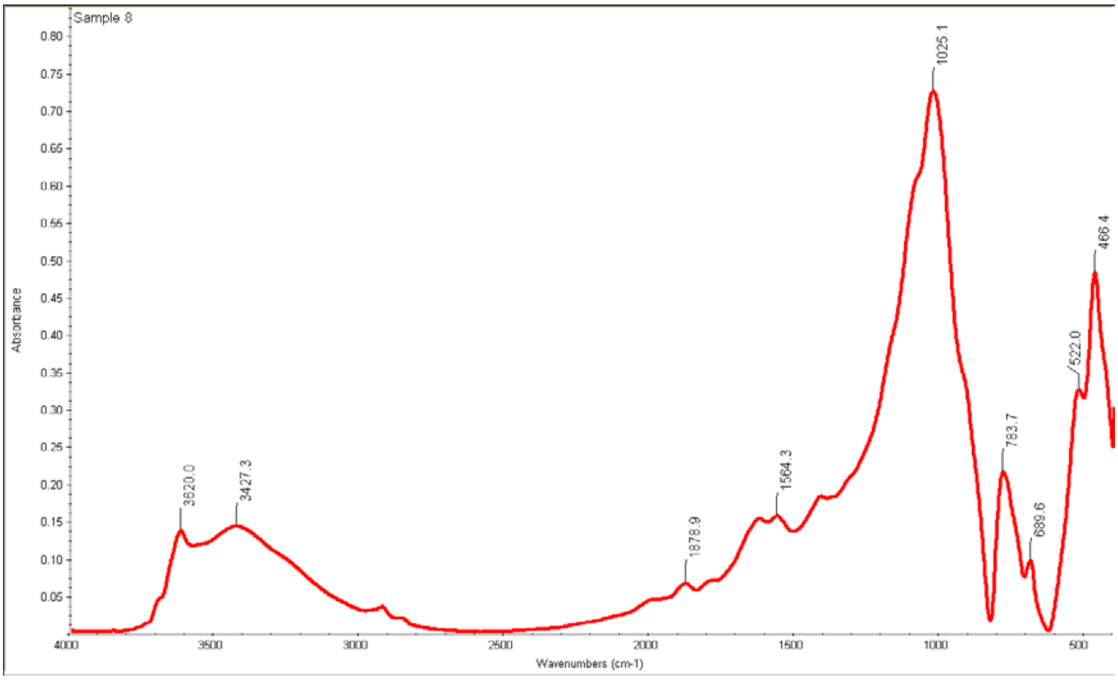
Photograph 15: FTIR Spectrum of Sample No. 5



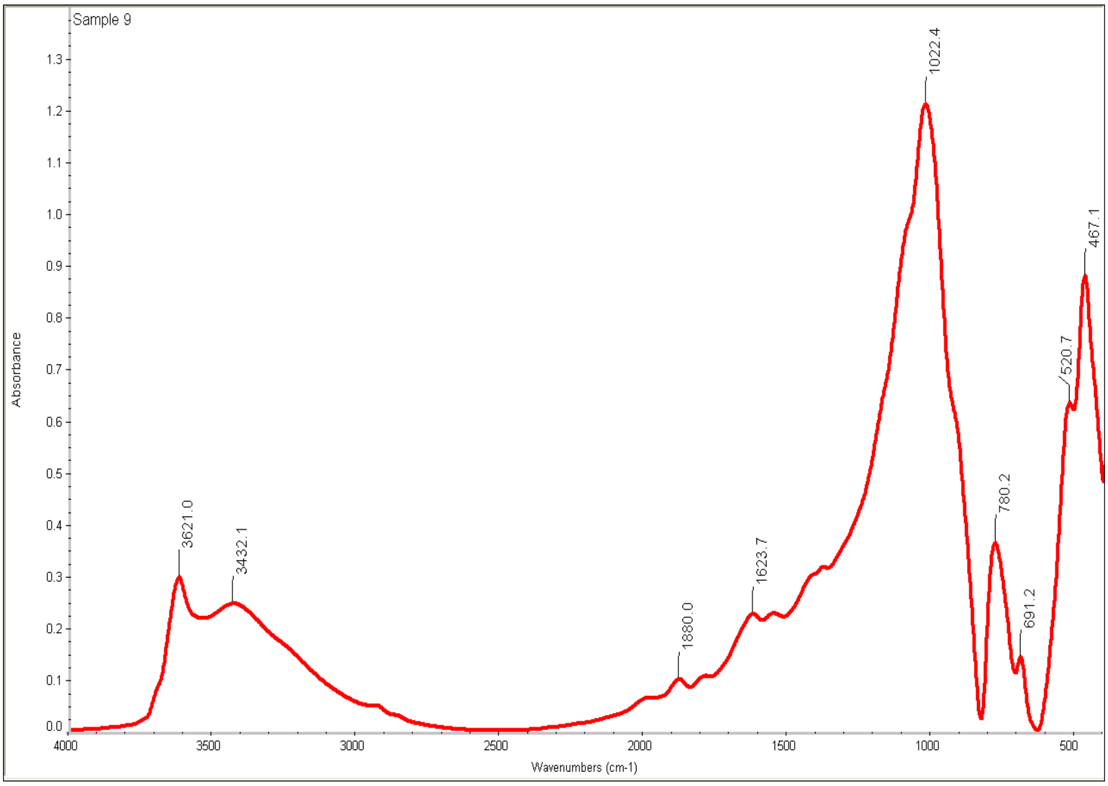
Photograph 16: FTIR Spectrum of Sample No. 6



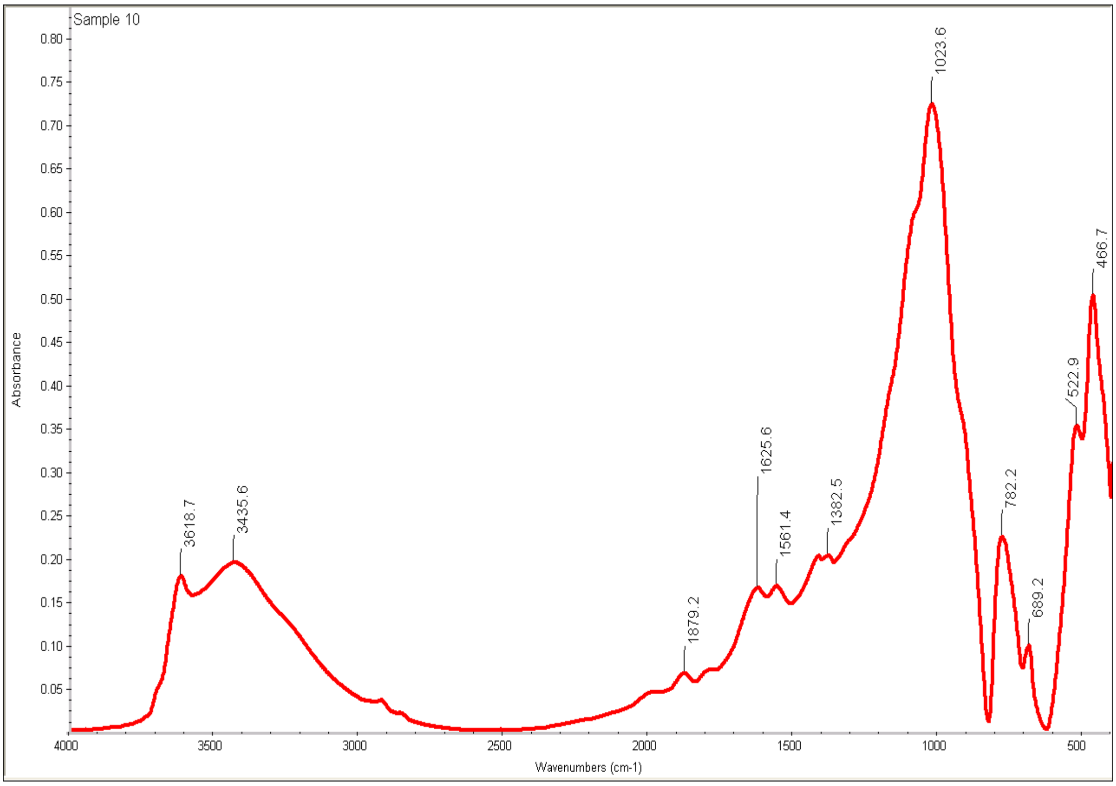
Photograph 17: FTIR Spectrum of Sample No. 7



Photograph 18: FTIR Spectrum of Sample No. 8



Photograph 19: FTIR Spectrum of Sample No. 9



Photograph 20: FTIR Spectrum of Sample No. 10

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Climate Change and Environmental Sustainability (October 2016) 4(2): 229-230
DOI: 10.5958/2320-642X.2016.00024.7

OPINION

Sustainable Development Goals (SDGs) and Jaipur Declaration: BRICS Women Parliamentarian's Commitment

Nandkishor S. More* • **Rana Pratap Singh**

Abstract The term 'BRIC' was coined in 2001 by the then chairman of Goldman Sachs Asset Management, Jim O'Neill, in his publication *Building Better Global Economic BRICS*. With the entry of South Africa, it became Brazil, Russia, India, China and South Africa (BRICS). The BRICS Forum, an independent international organisation encouraging commercial, political and cultural co-operation between the BRICS nations, was formed in 2011. Since then, many cross-cutting issues have deliberated the most recent being **sustainable development goals** (SDGs). It was under the aegis of **BRICS Women Parliamentarians' Conference** held at Jaipur, Rajasthan, India. The agenda contained 17 goals with 169 targets, covering a broad range of sustainable development issues. The article provides a critical narrative of the meeting and issues of importance that were resolved.

Keywords Sustainable development goals, BRICS, Women parliamentarian's, Jaipur declaration and climate change

1. Introduction

Two important factors that has catalysed the movement for ecology and environment for quite some time, one being globalisation and second climate change along with an urge to achieve the goal of sustainable development. Thus, even before the call of sustainable development much highlighted by Gro Harlem Brundtland in *Our Common Future*, the land mark report submitted under the aegis of United Nations Conference on Environment and Development (UNCED) popularly known as Earth Summit, the process of globalisation of world economies and use of natural resources was already in place.

2. Agenda of Sustainable Development

At the United Nations **Sustainable Development** Summit on 25 September 2015, world leaders adopted the 2030 Agenda for **Sustainable Development**, which includes a set of 17 **Sustainable Development Goals** (SDGs) and 169 targets to end poverty, fight inequality and injustice, and tackle climate change by 2030, though it is target for 15 yrs to all the nations of the world (UN-SDG, 2015) (CEE, MoEFCC, 2015). Moreover, the emissions from deforestation and in developing constitute about 17.4% of global green house gases which is 5.8 Gt of carbon dioxide equivalent (CO_2 eq)/year (IPCC, 2007). Technically, SDGs are modified and comprehensive version of Millennium Development Goals. It was a great occasion when women parliamentarians from Brazil, Russia, India, China and South Africa (BRICS) attended the two-day meeting that held at the state assembly at the state capital of Rajasthan. **BRICS** is the acronym for an association of five major emerging national economies: **BRICS** (Figure 1). Interestingly, the BRICS countries together comprise 43% of the world population, contributing 37% of the world GDP. As per one report of 2015, the five BRICS countries represent over 3 billion people, or 42% of the world population; all five members are in the top 25 of the world by population, and four are in the top 10. The five nations have a combined nominal GDP of US$16.039 trillion, equivalent to approximately 20% of the gross world product, and an estimated US$4 trillion in combined foreign reserves. Needless to state that the success of the SDGs will be heavily dependent on their successful implementation in the BRICS countries which was the concluding line of the two-day discussion on SDGs, the BRICS nations' women

Figure 1. BRICS on a global map

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parliamentarian forum also adopted the Jaipur declaration calling upon international financial institutions (FIs) to 'support and facilitate financing for development on favourable terms' to the developing and least developed countries.

It further called upon the international FIs to help such countries gain easier access to new and affordable technologies for capacity-building in accordance with the UN convention on climate change and the Paris Agreement.

3. BRICS Women Parliamentarian's Resolutions

The Jaipur declaration stated that the BRICS nations were committed to society's progress without endangering the capacity of coming generations. One thing is very clear from the content of the declaration that the society that constitutes half of world's population do matter in achieving the very goal of sustainable development. The philosophy also initiated by a lady only. Thus, there are many coincidences. The implementation of the SDGs will be successful only when it is a combined effort of all. To leverage our position with regard to issues of global concern, especially the SDGs, the BRICS countries need to strengthen cooperative mechanisms and to innovate new institutional means for meeting the needs of the member countries.

The declaration has compelled us to revisit the philosophy and policy of sustainable development, particularly its genesis and operational measures. Thus, it would be important in many ways as it would provide thrust on gender issues and the empowerment of women. The forum called upon the BRICS countries to present a united front for successful implementation of the SDGs, saying their success will be heavily dependent on the outcome in these nations.

In an Indian perspective, although the developmental perspective is complex but it is officially stated that India's development agenda is mirrored in the SDG and the country has chosen the path of removing poverty by empowering the poor. It is equally true with other developing nations of the world. There is consensus now that dialogue between parliamentarians was important to achieve SDGs, and must be inclusive, if it is to be equitable, sustainable and effective. Mainstreaming equity is too vital for ameliorating socio-economic conditions of people within the framework of sustainable development, the day is not far when New Development Bank (NDB) by the BRICS countries would soon be instrumental in filling the massive gap in investment in infrastructure and sustainable development resources in emerging and developing economies. The agenda for cooperation in addressing global and multilateral issues of mutual interest has been carried forward in the last seven summits and several ministerial meetings.

Although the BRICS was formed during negotiations at Climate summit at Copenhagen, its relevance has increased many folds due impeding threat of climate change on one hand and commitment of nations to combat it on the other (please see Figure 1). The BRICS Jaipur declaration mentioned the need to address climate change and protection of ecological system and forest as well as food security, expeditious parliamentary approval of SDG-related legislations and adequate budgetary resources, and that climate change affected humanity as a whole, but the developing countries had their own challenges.

So such an active involvement of women parliamentarians in the development process would result in meaningful and inclusive growth. Naturally, women have a natural instinct towards development and progress. Nowadays, they are seen as agents of change. It is widely recognised elsewhere that if there is money in a woman's hand, there is money in her house; if the woman's hand is strong, her family is strong and if there is happiness on a woman's face, there is happiness in her home. The silver lining is with agreement reached on the 'what' we have to get on with the 'how', it is mandatory now to lay stress on strengthening cooperative mechanism among the member countries. What can be more crucial is despite being a relatively young group BRICS has taken impressive strides beginning from forum for consultation on economic issues of mutual interest to evolving into a group which now has various topical global issues on its agenda.

4. Conclusion

Indeed, the 17 SDGs and targets reflect the scale and ambition of this new global agenda. The goals shall stimulate versatile action over the next 15 yr in the areas of critical importance to humanity and the planet.

The bottom line of the forum was stated by the Indian Lok Sabha Speaker, Sumitra Mahajan. 'It is she who holds the world together. Women are the fountainhead of life, natural caregivers and are the first providers, the first educators, the first resource allocators in the family and society. As women parliamentarians from the BRICS Parliaments, we are here to make a forceful statement that we have a pivotal role to play in ensuring that all these happen in our respective countries.'

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OPINION

COP-21, Conference of Parties on Climate Change: Resurrection from Lima to Paris

Nandkishor S. More* • Rana Pratap Singh

Abstract Although the prime focus of climate policy had been to reduce fossil fuel consumption and subsequent emission, substantial cuts in carbon dioxide (CO_2) emission alone was not enough to abate climate change. It had been initiated during Kyoto Convention in the 1990s and carried forward at Copenhagen Accord, Lima, Conference of Parties (COPs) and the most recent COP 21 at Paris. One of the most important outcomes of Kyoto Protocol had been consensus of signatory nations barring couple of major economies on agreement to initiate Clean Development Mechanisms and Emission Trading. The reason for such protocol was because of high degree of environmental degradation all over reflecting negatively on environmental and human health. The issue of global warming owing to alarming levels of green house gases was again on anvil in the other meetings. The levels of CO_2, NO_x, methane and others reflected grave ecological and health consequences. To top it all, climate change became one of the major issues of the twenty-first century. Earth's mean global temperature rose by 0.6 ± 0.2°C during the second half of the twentieth century, at a rate of 0.17°C/decade. If the present trend continues, a drastic increase in global temperature is projected by the end of the twenty-first century with rise in sea level and accelerated meltdown of polar ice sheets. The paper attempts to sum up policy framework under United Nations Framework Convention on Climate Change and other international agreements emphasising the deliberations of COP 21 on climate change.

Keywords Climate change, UNFCC, Carbon emission, GHGs, Natural disaster

1. Introduction

The **United Nations Framework Convention on Climate Change**, or 'UNFCCC', was adopted during the Rio de Janeiro Earth Summit in 1992 (lien vers la frise). It entered into force on 21 March 1994 and has been ratified by more than 196 Nations/States, which constitutes the 'Parties' to the convention and are its stakeholders. This framework convention, therefore, is a universal convention of principle, acknowledging the existence of anthropogenic (human-induced) climate change and giving industrialised countries the major part of responsibility for combating it. The Conference of Parties (**COP**), made up of all 'States Parties', is the convention's supreme decision-making body. It meets every year in a global session where decisions are made to meet goals for combating climate change. Decisions can only be made unanimously by the States Parties or by consensus. It also involves long deliberations of other stakeholders too (IPCC, 2007).

2. Background

Weather events such as the European heat wave in 2003 killed more than 30,000 people, Hurricane Katrina in the United States in 2005, and the droughts, bushfires, snow (almost simultaneously) in Australia in 2006 and breaking of 160-square-mile section of the Wilkins Ice Shelf from the coast of Antarctica made climate change as political agenda. So, there is requirement of continuous research towards the development of techniques to manage increasing concentration of atmospheric carbon. Carbon dioxide (CO_2) is the primary green house gas (GHG) produced by anthropogenic activities leading to climate change (Behera, 2016). The atmospheric concentration of CO_2, 255 to 280 ppm in pre-industrial time, has increased to ~400 ppm at present as reported by US science agency National Oceanic and Atmospheric Administration (NOAA) (Figures 1 and 2). Carbon management covers the various activities like CO_2 capture and utilisation, waste management involving both chemical and biological tools. Many natural and anthropogenic events have to be considered before projecting sustainable carbon management strategies. General plans be focused on (a) minimising emission; (b) maximising

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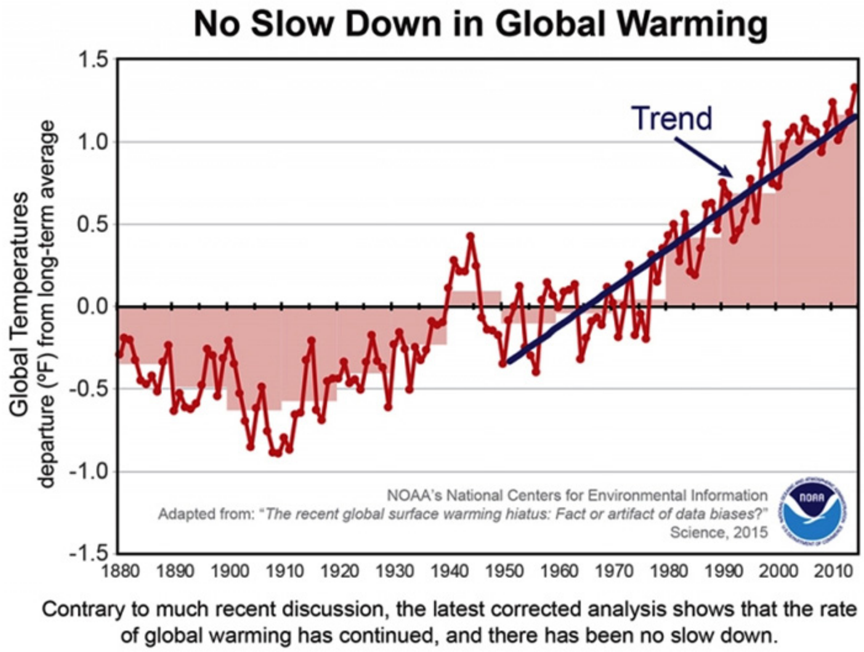


Figure 1. Present status of global warming
Credit: NASA archives

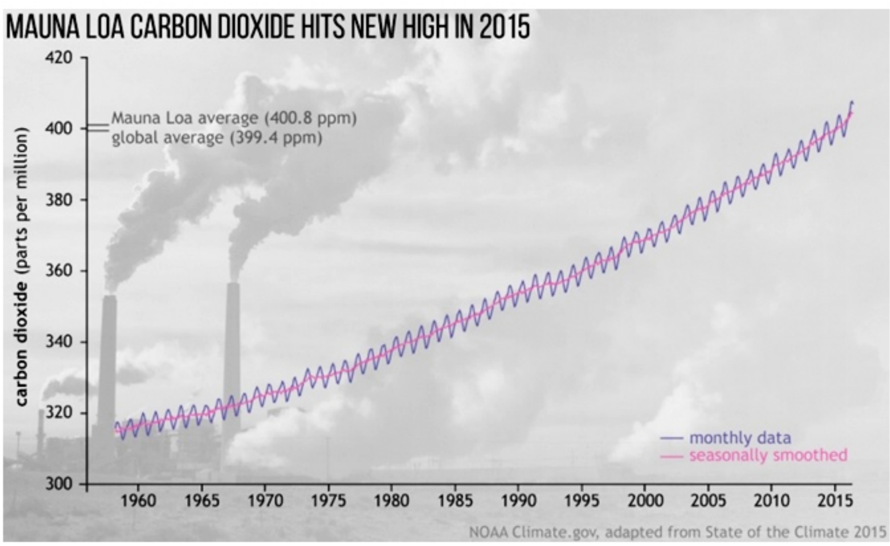


Figure 2. Scenario of CO_2 emission
Credit: NASA achieves

environmentally sound reuse, reduce and recycling; (c) effective treatment and (d) converting carbon into valuable products with atom economy.

3. Indian Scope of Negotiations at COP 21

Reason: India grapples with food security, sustainable agriculture and impending threats of climate change.

Drought conditions are crippling vast swaths of India's farmland as the country faces its driest monsoon ever since 2009. With more than 60% of India's agriculture reliant on monsoon rains, farmers are highly vulnerable to changes in rainfall patterns and rising global temperatures, the Indian Council for Research on International Economic Relations observed in a recent report. Further, it is also true that Government of India has imported stapled key food this year as water-starved soil in major producing states showed declined production of rice, sugar and corn. Needless to state that economy based mainly on agriculture amounting to 70% that took a giant rain-fed agro ecosystem puts India in a perilous situation.

Second, 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 [Report of Indian Council for Research on International Economic Relations (ICRIER), 2015]. There is an urgent need to sustain employment growth in unorganised agricultural sector which employs a huge lot of young people almost 10–12 million people, joining the workforce every year. The real issue is to create good jobs for them to sustain their livelihood security.

The impacts of climate change in Indian subcontinent are important in many ways due to diverse topography, seasons and others. 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 (UNISDAR, 2015). 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 namely water resources, agriculture, forests animal husbandry, fisheries and others for employment. 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.

4. National Interventions

As Indian nation confronts with the effects of climate change, Indian administration is also grappling with as to how to limit the nation's GHG emissions. India is the world's third-biggest carbon emitter, after China and the US Indian officials have said repeatedly that the nation's top priorities are expanding the economy, reducing rates of poverty and providing electricity to the 400 million people without access to power. Yet India's emissions will soar if leaders depend on building new coal plants and guzzling more diesel and gasoline to meet those targets.

Although India has recently announced its plans for cutting emissions as part of the United Nations-backed talks on climate change. As more than 150 countries this year have submitted individual climate plans, it will form an important backbone of broader negotiations at the U.N. climate summit in Paris in December. In our plan, India pledged to cut its emissions intensity of CO_2 emissions per unit of gross domestic product by up to 35% from 2005 to 2030. Climate policy experts though have doubts over India's plan but said the climate strategy is vague on details and can be achieved, suggesting the country could do more to curb emissions with more stringent measures. To that end, government has pledged to boost India's solar power capacity by 100,000 MW within the decade, a 30-fold rise from today. India also aims to add 60,000 MW of wind power, 10,000 MW of biomass and 5,000 MW of hydroelectric projects by 2022. To meet these targets, the country needs to raise at least \$100 billion in total financing – which could spell a huge opportunity for banks and global companies to enter the sector and make investments.

5. Soil and Carbon Sequestration Potentials

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. Thus, with conservative and modern agricultural practises and a chunk of terrestrial ecosystem has good mitigation potential.

6. GHG and Intended Nationally Determined Contributions (INDC)

In the global frame, the situation is equally complex as issues on important global environmental challenges with implications for food production, GHG emissions, health, energy and water supply and others. 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 3°C 1° above the goal of limiting global warming to 2°C is a matter of serious thought (Figure 1). Although a total of over 200 countries which represent about 95% of global emissions have already submitted their Intended Nationally Determined Contributions (INDCs) on climate policy to the UNFCC to get prepared for new climate negotiations at COPs on climate change (COP 21) to be held at Paris. If wishes are compiled and effectively implemented fully would set overall growth of global emissions around 15% above 2010 level by the year 2030 that too without International Climate Fund support or other International cooperation mechanism has been vetted by report of European Commissions Joint Research Centre. The said report points out that owing to variety of reasons; natural and manmade reasons; the global emission would peak in 2020 and would tend to decline by 10% below 2010 levels by stipulated 2030 (EU JRC, 2015). Let us assume that most of the countries would continue keep their efforts even after 2030 only then the 3° rise would be possible. It was deliberated at preparatory meeting for INDC forum at Rabat, Morocco. Thus, limiting emissions is going to be top agenda of climate negotiations at COP 21 on climate change.

7. Who Report Linking Environment and Health

Another important issue for negotiations that was to be considered is of United Nations Health agency WHO's report linking environment and health, it has stressed for quick action to limit climate change by reducing emissions of black carbon, ozone and methane as well as CO_2 mainly. It is noteworthy that WHO felt that it is more crucial at this juncture to recommend actions to reduce emissions that alone account for more than seven million premature deaths every year. Other suggested measures include encouraging people to go for vegetarian or eat plant-based foods and reduce methane emissions associated with paddy fields, ruminants and animal-sourced food. Other recommendations have long standing impacts like reduction of vehicular emissions making it obligatory for the automobile industry and consumers, It calls upon more investments over and above the existing one as policy and to provide alternative cooking fuel to the billions of households in the low income and Least Developed Countries (LDC) which are dependent on wood, dung and other solid fuels for domestic heating and cooking and is one of the causes of emission associated with health risks among women population. This intervention of WHO comes at a time when COP 21 is scheduled later this year, thus thrust for fast track actions to reduce emission depends on global warming and underlines major health risks associated with air pollution. WHO further recommends ancillary measures like improved diets, increase in physical activity, food security and its direct relationship with air pollution; it further accelerates the debate of investments by governments in rapid public transport system of buses and trains along with safe pedestrian and cycle network which is missing in many countries. It is envisaged to promote numerous benefits of rapid safe travel reduced health risks for pollutions of air and noise, do away with physical inactivity and road traffic injuries, which is the second important cause of millions of deaths annually. Dr Flavia Bustreo, assistant director general WHO said, 'It is for the first time our report recommends actions that countries environment and health ministries and cities can act right now to reduce emissions, protect health and avoid illness and premature deaths which often take the greatest toll on the most vulnerable'.

8. Changing Climate and Natural Disasters

Under the aegis United Nations Office of Disaster Risk Reduction (UNISDR), the Centre for Research in Epidemiology of Disasters (CRED) in its recent report named the *Human Cost of Weather-Related Disasters* brought out few more facts that India along with China, USA, Philippines and Indonesia are greatly affected due to changing climate. The South Asian countries toll of disasters is much more and so is its impact as compared with USA and China because of their preparedness. The data from 1995 to 2015 indicates that out of 4.1 billion affected people, India and China constitute 75% with 80.5 and 227.4 crores in India and China, respectively. In last 20 years, climate-related disasters in India were 288 where as 472 in USA and 411 in China. During this period, Philippines and Indonesia encountered 274 and 163 disasters. Although there are indications of reductions in the events, diseases and casualties owing to preparedness still a long way to go. So it makes it an agenda along with China for the block BRICS and was for table discussion at COP.

Lastly, COP 21 would have number of agendas on funding from a conference on funding in September and deliberations of International Scientific Conference on Our Common Future under Climate Change (CFCC 2015) held under the aegis of UNESCO and other partners in July 2015. COP 21 is scheduled at an interesting juncture when the reports of EUs Joint Research Centre's report differs with the pledges of INDC but would provide an essential global context of transparency, assessment with common accounting rules which Lima, COPs repeated to keeping global warming to 2°C which as per above report stands deviated. COP 21 has in store such speculations as to how to reach consensus and frame new guidelines on a plethora of issues on important global environmental challenges with implications for food production and its security, GHG emissions, health, energy and water supply and others for resolution and subsequent negotiations. In a nutshell, from 20th session at Lima to 21st at Paris provided many new intriguing challenges that would be on the platter before it concluded.

9. Paris Agreement in a Nutshell

Deliberations on climate change achievements and grey areas

On 12 December 2015, the UNFCC finally came to a landmark agreement in Paris and consists of 29 articles. It could be considered as successful on many counts; one of the important counts was the same city faced an onslaught of terror eliminating innocent French Nationals who were hosting and thus crushed the fear/phobia it might have generated in the first half of November. It has been signed by almost 196 nations that the Paris Agreement is first recent comprehensive global treaty to combat climate change, and would effectively follow on from the Kyoto Protocol when it ceases in 2020 (More, 2015, 2016). Further on technicality, it would enter into force once it is ratified by at least 55 countries that are covering at least 55% of global GHG emissions.

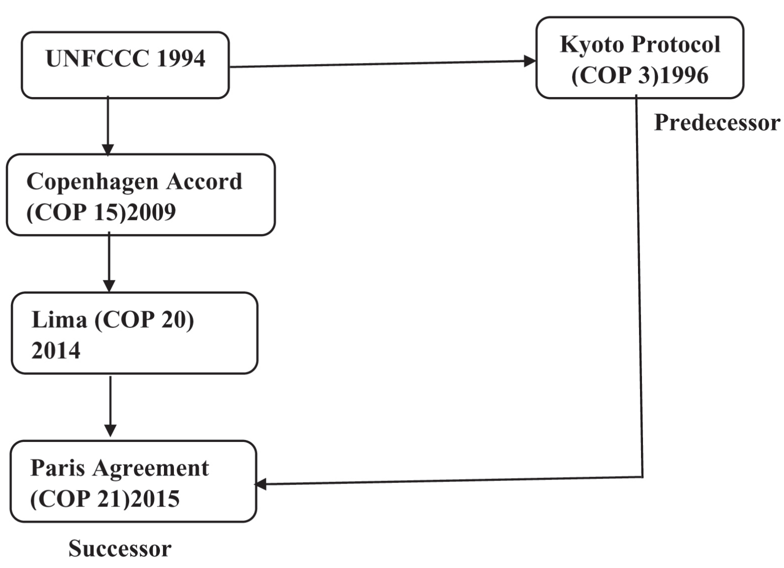
The agreement commits nations to keep temperatures 'well below 2°C', above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C. It, further, envisages the nations on carbon budget that to keep warming below 2°C, we can emit a total of around 3.6 trillion tonnes of GHGs, but it only provides us 66% chance for a better management or for a lower warming limit, we have emit even lesser in practice. This global agreement calls the parties for global emissions to peak 'as soon as possible' and for a balance to be achieved between the rate of GHG emissions and their removal from the atmosphere by sometime between 2050 and 2100 (please see Figure 2). As of today, the coverage of countries pledges INDC submitted by 185 countries ahead of COP 21 cover 94% of global emissions and 97% of global population, so the remaining 11 countries have been asked to submit their INDC before the next years' climate talk in Marrakech.

Moreover, it is also said that the targets are not yet enough to limit warming below 2°C. Next is under the frame of the agreement, the targets would be reviewed every 5 years, after the first stock take in 2023. Nations would be expected to reaffirm their pledge each time to eliminate deviations. The argument of developed versus developing countries have been de-sharpened as it makes no formal distinction between their responsibility to cut emissions, but rich countries are required to take lead by undertaking economy-wide absolute emission reduction targets, and developing countries are encouraged to this over time, thus protecting environment is everyone's baby. One of the most significant resolutions was on funding for the developing countries to assist reduce their emissions, under the agreement developed countries would provide at US$ 100 billion a year in climate finance from 2020. On the legality, this agreement is legally binding but on some specific details, such as exact amount of climate finance involved are exceptions.

On two accounts, one on no compensations for loss and damage as some of the nations would inevitably experience damages from climate change known as loss and damage. Though the agreement acknowledges the significance of such impacts, the treaty rules out any liability or compensation payable by most nations, mostly responsible for climate change. This matter is very dicey as one does not know if it's a favour or waiver. However, on the issue of transparency and accountability, it makes it clear that developed nations will have to disclose their GHG emissions, progress on targets, climate adaptations and important finance at least every 2 years, whereas the others have been asked to do it voluntarily in a general interest. Finally, the issues before COP 21 and its precipitate in an agreement are of paramount importance. Numerous viewpoints have been expressed by many, some have called Paris Climate summit as historic and political achievement but unclear how and when the hard problem of emission cuts and climate finance get tackled. On the other hand, some feel that the agreement clearly establishes a new international carbon market mechanism. While concluding the meet, the French Foreign minister, Laurent Fabius and the President of COP 21 summit said, 'This agreement is differentiated, fair, durable, dynamic, balanced and legally binding'.

Finally, to sum up the agenda of climate change, although was initiated under the aegis of UNFCCC, it has travelled a long way at Kyoto Protocol to begin action and

Diagrammatic sketch



other successive agreements (please see diagrammatic sketch). But owing to climate adversities strategists at Lima, COP resurrected the trust to combat climate threat with active engagement of stakeholders.

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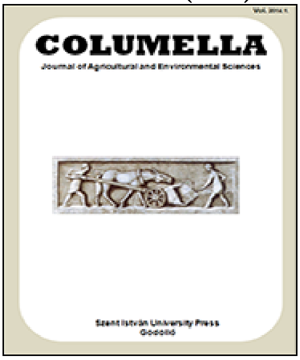
Vol.4 No.1 (2021)



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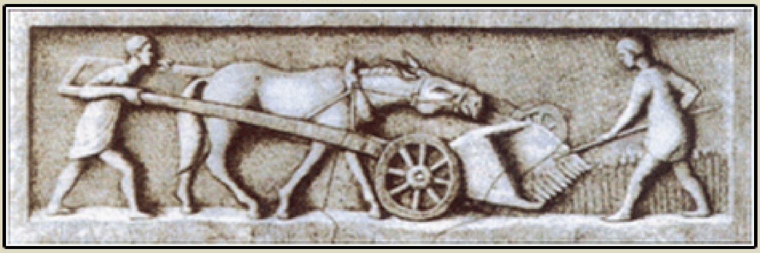

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HU ISSN 2064-7816 (print); HU ISSN 2064-9479 (online)

Estimation of different fractions of organic carbon and it's implication to carbon dynamics in agricultural soil

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Abstract: 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. Labile carbon is an oxidisable fraction of organic carbon. This pool of carbon is mainly composed of three components, i.e. physical fraction (including particulate organic matter), oxidizable fraction ($KMnO_4$-C) and biological fraction (microbial biomass). Recalcitrant fraction does not undergo mineralization easily, so it is not available for plant growth, only labile organic carbon fraction is available to plants and very rapidly responds to changes taking place in soil and surrounding environment. As, composition of total SOC determines the soil quality, it has beneficiary effects on soil quality and productivity. Agricultural practices also affect the soil organic pool as well as composition of SOC. Therefore, quantification of various fractions of soil organic carbon which is influenced by management practises is necessary for determining Carbon sequestration and as well as fertility status of soil.

Results indicate that Total carbon (TC), SOC and Total nitrogen (TN) ranged between 8.9-11.9 g/kg; 7.4-9.19 g kg^{-1} and 0.82-1.12 g kg^{-1} respectively. Pool I (Labile carbon) and II (Very labile carbon) together known as the labile pool, which ranged from 3.6 to 4.5 g kg^{-1} and pool III and IV constitute together the recalcitrant/refractory pool, which ranged from 3.2 to 3.8 g kg^{-1}.

Keywords: Soil organic carbon, Carbon sequestration, soil quality, Organic matter, carbon pool

Introduction

Soil organic carbon (SOC) pool is a measure of fertility of agricultural soil. Organic matter is a rich pool of nutrients required by plants for their growth and sustenance. But due to increasing population and thereby it's increasing demand for food have exerted a great pressure on agricultural lands, which resulted in degradation of soil quality and increased mineralization of soil organic matter. To improve the soil quality and nutrient availability a sustainable agricultural practice is required which can reduce the increasing pressure on agricultural soil. Recalcitrant fraction does not undergo mineralization easily, so it is not available for plant growth, only labile organic carbon fraction is available to plants. Composition of total SOC determines the soil quality.

The sedimentary/soil organic matter is widely distributed over the Earth's surface occurring in almost all terrestrial and aquatic environments *(Singh and Kazuo, 2004)*. Sediments contain a large variety of organic matter ranging from simple sugars and carbohydrates to more complex proteins, fats, waxes, and organic acids. Important characteristics of the organic matter include their ability to form water-soluble and water- insoluble complexes with metal ions and hydrous oxides; interact with clay minerals and bind particles together; absorb and desorb both naturally occurring and anthropogenically introduced organic compounds; absorb and release plant nutrients; and hold water in the soil environment. Naturally occurring organic carbon-forms are derived from the decomposition of plants and animals. In soils and sediments, a wide variety of organic carbon-forms are present and range from freshly deposited litter (e.g., leaves, twigs, branches) to highly decomposed forms such as humus. Sorption of dissolved organic matter (DOM) on to settling particles is considered to be a major process in the preservation of organic matter (OM) in marine sediments. Evidence for this hypothesis includes the close relationship between sediment particle surface area and organic carbon (OC) concentrations and strongly reduced biological degradability after DOM has adsorbed to mineral surfaces *(Kaiser et al., 2000)*.

In this paper an attempt has been made 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.

Materials and Methods

Soil samples (0-30 cm) were collected from wheat crop field with the help of PVC pipes. Soil samples (0–30 cm depth) were taken randomly in triplicate during August-September 2015-16, from the agricultural fields near Lucknow city, and analyzed individually. After initial soil identification other experiments were performed. In this investigation oxidizable-total organic carbon (SOC) was determined by using Walkley-Black method (Walkley and Black, 1934). Total N was determined by Gerhardt Kjeldhal method (Misra, 1968) that consists of three steps namely digestion, distillation and titration. The SOC content was calculated into different pools by the modified Walkley–Black method as described by Chan et al. (2001). All the fraction of SOC was estimated by using 12.0, 18.0 and 24.0 N H_2SO_4, respectively. Total SOC was divided into four different pools according to their order of stability against oxidation. Soil organic carbon, oxidized by 12.0 N H_2SO_4 was termed very labile pool (pool I). Labile pool (pool II) was calculated by taking difference in SOC oxidizable by 18.0 N H_2SO_4 and that by 12.0 N H_2SO_4, the difference in SOC oxidizable by 24.0 N H_2SO_4 and that by 18.0 N H_2SO_4 was pool III. The difference between total SOC and SOC oxidizable by 24.0 N H_2SO_4 was termed refractory pool (pool IV). Hence, it involves mixing 1N dichromate solution with H_2SO_4 in different proportions. The comparative analysis of physico-chemical properties of soil was done by different analytical methods. Soil pH and electrical conductivity (EC) were analyzed by pH and conductivity meter respectively**.** Phosphate – P and total Nitrogen – N were determined by Olsen's sodium bicarbonate method (Mackereth, 1963) and Micro-kjeldahl distillation assembly (Misra, 1968), respectively. Available potassium K^+ was estimated with the help of a flame photometer. Exchangeable sodium percentage was calculated as follows: ESP = (exchangeable sodium concentration (cmol/kg)/cation exchange capacity (cmol/kg))×100.

Results

Soil Analysis

Samples were analyzed individually for Soil type etc it revealed to be sandy, clay, loam, with pH ranged between 8.5 to 9.06. 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. TC ranged between 8.9 - 11.9 g kg^{-1}, SOC ranged between 7.4 - 9.19 g kg^{-1} and TN ranged from 0.82-1.12 g kg^{-1} (See Graph 2, 1 and Table 1 respectively). Pool I and II together known as the labile pool, which ranged from 3.6 to 4.5 g kg^{-1} and pool III and IV constitute together the recalcitrant/refractory pool, which ranged from 3.2 to 3.8 g kg^{-1}(See Graph 1).

 DOI: 10.18380/SZIE.COLUM.2017.4.1.suppl

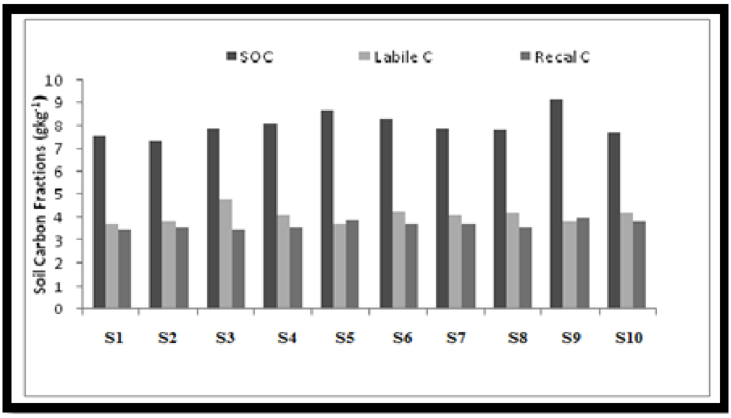

Figure 1. Soil carbon analysis

Table 1. Soil Analysis data

Sample	Soil organic C Pools (g kg^{-1})					
	Very labile (Pool I)	Labile (Pool II)	Labile (Pool I + Pool II)	Labile (Pool III)	Labile (Pool IV)	Total nitrogen (g kg^{-1})
S1	0.18	0.19	0.37	0.35	0.938	0.83
S2	0.2	0.18	0.38	0.36	0.892	0.82
S3	0.25	0.23	0.48	0.35	1.04	1.03
S4	0.2	0.21	0.41	0.36	0.940	1
S5	0.16	0.21	0.37	0.39	1.02	0.89
S6	0.23	0.2	0.43	0.37	0.934	0.95
S7	0.22	0.19	0.41	0.37	1.19	1.12
S8	0.23	0.19	0.42	0.36	1.01	0.9
S9	0.21	0.17	0.38	0.4	0.923	0.9
S10	0.24	0.18	0.42	0.38	1.13	1.02

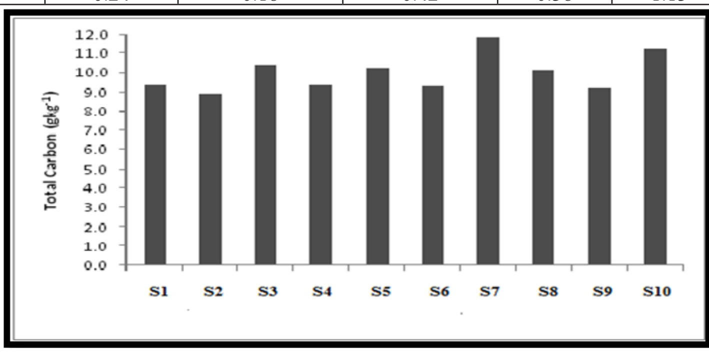

Figure 2. Total Carbon Analysis

The comparative analysis of physico-chemical properties of sodic soil as influenced by organic amendments

The highest decrease in soil pH, EC and ESP were observed in FYM and VC (T8) treated

Table 2. Chemical properties of sodic soil as influenced by organic amendments in sodic soil. Values are in means and range. Values in parenthesis represent % increase (+) or decrease (-) with respect to pre-harvest values.

Pre harvest	9.04	1.05	21.7	184
T1	9.03 (-0.11)	0.95 (-9.5)	22.5 (+3.69)	182.6 (-0.76)
	9.01-9.06	0.95-0.96	21.2 -23.8	174-185
T2	9.03 (-0.11)	0.94 (-10.4)	24.4 (+12.4)	189 (+2.72)
	9.00-9.05	0.90-0.95	23.3-25.7	167-196
T3	8.64 (-4.42)	0.75 (-28.5)	33.6 (+54.8)	205.3 (+11.5)
	8.62-8.66	0.70-0.79	25.5-39.7	188-218
T4	8.64 (-4.42)	0.71 (-32.3)	35.3 (+62.6)	214.6 (+16.6)
	8.62-8.68	0.70-0.73	27.4-42.8	187-233
T5	8.72 (-3.50)	0.77 (-26.6)	30.6 (+41.0)	196.3 (+6.68)
	8.71-8.74	0.77-0.78	23.7-34.6	178-216
T6	8.55 (-5.42)	0.65 (-38.0)	36.8 (+69.5)	225 (+22.2)
	8.55-8.66	0.64-0.66	27.4-39.3	199-140
T7	8.53 (-5.64)	0.64 (-39.0)	38.1 (+75.5)	231.6 (+25.8)
	8.52-8.55	0.63-0.65	26.8-49.4	195-258
T8	8.50 (-5.97)	0.61 (-41.9)	38.7 (+78.3)	238.3 (+29.5)
	8.50-8.51	0.60-0.62	28.6-46.4	197-248

T1=control; T2=NPK; T3=FYM (farm yard manure); T4=VC (Vermicompost); T5=NPK+VC; T6=FYM+VC (1:1); T7=FYM+VC (1:2); T8 =FYM+VC (2:1)

plots respectively. The soil nutrients N, P, K and SOC contents were higher in organically amendments sodic soils than soils amended with chemical fertilizers (T3; NPK amended soil) and control soil. The highest soil nutrients were observed in FYM and VC treated plots (T8). The increased values were N (2.62% - 33.2%), P (3.69% – 78.3%), K (2.72% - 29.5%) and OC % (16%-152%) in comparison to pre harvest values. Various physico-chemical properties of used organic amendments such as FYM and VC were also analyzed and given in Table 2. It further indicates that organically amended soil have a potential to reduce the sodicity and enhance fertility. Further FYM and VC in 2:1 can act as boosting element to improve soil structure by facilitating the growth of microbial population and in turn carbon assimilation.

Discussion

Labile organic carbon has been proved to be sensitive indicators of changes in SOC pool due to changes in agricultural management practices (Ghosh et al., 2013). The soil organic carbon pool and the total amount of labile carbon fraction has direct control over physiochemical and biological properties of the soil system and also influences self organization capacity of soil (Addiscott, 1995; Blair and Crocker, 2000;). In 1995 in a report the Carbon lability was defined as the ratio of labile C to non-labile C (Blair et al., 1995).

Changes in labile C pools occur within a short period (one to two years) and this labile pool can be used to assess land management effects. Walkley Black C (WBC) or oxidizable soil organic C mostly represents the entire labile C pool and some portion of long-lived C pools, which takes longer to change, due to land management effects (Six et al., 1999). Hence, several workers reported that the $KMnO_4$- oxidizable SOC or labile carbon is a more sensitive SOC indicator compared with total SOC or WBC (Moharana et al., 2012; Liu et al., 2014). This fraction of carbon is a crucial part of global carbon cycle. In the present analysis it is indicative of its complex dynamics. In the other observation of organic amendment the pH may reduce primarily due to high production of CO_2 and

 DOI: 10.18380/SZIE.COLUM.2017.4.1.suppl

organic acids in soil followed by solubilisations of $CaCO_3$ and even neutralization of sodicity is reported (Shiamma et al., 2012) .

Conclusion

Thus, quantification of soil carbon (C) cycling which is influenced by management practices is necessary for determining carbon sequestration dynamics as hypothesised is justified.

Acknowledgements

Authors gratefully acknowledge their Department and University authorities for infrastructural facilities during the course of work.

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16th Alps-Adria Workshop

Synergism in science

DOI: 10.18380/SZIE.COLUM.2017.4.1.suppl

Proceedings of

4th National Conference on Water, Environment & Society

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Contents

Climate Change Adaptations: Imperatives for Water Security

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ABSTRACT

In large parts of the world, climate change threatens the availability of sufficient freshwater resources, and will lead to an increase in extreme weather events. Most severe cold shock is being experienced by many across the globe while the South Asia suffered with high magnitude. It was at the fag end of 2016 we have encountered massive environmental damage in the South East Asia. In the South Indian City of Chennai (erstwhile Madras) had to bear the brunt of a cyclone that derailed the city for a while along with disruption in the island of Andaman and Nicobar. Similarly in the parts of America and China faced unprecedented cold wave. Some of the northern states of India continues with the severe cold wave and has embraced snow cover. Adapting to the effects of climate change on water systems is a crucial element of water security. Needless to state that water availability is also important for climate mitigation, observations of CDP's climate change program shows that 24% of GHG reduction activities depend on the availability of good quality water. The entry into force of the historic Paris Agreement marked a paradigm shift in the global effort to address climate change. Thus for all countries, the focus moves from planning to delivery. Further to the implementation of policies and measures that will deliver the ambitious goal to hold the increase in global temperatures to much below two degrees. Efficient water management can help reduce energy use and the associated emissions. It is reported that more efficient use of water has led to lower GHG emissions. Global efforts to decarbonize the economy could therefore sink or swim based on how we manage water. Lastly, the prediction that climate change would result in great changes in the global distribution of rainfall, causing drought and desertification in some regions and floods in others is a concern. Paper attempts to summarize that water plays an important role to sustain rural, urban and growing populations the world over and can secure low carbon transition to a sustained future.

Keywords: Climate change, Climate mitigation, and Paris agreement

INTRODUCTION

Climate change and possible response strategies have high scientific and policy relevance but are also associated with major controversies. The time frame of a century or more involved in any analysis of climate change, as well as, the complexity of natural and socio-economic systems and their interactions – all shrouded by deep uncertainties – pose major scientific and policy challenges. There needs to be a shared understanding of these challenges to come to grips with the possible magnitude and nature of climate change and to craft response strategies. This all makes climate change one of the most challenging issues to be addressed by interdisciplinary research and by policy measures. How the drivers ranging from the realm of demographics, economics, and technology to social behavior and institutions shape future emissions of greenhouse gasses (GHGs)? Are there ways of "bending down" the curve of ever increasing radiative forcing? What are the real consequences of radiative forcing change on global, regional, as well as local climates both in terms of changes in magnitude (e.g., warming, precipitation) as well as in nature (most prominently variability and possibilities of extreme events)? What will be the impacts on natural and human systems of a changing climate? Finally, what are the feasibilities, costs, and benefits (in terms of avoided impacts) of response strategies? (Grubler et al 2007).There are sufficient scientific and policy reasons to justify interest in climate change and to devote a full Special Issue to this topic. However, interest in itself needs to be complemented by new analytical and methodological perspectives. The work by Grubler et al. provides key findings that are also of wider interest beyond the climate change universe. The work suggests that developments in Asia will be particularly dramatic over the next five decades with an unprecedented scale of emerging urban agglomerations in terms of population and economic activities that could surpass many-fold the currently most dense urban corridors, such as Boswash in the USA or Shinkansen in Japan. Grubler et al. emphasize the need for new infrastructure "backbones" along urban clusters rather than networks of "island" cities, particularly in the Asian urbanization "hotspots" of Bengal and the Chinese coast.

Impact of Climate Change

Climate change is one of the most important global environmental challenges, with implications for food production, water supply, health, energy, etc. Addressing climate change requires a good scientific understanding as well as coordinated action at national and global level (see diagram). Historically, the responsibility for green house gas emissions ‘increase lies largely with the industrialized world, though the developing countries are likely to be the source of an increasing proportion of future emissions. The projected climate change under various scenarios is likely to have implications on food production, water supply, coastal settlements, forest ecosystems, health, energy security, etc. The adaptive capacity of communities likely to be impacted by climate change is low in developing countries. The efforts made by the UNFCCC and the Kyoto Protocol provision are clearly inadequate to address the climate change challenge. Thus most effective way to address climate change is to adopt a sustainable development pathway by shifting to environmentally sustainable technologies and promotion of energy efficiency, renewable energy, forest conservation, reforestation, water conservation, etc. (Sathaye et al., 2007) The issue of highest importance to developing countries is reducing the vulnerability of their natural and socio-economic systems to the projected climate change. India and other developing countries will face the challenge of promoting mitigation and adaption strategies, bearing the cost of such an effort, and its implications for economic development.

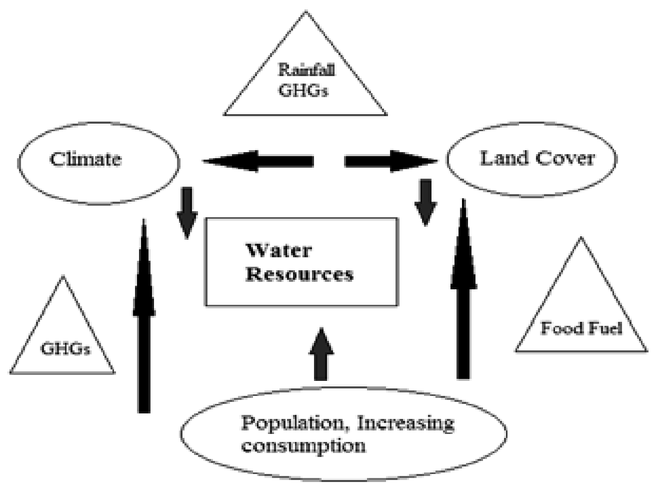


Figure 1 Climate change and water linkages

Global Carbon Cycle: Causes and Linkages

The global carbon cycle involves interaction among the atmosphere, oceans, soils and vegetation and fossil fuel deposits. The ocean contains 39,000giga tonnes of carbon (GtC), fossil fuel deposits about 16,000 GtC, and the atmosphere about 760 GtC2 and fossil fuel combustion, about 270 GtC. Of this, 180 GtC has ended up in the atmosphere, while 110 GtC has been absorbed by growing vegetation and the remainder by the oceans. It is the increasing concentration of atmospheric CO2 that is the cause for concern about global climate change. (Sathaye et. al., 2006)

The consumption of fossil fuels and other human activities are the primary sources of increased concentrations of CO2 and other greenhouse gasses. Between 1990 and 1999, an estimated 6.3 GtC/year was released due to the combustion of fossil fuels, and another 1.6 GtC/year was due to the burning of forest vegetation. This was offset by the absorption of 2.3 GtC/year each by growing vegetation and the oceans. This left a balance of 3.3 GtC/year in the atmosphere. Controlling the release of greenhouse gasses from fossil fuel combustion, land-use change and the burning of vegetation are therefore obvious opportunities for reducing greenhouse gas emissions. Reducing greenhouse gas emissions can lessen the projected rate and magnitude of warning and sea level rise. The greater the reduction in emissions the smaller and slower would be projected warming and the rise in sea levels. Future climate change is determined by historic, current and future emissions. Of the six GHGs above, CO2 accounted for 63% , methane 24%, nitrous oxide 10% and the other gases the remaining 3% of the carbon equivalent emissions in 2000. Thus in addition to CO2, global mitigation efforts need to focus on the two largest and rapidly increasing GHGs (Pl. see figure 1 & graph 1).

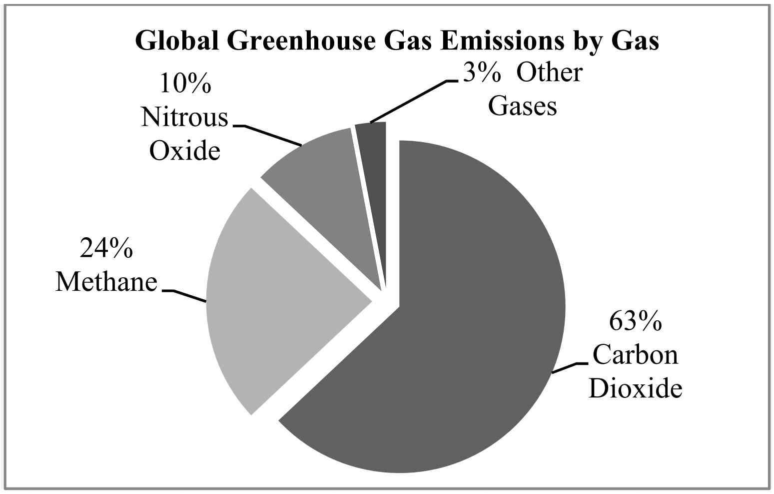
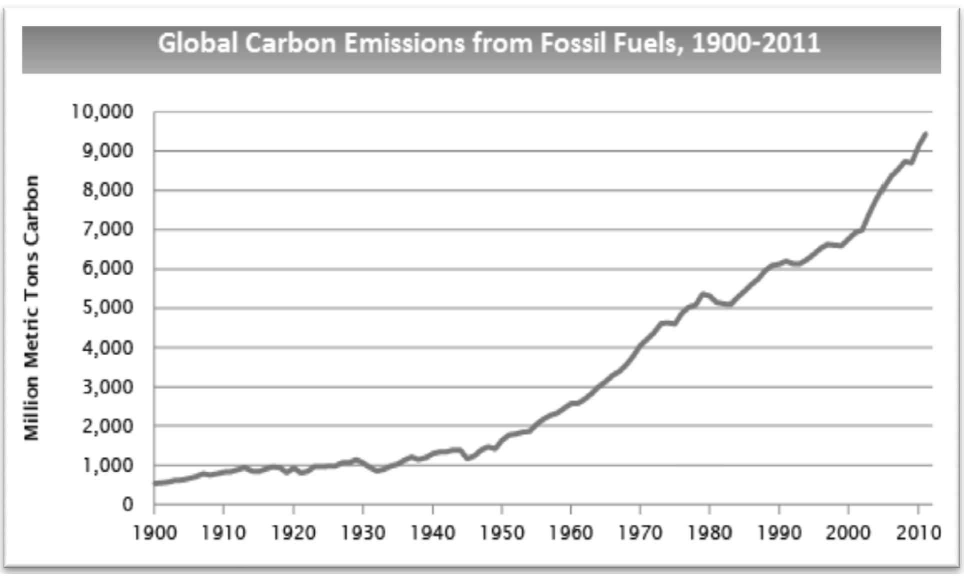


Figure 2 Source: IPCC (2014)



Graph 1: Source: Boden, T.A., Marland, G., and Andres R.J. (2015). Global, Regional, and National Fossil-Fuel CO_2 Emissions. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, doi 10.3334/CDIAC/00001_V2015.

India is a large developing country with nearly 700 million rural population directly depending on climate – sensitive sectors (agriculture, forests and fisheries) and natural resources (such as water, biodiversity, mangroves, coastal zones, grasslands) for their subsistence and livelihoods. Further, the adaptive capacity of dry land farmers, forest dwellers , fisher folk, and nomadic shepherds is very low (Sathaye et. al., 2006). Climate change is likely to impact all the National Communications Report of India to the UNFCCC (GoI, 2004,2006,2007,2008,2009).

Regional Issues

South Asia is most vulnerable to climate change. The region faces daunting climate related development challenges. The impacts of climate change in the form of higher temperature, more variable precipitation and more extreme weather events are already felt in South Asia. The region is already marked by climate variability and a higher incidence of natural disasters. The region has also a long and densely populated coast line with low lying island that are vulnerable to sea level rise. Urbanization poses an additional challenge in the region. Women, poor and indigenous people are most vulnerable to climate risk (Berggren et al, 2008).

Among the 32 states and Union Territories in the country, 22 are multidisaster prone. About 40 million hectares of land in the country has been identified as flood prone and on an average 18.6 million hectare of land is flooded annually. About 57 per cent of area of the country is vulnerable to seismic activity. About 18 per cent of country's total area is drought prone, approximately 50 million people are annually affected by droughts and about 68 percent of total sown area of the country is drought prone. (Singh U B et al 2014) India has a long coastline of 8040km. This is exposed to tropical cyclones arising in the Bay of Bengal, the Arabian Sea and Indian Sea. The Indian Ocean is one of the six major cyclonic prone regions of the globe. The Coromandal coastline is more cyclones prone, with 80 percent of the total cyclones generated in these regions. About 3.9 million houses are susceptible to earthquakes of very high intensity, about 20 million houses are susceptible to damage due to winds and about 9.3 millio9n houses are susceptible to damage due to floods. Besides the risk of earth quakes, cyclones and floods are liable to very high damage and destruction of vulnerable houses under heavy rains. (Prasad et. al., 2009). Some 49 percent of the total housing stock is liable to very high damage from natural hazards, while about 1 percent of the total housing stock gets destroyed every year. It is to be noted that in earth quake, 80 percent of the causalities are due to collapsing buildings. Brick and stone buildings without proper support are liable to collapse. Non-engineered building continues to be built in the areas prone to natural disasters. Unemployment, poverty backwardness, migration from rural areas and increasing price of land and construction, millions of people are occupying disaster prone areas. Thus about 6 percent increase in disaster affected population has been reported. (SINGH The changing topography due to environmental degradation has also increased the vulnerability in the country. In 1988, 11.2 percent of total land areas was flood prone, but in 1998 floods inundated 37 percent geographical area. Three major disasters that India have experienced in the recent past are the super cyclone in Orissa (1999) , earthquake in Gujarat (2001) and Tsunami (2004) in Tamil Nadu, Pondicherry, Andaman Nicobar Island and parts of other southern states. Frequent disasters lead to erosion of development gains restricted options threatened by hazards (World Bank 2006, 2010) (Satterthwaite et al., 2007)

The continent of Asia is particularly vulnerable to disaster strikes. Between the years 1991 to 2000 Asia has accounted for 83 percent of the population affected by disasters globally. Within Asia, 24 percent of deaths due to disasters occurred in India, o9n account of its size population and vulnerability. Floods and high winds account for 60 percent of all disasters in India. Many parts of the Indian sub –continent are susceptible to different types of disasters owing to the unique topography and climatic characteristics . About 54 per cent of the sub continent's landmass is vulnerable to earthquake while about 4 crore hectares is vulnerable to periodic floods. The country has suffered four four major earthquakes in the span of last 50 years along- with a series of moderate intensity earthquakes that have occurred at regular intervals. Since 1988, six earthquakes have struck different parts of the country. Tsunami in India killed 10749 persons while $1068 million loss or damage to properties was reported. Short term and long – term changes in climatic variables such as temperature and perception may pose hazards to urban system. Changes in the climatic variables are likely to impact future patterns of spatial growth and development in cities and act as a stressor in addition to existing pressures. The populations most venerable to climate change are those living in slums and informal settlements that often lack access to basic services and infrastructure (IDS, 2007). Apart from the risk to coastal populations from sea level rise, cyclones, storm surges and other associated impacts, a high proportion of urban settlements in the low and middle-income countries are one sites that are at risk from flooding or landslides . The key primary and secondary order impacts on cities are due to short –term and long- term changes in climatic variables have been stressed elsewhere too.

Carbon Dynamics of Soil and Water

Various types of wetlands – including swamp forests, mangroves, peat lands, mires and marshes – are also important carbon sinks and stores. Anaerobic conditions in inundated wetland soils and slow decomposition rates contribute to long term soil carbon storage and formation of carbon rich peats. Peat lands can extend up to 20 m in depth and represent some 25 percent of the world soil carbon pool, an estimated 550 GtC; they are estimated to sequester another 0.3 tC/ha/yr. Maintaining and restoring wetland habitats protects these carbon sinks; clearance and drainage can lead to peat collapse and further carbon emissions. Grasslands occur on every continent except Antarctica, and constitute about 34 percent of the global terrestrial carbon stock. Changes in grassland vegetation due to overgrazing, conversion to crop land, desertification, fire, fragmentation, and introduction of non-native species affect their carbon storage capacity, and may in some cases even lead to grasslands becoming a net source of CO2. For example, they may lose 20 to 50 percent of their soil organic carbon content through cultivation, soil erosion, and land degradation. Burning of biomass, especially in tropical savannas, contributes over 40 percent of gross global carbon dioxide emissions. Oceans, too, are substantial reservoirs of carbon, holding approximately 50 times more carbon than presently in the atmosphere (Loske 1996). They are efficient in taking up atmospheric carbon through plankton photosynthesis, mixing of atmospheric CO2 with sea water, formation of carbonates and bicarbonates, conversion of inorganic carbon to particulate organic matter and by burial of carbon rich particles in the deep sea. Clearly enhanced protection and improved management of natural ecosystems can contribute to both reductions in GHG emissions and carbon sequestration. Many protected areas, for instance, overlie areas of high carbon stocks. It has been estimated that globally, ecosystems represented within terrestrial protected areas store over 312 GtC or 15 percent of the terrestrial carbon stock, although the extent to which these stocks are protected varies with management effectiveness. Ecosystem-based Adaptation is becoming an increasingly important part of the development agenda. Protecting forests, wetlands, coastal habitats and other natural ecosystem can provide social, economic, and environmental benefits, both directly through more sustainable management of biological resources and, indirectly, through protection of ecosystem services. Natural ecosystems maintain the full range of goods and ecosystem services, including natural resources such as water, timber and fisheries on which human livelihoods depend; these services are especially important to the most vulnerable sectors of society.

Adaption to Ecosystem-based Approaches to Climate Change

In a report on 'Convenient Solutions to an Inconvenient Truth', It is envisaged to protect watersheds and regulate water flow and water quality; prevent soil erosion; influence rainfall regimes and local climate; conserve renewable harvestable resources and genetic reservoirs; and protect breeding stocks, natural pollinators, and seed dispersers, which maintain ecosystem health. Over the last decade, an increasing number of Bank projects have been making explicit linkages between conservation and sustainable use of natural ecosystems, carbon sequestration and watershed values associated with erosion control, clean water supplies, and flood control (ADB 2006) (Prasad et al 2009). Better protection and management of key habitats and natural resources can benefit poor, marginalized and indigenous communities by protecting ecosystem services and maintaining access to resources during difficult times, including drought and disaster. In response to climate change, many countries are likely to invest in even more infrastructure for coastal defenses and flood control to reduce the vulnerability of human settlements to climate change. Increased water shortages will increase demand for new irrigation facilities and new reservoirs. Similarly, natural ecosystems can reduce vulnerability to natural hazards and extreme climatic events and complement, or substitute for, more expensive infrastructure investments to protect coastal and riverine settlements. Flood plain forests and coastal mangroves provide storm protection, coastal defenses, and water recharge, and act as safety barriers against natural hazards such as floods, hurricanes, and tsunamis, while wetlands filter pollutants and serve as water recharge areas and nurseries for local fisheries. Traditional engineered solutions often work against nature, particularly when they aim to constrain regular ecological cycles, such as annual river flooding and coastal erosion, and could further threaten ecosystem services if creation of dams, sea walls, and flood canals leads to habitat loss. (WB 2010). Three of the world's greatest challenges over the coming decades are biodiversity loss, climate change, and water shortages. Biodiversity loss leads to the erosion of ecosystem services and will increase vulnerability to the impacts of climate change.

Climate change will lead to water scarcity, increased risk of crop failure, pest infestation, overstocking and permanent degradation of grazing lands and livestock deaths. Water shortages affect agricultural productivity, food security and human health. But Impacts from these challenges are already imposing severe economic and social costs, and they are likely to get more severe as climate change continues, particularly affecting already vulnerable communities. Changing climate and rainfall patterns are expected to have significant impacts on agricultural productivity, especially in arid and semi-arid regions that are already marginal for agriculture. Most climate modeling scenarios indicate that the dry lands of West and Central Asia and North Africa, for instance, will be severely affected by droughts and high temperatures in the years to come. This could lead to land degradation and agricultural expansion. By 2050, almost 40 percent of the land currently under low impact agriculture could be converted to more intensive agricultural use with poor farmers being forced to open up ever more marginal lands. One study estimates that climate change could lead to a 50 percent reduction in crop yields for rain-fed agricultural crops by 2020. According to crop-climate models, in tropical countries even moderate warming can reduce yields significantly (1°C for wheat and maize and 2°C for rice) because many crops are already at the limit of their heat tolerance.

Agriculture, Livelihood Issues and Strategies

The areas most vulnerable particularly in South Asia and Sub-Saharan Africa—also have the largest number of rural poor and rural populations dependent on agriculture. Recent studies show that farming, animal husbandry, informal forestry and fisheries make up only 7.3 percent of India's GDP, but these activities constitute 57 percent of GDP of the poor who are most reliant on natural resources and ecosystem services (see Diagram). Climate change is likely to aid the spread of invasive alien species, further threatening agricultural productivity and food security through spread of weeds, pests, and diseases of crops and livestock. The introduction of new and adaptable exotic species for agriculture and to meet increasing demands for biofuels, mariculture, aquaculture, and reforestation presents a particular challenge. Ironically, in some cases, the very characteristics that make a species attractive for introduction under development assistance programs (fast-growing, adaptable, high reproductive output, tolerant of disturbance and a range of environmental conditions,) are the same properties that increase the likelihood of the species becoming invasive. Such events are costly; invasives accidentally introduced through development assistance programs include itch grass, a major weed in cereals in South and Central America, and a range of nematode pests.

Climate change is expected to have serious consequences on water resources. Melting glaciers, higher intensity and more variable rainfall events, and increasing temperatures will contribute to increased inland flooding, water scarcity and decrease water quality. Overall, the greatest human requirement for freshwater resources is for crop irrigation, particularly for farming in arid regions and in the great paddy fields of Asia (World Bank 2010). In South Asia, hundreds of millions of people depend on perennial rivers such as the Indus, Ganges, and Brahmaputra –all fed by the unique water reservoir formed by the 16,000 Himalayan glaciers. Current trends in glacial melt suggests that the low flows will be substantially reduced as a consequence of climate change even as the demand for agricultural water is projected to rise by 6 to 10 percent for every 1 ˚C rise in temperature. As a result, even under the most conservative climate projections, the net cereal production in South Asian countries is likely to decrease by 4 to 10 percent by the end of this century.

Water security to Urban Areas

Today, half of the global population lives in towns and cities and one-third of this urban population live without clean drinking water. Municipal water accounts for less than a tenth of human water use, but clean drinking water is a critical need. These billion have-nots are unevenly distributed across the globe: 700 million city dwellers in Asia, 150 million in Africa, and 120 million in Latin America and the Caribbean. (http://siteresources.worldbank.org) In recent years, governments and city councils have begun to take an increasing interest in the opportunities for offsetting or reducing some of the costs of maintaining urban water supplies—and, perhaps even more importantly, water quality—through management of natural resources, particularly forests and wetlands. Most protected areas are established to protect their biodiversity values, but many could be justified on the basis of the other ecosystem services that they provide. From China to Ecuador and Mexico to Kenya, protected areas in forest watersheds safeguard the drinking supplies for some of the world's major cities.

Other Ecosystem-based Approaches is by supporting biodiversity conservation and protecting natural habitats and ecosystem services, thereby contributing to effective mitigation and adaptation strategies. Pilot projects which integrate protection of natural habitats and "green" infrastructure into watershed management, flood control, and coastal defense, already demonstrate the cost effectiveness of such ecosystem-based approaches. Climate change highlights the need to replicate and scale up such interventions including the ones that reported and are success stories elsewhere like:

- Protecting terrestrial, freshwater, and marine ecosystems and ecological corridors to conserve terrestrial and aquatic biodiversity and ecosystem services.
- Integrating protection of natural habitats into strategies to reduce vulnerability and disaster risks (including protection from natural hazards such as floods, cyclones, and other natural disasters). Emphasizing the linkages between protection of natural habitats and regulation of water flows and quality of water, essential for agriculture, food security, and domestic and industrial supplies.
- Scaling up investments for protected areas and ecosystem services linked to sector lending, such as infrastructure, agriculture, tourism, water supply, fisheries, forestry.

- Promoting greater action on management of invasive alien species, which are linked to land degradation, and impact negatively on food security, and water supplies.
- Emphasizing the multiple benefits of forest conservation and sustainable forest management (carbon sequestration, water quality, reducing risks from natural hazards, poverty alleviation, and biodiversity conservation).
- Promoting investments in natural ecosystems as a response to mitigation (avoided deforestation) and adaptation (wetland services).
- Integrating indigenous crops and traditional knowledge on agro-biodiversity and water management into agricultural projects as part of adaptation strategies.
- Promoting more sustainable natural resource management strategies linked to agriculture, land use, habitat restoration, forest management and fisheries.
- Developing new tools to measure the benefits of integrated approaches to climate change (ecosystem services, biodiversity conservation, carbon sequestration, livelihood co-benefits and resilience). In the global climate change debate, the issue of largest importance to developing countries is reducing the vulnerability of their natural and socio-economic systems to projected climate change (Sathaye et al). Over time, there has been a visible shift in the global climate change discussions towards adaptation. Adaptation can complement mitigation as a cost-effective strategy to reduce climate change risks. The impact of climate change is projected to have different effects within and between countries (Sathaye et al). Mitigation and adaptation actions can augment sustainable development and equity both within and across countries and between generations

CONCLUSION

Numerous studies have shown that over few decades anthropogenic activities have changed ecosystems more rapidly and extensively than at any comparable period. These changes have contributed to many net development gains but at growing environmental and social costs: habitat loss, land degradation, and reduced access to adequate water and natural resources for many of the world's poorest people. Climate change is likely to compound this environmental degradation. Water is essential for all life on Earth. Climate change impacts can be expected to have serious consequences on the availability and quality of water resources. Melting glaciers, higher intensity and more variable rainfall events, and increasing temperatures will contribute to increased inland flooding, water scarcity and decreasing water quality. Restoration and maintenance of watersheds, including management of soils, can contribute to reduce the risk of flooding and maintaining regular water supplies. Natural ecosystems such as wetlands and forests act as natural water recharge areas, storing runoff, recharging aquifers, and replenishing stream flows. This reduces flood risks associated with heavy rainfall or a glacier melt events.

ACKNOWLEDGEMENTS

Authors are grateful to Department of Environmental Science and Babasaheb Bhimrao Ambedkar University, Lucknow authorities for infrastructural support.

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GLOBALISATION, SOCIAL JUSTICE AND SUSTAINABLE DEVELOPMENT IN INDIA

Manish K. Verma

Contents

Chapter - 13

Globalisation, Climate Change and the Dynamics of Sustainable Development

—Nandkishor More and Shashi Kumar

*Even before the call of sustainable development much highlighted by Gro-Harlem Brundtland in O*ur Common Future, *the land mark report submitted under the aegis of United Nations Conference on Environment and Development (UNCED) popularly known as Earth Summit, the process of globalisation of world economies and use of natural resources was already in place. The division of world into two major 'Blocks' representing Developed and Developing nations have introduced new dimensions of alignment: one with technology centric and the other conservation based but technology deficient. It thus appeared as if on the existence of former, the genesis of the later is dependent. However, those who contemplated the issues of sustainable development brought attention towards the most pertinent questions, development for whom? by whom? and how? The interesting dimension to the duo of Globalisation and Sustainable Development added another feather with the emerging threats of Climate Change directly affecting the society and indirectly to the forces which govern it. Thus, new dimension of Climate change as one of the most important global environmental challenges emerged with deep seated implication for food production, water supply, health, energy etc. Moreover, the heat of Climate Change has already started producing results having very real consequences on people's lives. Because of increase in surface temperature, melting of snow and rise in sea levels is rampant resulting into several climate related eventualities like flooding, droughts, cyclone etc. occurring in many parts of the world eventually affecting the socio-economic life of people. Rethinking of global development model, based on principles of scientific sustainability is an absolute necessity at present and the scientists are by and large convinced now that human beings have caused much harm to mother Earth by letting global warming over the last 60 years or so. The IPCC's Fifth Assessment Report (AR5) suggests that without additional efforts to reduce GHG emissions beyond those in place today, the global surface temperature towards the end of the twenty-first century will increase by 4.8°C, and sea levels could rise as much as 0.8*

meters, compared to pre-industrial levels. Significantly, the adverse impact of climate change has hindered in accomplishing the task of protection and promotion of human rights of common masses. In this context, sustainable development has direct bearing on the concerns of human rights. Moreover, the environmental degradation and problem of climate change has given a new dimension to sustainable development by making it more complex and intriguing issue.

Key Words: *Globalisation, Global Warming, Climate Change, Sustainable Development, Social Justice.*

Introduction

In 1983, the U.N. General Assembly created the World Commission on Environment and Development, an independent committee of twenty-two members, headed by Gro Harlem Brundtland, the Prime Minister of Norway. Designed to examine global environment and development to the year 2000 and beyond, the commission was constituted to reassess critical problems, to formulate realistic proposals for solving them, and to raise the level of understanding and commitment to the issues of environment and development. Rather than presenting a gloom and doom report about the destruction of natural resources, the Commission brought important report *Our Common Future* in 1987, that offers an agenda advocating the growth of economies based on policies that do not harm, and can even enhance, the environment. The commission recognises that the time has come for a marriage of economy and ecology, in order to ensure the growth of human progress through development without bankrupting the resources of future generations. This was however an arduous task for anyone regarding the object the chairman remarked. "A Global Agenda for Change" was what the world commission on environment and development was asked to formulate. It was an urgent call of United Nations General Assembly.

Sustainable Development: Conceptualisation

The concept of Sustainable Development seems to be "a seductively simple concept" (Birinie and Boyle, 1992), but it becomes complex and controversial notion when its applicability is made in the context of determining the indictors of sustainable development in relation to developed and developing countries. (M. Redclift, 1982; Kuik and Verbruggen, 1991) Originally, the term Sustainable Development primarily used in the report of Brundtland Commission (*Our Common Future*, 1987). The Commission draws upon several notions in its definition of sustainable development which is the most frequently cited definition of the concept to date. A key element in the definition of Sustainable Development is the unity of environment and development. The Brundtland Commission argues against the assertions of the 1972 Stockholm Conference on the Human Environment and provides an alternative perspective on sustainable development, unique from that of the 1980 World

Conservation Strategy of the International Union for the Conservation of Nature. The Brundtland Commission pushed for the idea that while the "environment" was previously perceived as a sphere separate from human emotion or action, and while "development" was a term habitually used to describe political goals or economic progress, it is more comprehensive to understand the two terms in relation to each other (We can better understand the environment in relation to development and we can better understand development in relation to the environment, because they cannot and should not be distinguished as separate entities). Brundtland argues: "...the "environment" is where we live; and "development" is what we all do in attempting to improve our lot within that abode. The two are inseparable."

The Brundtland Commission insists upon the environment being something beyond physicality, going beyond that traditional school of thought to include social and political atmospheres and circumstances. It also emphasise that development is not just about how poor countries can ameliorate their situation, but what the entire world, including developed countries, can do to ameliorate our common problems.

Sustainable development is the kind of development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The two key concepts of sustainable development are: (1) the concept of "needs" in particular the essential needs of the world's poorest people, to which they should be given overriding priority; and (2) the idea of limitations which is imposed by the state of technology and social organisation on the environment's ability to meet both present and future needs.

Most agree that the central idea of the Brundtland Commission's definition of "sustainable development" is that of intergenerational equity. In sum, the "needs" are basic and essential, economic growth will facilitate their fulfilment, and equity is encouraged by citizen participation. Thus, another characteristic that really sets this definition apart from others is the element of humanity that the Brundtland Commission integrates.

The definition gave light to new perspectives on the sustainability of an ever-changing planet with an ever-changing population. Brundtland Commission (Our Common Future) The document was the culmination of a "900 day" international-exercise which catalogued, analysed, and synthesised written submissions and expert testimony from "senior government representatives, scientists and experts, research institutes, industrialists, representatives of non-governmental organisations, and the general public" held at public hearings throughout the world.

Its mandate was to: "[1] re-examine the critical issues of environment and development and to formulate innovative, concrete, and realistic action proposals to deal with them; [2] strengthen international cooperation on environment and development and assess and propose new forms of cooperation that can break out of existing patterns and influence policies and events in the direction of needed change; and [3] raise the level of understanding and commitment to action on the part of individuals, voluntary organisations, businesses, institutes, and governments". (Our Common Future, 1987) "The Commission focused its attention on the areas of population, food security, the loss of species and genetic resources, energy, industry, and human settlements - realising that all of these are connected and cannot be treated in isolation one from another" (*Ibid* : 27). The Brundtland Commission Report recognised that human resource development in the form of poverty reduction, gender equity, and wealth redistribution was crucial to formulating strategies for environmental conservation, and it also recognised that environmental-limits to economic growth in industrialised and industrialising societies existed. As such, the Report offered "the analysis, the broad remedies, and the recommendations for a sustainable course of development" within such societies. (*Ibid* : 16)

However, the Report was unable to identify the mode(s) of production that are responsible for degradation of the environment, and in the absence of analysing the principles governing market-led economic growth, the Report postulated that such growth could be reformed and expanded; this lack of analysis resulted in an obfuscated-introduction of the term sustainable development.

The report deals with sustainable development and the change of politics needed for achieving it. The definition of this term in the report is quite well known and often cited elsewhere too:

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". It contains two key concepts:

- the concept of "needs", in particular the essential needs of the world's poor, to which overriding priority should be given; and
- the idea of limitations imposed by the state of technology and social organisation on the environment's ability to meet present and future needs."

Sustainable Development and Human Rights have close relation. Dominic McGoldrick argues that Sustainable Development and Human Rights are integrated conceptions. According to him, the protection and promotion of human rights values as enshrined in International Human Rights law is the core of integrated structure of Sustainable Development. (McGoldrick, 1996) The Principle 1 of the UN Conference on Environment and Development's Rio Declaration states that "human beings are the centre of concern for sustainable development" and that "are entitled to a healthy and productive life in harmony with nature." [See the Stockholm Declaration (1972), Principle.1]. The environmental protection is also important component of Sustainable Development. A World Charter for Nature was adopted in 1982, Principle 4 of the Rio Declaration states that "in order to achieve Sustainable Development environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it."[1] Economic development is also concern with Sustainable Development. The World Trade Organisation also plays a key role in focusing on the trade-related aspect for having sustainable development. Importantly, the UN Secretary General's *Agenda for Development* formulated in 1995 has a "five dimension of development": peace as the condition, the economy as engine of growth, the environment as the basis for sustainability, justice as a pillar of society, and democracy as good governance.

At the international levels, under the aegis of United Nation the Sustainable Development Goals (SDG) has been recently formulated 25th September 2015 which is also known as Post-2015 SDG, replacing the Millennium Development Goal (MDG) which was set in 2000 and got ended in 2015. The Post-2015 SDG adopted by UN Member States has contains seventeen sustainable development goals that would guide global development efforts on poverty eradication, food security, environmental sustainability and the rule of law to be achieved till 2030.[2] The SDG officially known as *Transforming our World: The 2030 Agenda for Sustainable Development*, considered as successor to the Millennium Development Goals. The resolution is broader intergovernmental agreement among nations of the world to ameliorate the problems of the world being faced by the peoples at present time. Largely, it includes ending poverty and hunger, improving health and education, making cities more sustainable, combating climate change, and protecting oceans and forests.

The environmental problem like climate change is understood as problem of consumption rather than production patterns. Therefore, judicious consumption pattern rather than a production-based vision for environmentally sustainable economic development is need of the hour for the protection of environment and for prevention from the adverse impact of climate change. (Prasad *et al.,* 2009; Sanwal, 2008). In economic term, Sustainable development means maintenance of inter-generational well-being, that is, the total well-being of the individuals in future generation does affect decline in compare to present generations (Stavins, R.N, *et al.* 2003). In other words, sustainability understood as non-declining intergenerational well-beings over time (Arrow *et al.,* 2012).

Globalisation and Sustainable Development

Globalisation is both a result and a force of modernisation and capital expansion. It entails the integration of all economic activity (local, national and regional) into a 'global' market place, and transcending geo-political borders and is not subject to regulation by nation states.

Globalisation is derived by neo-liberal economic measures that based on principles of 'economic freedom' and 'consumer choice'. These measures include liberation of trade and finance, deregulation and privatisation which have been nailed down over the past more than three decades by the Washington Consensus, the unprecedented rise of corporate power, the formation of WTO and burgeoning bilateral and regional free trade and investment agreements.

It has been argued that many of the world's people live in what may be described as a corporatist society with soft pretensions to democracy. Globalisation affects them in tangible and intangible ways. The neo-liberalist forces that tend to shape and frame globalisation in terms of markets and opportunities for growth result in power slipping away from citizens to corporate elites. In examining this argument, John Ralston Saul suggests that globalisation refers to the rise of economic ideologies embodied by the corporate sector, and to the erosion of grassroots democracy. In fact, he argues that the corporatist movement started in the nineteenth century as an alternative to democracy (Saul, 2005). Crossley and Watson argues that it is the executive directors of these powerful banks [i.e. International Monetary Fund and World Bank] and transnational corporations (TNCs) that can direct, or at the least influence, the policies of individual countries and national economies by integrating them into regional or global economies, and by making it increasingly impossible for them to regulate and control their own affairs (Michael, C and Watson, K, 2003; Satterthwaite *et al.*, 2007).

It was assumed that globalisation would bring economic growth in developing countries, but instead of this, the economies of developing countries have become even more depended on forces of international market mainly controlled by corporate powers houses of the world. Consequently, it led to economic stagnation, increased unemployment, income poverty, economic vulnerability and environmental destruction in several developing countries (Guttal, 2007; U B Singh *et al.*, 2014).

Globalisation a process with many facets. Globalisation of capital market leads to greater international capital flows which increase the vulnerability of emerging markets into crises. Makin says that globalisation supports growth in developing countries. However, during bad times, globalisation also increases human sufferings (Wall Street Journal, 1999).

Globalisation is a dynamic process driving the integration of national markets into world market. WTO promotes free international trade in goods and services around the world. Large regional trading alliance treaties of the countries like ASEAN, NAFTA, European Union, APEC have also been founded to encourage cross-broader trade flows by eliminating import quotas, tariffs and export restriction (Markin, 2000).

Impact of Climate Change

Climate change is one of the most important global environmental challenges, with implications on food production, water supply, health, energy, etc. Addressing climate change requires a good scientific understanding as well as coordinated action at national and global level. It is argued that as the developed countries have contributed much in green house gas emission, hence the responsibility for restriction on green house gas emissions largely lies with the industrialised world, though the developing countries are also likely to be the source of an increasing proportion of emission level in present era and in future. The projected climate change under various scenarios is likely to have implications on food production, water supply, coastal settlements, forest ecosystems, health, energy security etc. The adaptive capacity of communities likely to be impacted by climate change is low in developing countries. The efforts made by the UNFCCC and the Kyoto Protocol provision are clearly inadequate to address the climate change challenge but are important. The most effective way to address climate change is to adopt a sustainable development pathway by shifting to environmentally sustainable technologies and promotion of energy efficiency, renewable energy, forest conservation, reforestation, water conservation, etc. The issue of highest importance to developing countries is reducing the vulnerability of their natural and socio-economic systems to the projected climate change. India and other developing countries will face the challenge of promoting mitigation and adaption strategies, bearing the cost of such an effort, and its implications for economic development (R Loske,1996).

The global carbon cycle involves interaction among the atmosphere, oceans, soils and vegetation and fossil fuel deposits. The ocean contain 39,000 giga tonnes of carbon (GtC), fossil fuel deposits about 16,000 GtC, and the atmosphere about 760 GtC and fossil fuel combustion, about 270 GtC. Of this, 180 GtC has ended up in the atmosphere, while 110 GtC has been absorbed by growing vegetation and the remainder by the oceans. It is the increasing concentration of atmospheric CO_2 that is the cause for concern about global climate change.

The combustion of fossil fuels and other human activities are the primary reasons for increased concentrations of CO_2 and other greenhouse gases. Between 1990 and 1999, an estimated 6.3 GtC/year was released due to the combustion of fossil fuels, and another 1.6 GtC/year was released due to the burning of forest vegetation. This was offset by the absorption of 2.3 GtC/year each by growing vegetation and the oceans. This left a balance of 3.3 GtC/year in atmosphere[3]. Controlling the release of greenhouse gases from fossil fuel combustion, land-use change and the burning of vegetation are therefore obvious opportunities for reducing greenhouse gas emissions. Reducing greenhouse gas emissions can lessen the projected rate and magnitude of warning and sea level rise. The greater the reduction in emissions and the earlier they are introduced, the smaller and slower the projected warming and the rise in sea levels. Future climate change is thus determined by historic, current and future emissions. Of the six aforementioned GHGs, CO_2 accounted for 63 per cent, methane 24 per cent, nitrous oxide 10 per cent and the other gases the remaining 3 per cent of the carbon equivalent emissions in 2000. Thus, in addition to CO_2, global mitigation efforts need to focus on the two largest and rapidly increasing GHGs.

India is a large developing country with nearly 700 million rural population directly depending on climate–sensitive sectors (agriculture, forests and fisheries) and natural resources (such as water, biodiversity, mangroves, coastal zones, grasslands) for their subsistence and livelihoods. Further, the adaptive capacity of dry land farmers, forest dwellers, fisher folk, and nomadic shepherds is very low (Ravindra Nath and Sathaye, 2002). Climate change is likely to impact all the National Communications Report of India to the UNFCCC (GoI, 2004, 2005, 2006, 2007, 2008, 2009).

South Asia is most vulnerable to climate change. The region faces daunting climate related development challenges. The impacts of climate change in the form of higher temperature, more variable precipitation and more extreme weather events are already felt in South Asia. The region is already marked by climate variability and a higher incidence of natural disasters. The region has also a long and densely populated coast line with low lying island that are vulnerable to sea level rise. Urbanisation poses an additional challenge in the region. Women, poor and indigenous people are most vulnerable to climate risk.

Among the 32 states and Union Territories in the country, 22 are multi-disaster prone. About 40 million hectares of land in the country has been identified as flood prone and on an average 18.6 million hectare of land is flooded annually. About 57 per cent of area of the country is vulnerable to seismic activity. About 18 per cent of country's total area is drought prone, approximately 50 million people are annually affected by droughts and about 68 per cent of total sown area of the country is drought prone. India has a long coastline of 8040 km. which is exposed to tropical cyclones arising in the Bay of Bengal, the Arabian Sea and Indian Ocean. The Indian Ocean is one of the six major cyclonic prone regions of the globe The Coromandal coastline is more cyclones prone, with 80 per cent of the total cyclones generated in this regions. Risk to the existing housing stock in various states and union-territories had been estimated by Expert Group set up by the Ministry of Urban Affairs and Employment, Government of India. About 3.9 million houses are susceptible to earthquakes of very high intensity, about 20 million houses are susceptible to damage due to winds and about 9.3 million houses are susceptible to damage due to floods. Besides the risk of earthquakes, cyclones and floods are liable to very high damage and destruction of vulnerable houses under heavy rains. Some 49 per cent of the total housing stock is liable to very high damage from natural hazards, while about one per cent of the total housing stock gets destroyed every year. It is to be noted that in earthquake, 80 per cent of the casualities are due to collapsing buildings. Brick and stone buildings without proper support are liable to collapse. Non-engineered building continue to be built in the areas prone to natural disasters. Unemployment, poverty backwardness, migration from rural areas and increasing price of land and construction, million of people are occupying disaster prone areas. Thus, about six per cent increase in disaster affected population has been reported. The changing topography due to environmental degradation has also increased the vulnerability in the country. In 1988, 11.2 per cent of total land areas was flood prone, but in 1998 floods inundated 37 per cent geographical area. Three major disasters that India have experienced in the recent past are the super cyclone in Orissa (1999), earthquake in Gujarat (2001) and Tsunami (2004) in Tamil Nadu, Pondicherry, Andaman Nicobar Island and parts of other southern states. Frequent disasters lead to erosion of development gains restricted options threatened by hazards.

The continent of Asia is particularly vulnerable to disaster strikes. Between the years 1991 to 2000 Asia has accounted for 83 per cent of the population affected by disasters globally. Within Asia, 24 per cent of deaths due to disasters occurred in India, on account of its size of population and vulnerability. Floods and high winds account for 60 per cent of all disasters in India. Many parts of the Indian sub-continent are susceptible to different types of disasters owing to the unique topography and climatic characteristics. About 54 per cent of the sub-continent's landmass is vulnerable to earthquake while about 4 crores hectares is vulnerable to periodic floods. The country has suffered four major earthquakes in the span of last 50 years along with a series of moderate intensity earthquakes that have occurred at regular intervals. Since 1988, six earthquakes have struck different parts of the country. Tsunami in India killed 10749 persons while $1068 million loss or damage to properties was reported.

Short-term and long-term changes in climatic variables such as temperature and perception may pose hazards to urban system. Changes in the climatic variables are likely to impact future patterns of spatial growth and development in cities and act as a stressor in addition to existing pressures. The populations most venerable to climate change are those living in slums and informal settlements that often lack access to basic services and infrastructure (IDS, 2007). Apart from the risk to coastal populations from sea level rise, cyclones, storm surges and other associated impacts, a high proportion of urban settlements in the low and middle-income countries are one sites that are at risk from flooding or landslides. The key primary and secondary order impacts on cities are due to short-term and long-term changes in climatic variables have been stressed elsewhere too (Kuik, O and Verbruggen, H, 1991).

Urbanisation vis-à-vis Globalisation

Growing urbanisation is possing serious environmental challenges in India in terms of changing land use pattern, increasing carbon emission, solid wastes generation and disposal, air and water pollution and poor sanitation amenities. A large segment of urban population in India resides in slums, squatters and informal settlements. These settlements are often located in low laying areas prone to direct and indirect risks due to various forms of environmental degradation including changes in the climate and lack of basic urban services (Satterthwaite *et al.,* 2007). It is to be noted that out of 35 cities in India having population over a million, 18 are in coastal states. Major challenge for cities in the face of rapid population growth is to maintaining sustainability within the social, economic and environmental dimension. Urban systems are at risk to different kinds of hazards. Several factors contribute to the urban risk profile (Tony Markin, 2000).

The implementation plan of the parties to the 2002 World Summit on Sustainable Development has 81 references to "at all levels" in just 50 pages. This could be read as either an acknowledgement that many problems have causes and solutions that span multiple levels or as an admission of ignorance or willingness to address particular levels and cross level interactions (Arrow *et al.,* 2012). Either way, understanding cross scale interactions in the human-environment system is seen as increasingly important. Further there is a long history of disappointments in policy, management, and assessment arising from the failure to take into proper account the scale and cross-scale dynamics in human-environment systems: collapsing fisheries, trans-boundary pollution problems, vulnerability to repeated extreme events like floods and droughts, and the inability to address human-induced disease outbreaks (Millennium Ecosystem Assessment, 2005).

Climate change and possible response strategies have high scientific and policy relevance but are also associated with major controversies. The time frame of a century or more involved in any analysis of climate change, as well as, the complexity of natural and socio-economic systems and their interactions–all shrouded by deep uncertainties–pose major scientific and policy challenges. There needs to be a shared understanding of these challenges in order to come to grips with the possible magnitude and nature of climate change and to craft response strategies. This all makes climate change perhaps one of the most challenging issues to be addressed by interdisciplinary research and by policy measures to date. How will human drivers ranging from the realm of demographics, economics, and technology to social behaviour and institutions shape future emissions of greenhouse gases (GHGs)? Are there ways of "bending down" the curve of ever increasing radiative forcing? What will be the consequences of radiative forcing change on global, regional, as well as local climates both in terms of changes in magnitude (e.g., warming, precipitation) as well as in nature (most prominently variability and possibilities of extreme events)? What will be the impacts on natural and human systems of a changing climate? Finally, what are the feasibilities, costs, and benefits (in terms of avoided impacts) of response strategies? There are sufficient scientific and policy reasons to justify interest in climate change and to devote a full Special Issue to this topic. However, interest in itself needs to be complemented by new analytical and methodological perspectives. The work by Grubler *et al.* provides key findings that are also of wider interest beyond the climate change universe. For instance, the paper highlights the importance of the persistence of urban clusters in industrialised countries (as well as Latin America) combined with a vast potential for megacity (Africa) and urban corridor (Asia) growth in developing countries. The paper suggests that developments in Asia will be particularly dramatic over the next five decades considering the economic growth with an unprecedented scale of emerging urban agglomerations in terms of population and economic activities that could surpass many-fold the currently most dense urban corridors, such as Boswash in the USA or Shinkansen in Japan. Grubler *et al.* emphasise the need for new infrastructure "backbones" along urban clusters rather than networks of "island" cities, particularly in the Asian urbanisation "hotspots" of Bengal and the Chinese coast (Satterthwaite *et al.* 2007; ADB, 2009; IDS, 2006; WB, 2009).

Conclusion

To conclude it is reiterated that South Asia is the most vulnerable to climate change. The region faces daunting climate related development challenges. The impacts of climate change in the form of higher temperature, more variable precipitation and more extreme weather events are already felt in South Asia. The region is already marked by climate variability and a higher incidence of natural disasters. The region has also a long and densely populated coast line with low lying island that are vulnerable to sea level rise. Urbanisation poses an additional challenge in the region. Women, poor and indigenous people are most vulnerable to climate risk. Though Agenda for Sustainable Development, which includes a set of 17 Sustainable Development Goals (SDGs) and 169 targets to end poverty, fight inequality and injustice, and tackle climate change by 2030 though it is target for 15 yrs to all the nations of the world (UN-SDG, 2015; CEE, MoEFCC, 2015). In many ways it is a challenge to complete the force of globalisation and to achieve the goals of sustainable development.

Notes

1. UN General Assembly Res. 37/7, See D. McGoldrick, "From the New International Economic Order to the Agenda for Development", in BIICL, Essays on Privatisation (1996).
2. See https://sustainabledevelopment.un.org, UN Res. A/RES/70/1.

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Plant Responses to Soil Pollution

Springer

Contents

2 Challenges to Organic Farming in Restoration of Degraded Land in India

Ashima Singh, Rana Pratap Singh, and Nandkishor More

Abstract

Degraded land is not only a subject of soil quality but also an indication of declined levels of productivity and economy of a country. India had 29.3% (96.4 million hectare) degraded land area in 2013. It included 1.87 million hectare (0.57%) increment of degraded land as well as 1.95 million hectare reclaimed land. Annual economic loss due to changes in land use or degraded land in India was ($46.90 billion) in 2014–2015, i.e. 2.5% of the country's gross domestic product (GDP) in 2014–2015. On the other hand, India supports 60–70% work-force in 60.45% agricultural land with a landmark position in most production crops like wheat, rice, milk, etc. However, in the case of yield, its position is not the same when compared to other most production countries, and its agricultural growth also declined from 8.6 (in 2010–2011) to 0.8 (in 2015–2016). The most interesting is the decrease of Gross Domestic Product (GDP), which declined from 54% to 15.4% from 1950–1951 to 2015–2016 against in service sector, which grew from 30 to 53% for the same duration. Therefore, land reform is a demanding and challenging area in Indian economy. To focus on this framework, our agricultural management practices play a vital role in which organic farming as eco-friendly, soil-sustaining agricultural technique, sharing highest organic producers of 2.7 million (30%) of total organic producers with 1.49 million hectare organic agricultural land, can play a significant role in land reformation. The chapter discusses some possible opportunities and challenges of organic agriculture in degraded land as reformative measure.

Keywords

Land Degradation · Economy · Organic farming

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P. Singh et al. (eds.), *Plant Responses to Soil Pollution*,
https://doi.org/10.1007/978-981-15-4964-9_2

2.1 Concept of Organic Farming in Indian Agriculture

Organic farming is now a holistic approach against the contaminated food production, health security, falls in bio-diversity, disturbed soil nutrient cycles, soil pollution and degraded agricultural land (Lal 2015; Elpiniki et al. 2016). Use of natural inputs, neither mining nor lead to degradation of soil nutrients, promotion of soil microbial growth, maintenance of soil from texture to soil ecosystem are today's ethics of organic farming.

Promotion of organic farming in India is mainly based on the requirement of huge quantity as well as quality of food for fast-growing population, increased agricultural-based economy, reduced GDP rate due to farming sector, overcoming degraded agricultural land area, requirement of soil sustainability and also saying "NO" to the use of chemicals for crop production.

2.2 Importance of Organic Farming in Sustainable Agriculture

Sustainable agriculture is the maintenance of regenerative capacity of natural resources like soil, biological diversity, particularly pollinators, micronutrients, pesticide resistance capacity, higher soil carbon level and ground water level along with quality and quantity of food production.

Microorganisms in soil play a leading role in rapid availability of micronutrients in soil as they promote the secretion of exo-polysaccharides, proteins, organic acids and other metabolites, which glue the soil particles and promote soil aggregation. This process enhances the availability of soil nutrients to plant uptake (Aislabie and Deslippe 2013; Rashid et al. 2016; Jacoby et al. 2017; Costa OYA et al. 2018). Organic supplements are easily colonized by microbes and increase other soil properties maintaining fertility stability. A balanced ratio of microbial biomass and activity is needed to consistently release nutrients for plant and microbial growth. Nutrient management through organic farming helps stabilizing soil fertility via improving nitrogen fixation and reducing nutrient leaching (Pandey and Singh 2012). Soil organic matter is a significant factor in soil sustainability, which depends upon the amount and type of organic matter applied. According to Bai et al. 2018, addition of compost, farmyard manure and slurry application enhanced soil organic matter (SOM) by 37%, 23% and 21%, respectively, in upper 10-cm soil cover (Spiegel et al. 2015).

Sustainable agriculture leads not only bio-ecological environment but also promotes economic and social sustainability in the form of cost to benefit ratio, mental and economic satisfaction of small farmers holders, rise in their living standard, their participation in country growth, etc. The cost of production of organic ragi and maize per acre was reported Rs. 24,817 and Rs. 30,299 versus conventional farming, which is Rs. 17,128 and Rs. 21,655, respectively, as reported by Kumar et al. (2017). It also indicates 9.2% reduced crop productivity with 22% net profit to farmers due to 20–40% available premium price for certified organic produce and 11.7% cost cultivation reduction.

2.3 Status of Degraded Agricultural Land in India

The modern lifestyle of human beings is the foremost basis of deforestation, degraded agricultural land worldwide using overloaded fertilizer application, short irrigation practice, use of harmful chemicals as fertilizer and pesticides, industrialization without using proper norms. Approximately, 40% of the world's agricultural soil is critically degraded and 24% area of productive soil requires attention (Rashid et al. 2016; Bai et al. 2018). On the basis of the report of ISRO 2016, in India, 29.3% of the total land was degraded till 2011–2013 with an increment of 0.57% (1.87 million hectare) compared to 2003–2005. TERI estimated the loss of 2.54% of India's GDP (US$ 46.9 billion) in 2014–2015. Therefore, serious attention is required to overcome the degraded agricultural land in India not only for sustainable agriculture but rather to sustain ecological and economic systems.

2.4 Challenges of Land Degradation in Productivity

Due to reduced reforming agricultural land, direct effect on productivity, food insecurity, economic depletion and land degradation remains an important subject of the twenty-first century. Actually, there are so many imperceptible aspects, which may lead to retention of degraded land ratio and need some attention.

According to the UN Department of Economic and Social affairs, "In roughly seven years, or around 2024, the population of India is expected to surpass that of China (United Nations [UN] et al. 2017)." This uncontrolled population and continuously increasing pressure on food demand leads to the use of high amount of chemical fertilizers, change in soil health status and loss of actual potential of soil.

Global warming is also an effective constraint of land degradation productivity mainly in tropical regions as it accelerates the rate of evaporation and indirectly promotes desertification (Karmakar et al. 2016). Availability of water resources is also based on climate change. High latitude contains 10–40%, while mid-latitude or dry tropics comprises 10–30% river runoff. On the other hand, the decomposition rate of soil organic matter is also high in high temperature and lost as carbon dioxide in the atmosphere as greenhouse gases (Kumar and Das 2014; Zhu et al. 2019). The amount of rainfall is also positively correlated with nutrient leaching and land acidification. Therefore, degraded land indirectly takes part in climate change in place of food productivity (International Union for Conservation of Nature [IUCN] 2017).

Above and beyond these reasons, loss of productivity is also affected by overuse and rough use of land, inequality of land capacity and application technology, adoption of mechanized and intensive agriculture (Eriksson et al. 1974; Eswaran et al. 2001), soil erosion (Dregne and Chou 1992), etc. Due to its distinguished effect on food productivity and its security, the degraded land issue is a global concern and demands global attention via some projects and policies for the conservation of soil resources.

2.5 Types of Land Degradation

Nkonya et al. (2016) state that 30% land of the world with about 3 billion population accounts for 300 billion USD annual global cost of land degradation. Sub-Saharan Africa (SSA) accounts for the largest share (22%) of the total global cost of land degradation. In the case of India, with only 2.4% of the world land area, it holds up to 18% of human and 15% of livestock population. However, the declining rate in the size of land holdings in agriculture from 2.30 to 1.16 ha during 1970–2010 was noticed. Therefore, to take any action or to make any policy against these issues, a detailed knowledge of land degradation type is very important (Fig. 2.1).

The world celebrates every fifth December as world soil day and the theme of 2018 was "Stop soil pollution." A Global Symposium on Soil Erosion 2019 with theme "Stop soil erosion save our future" was also organized by the UN Food and Agriculture Organization, Rome. So these are some events that were organized every year to make aware people of soil erosion, but over the last decade 20–30 Gt $yr.^{-1}$ and 5 Gt $yr.^{-1}$ loss of soil by water and wind erosion is estimated (FAO and ITPS 2015). The same data for India are 36.10 and 18.23 mha land in 2011–2013 (Indian Space Research Organization [ISRO] 2016), respectively.

Atmospheric depositions of heavy metals, excessive use of nutrient and pesticide applications in agriculture, and flood events are some influential anthropogenic activities responsible for land degradation. Asia is an important supplier of heavy metals such as cadmium (Cd), mercury (Hg), arsenic (As), etc. in which Cd is most hazardous due to its high mobility in the food chain to affect human health. According to the report of Huang (2011), about 12 million tons of grains were contaminated by heavy metals annually causing economic loss of 20 billion RMB (3.3 billion US Dollars). In India, approx 29.33 Mha land is represented by vegetative degradation (Indian Space Research Organization [ISRO] 2016), which is concerned with the above anthropogenic activities. Thus, various types of land degradation affect our land simultaneously, which need quick and serious attention.

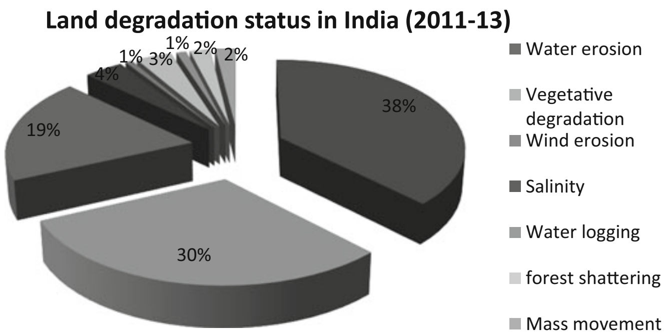

Fig. 2.1 Types and status of organic farming in India

2.6 Need and General Process of Reforming Land

According to FAO terminology, the total agricultural area has been estimated to be 4.889 billion hectares consisting of arable land (28%), permanent crops (3%) and meadows and pastures (69%) (Rangel et al. 2019). Over the last century, the rate of degradation is continuously lagging behind the rate of land-reforming process. Soil erosion process in exhaustive arable of grazing land is found to be 100–1000 times higher than natural soil erosion rate. Due to this, loss of fertile soil affects the soil productivity and is a burden to farmers for fertilizer applications. Water erosion promotes the annual loss of 23–42 Mt. (megaton) N and 14.6–26.4 Mt. P from agricultural land, which requires annual fertilizer application rates of 112 Tg for N and 18 Tg of P; this demand may have a change in significant economic cost (FAO and ITPS 2015). On the other hand, the need of an increase in agricultural production by about 70% from 2005–2050 to feed the population of 7.3 billion to 9.5 billion from 2015 to 2050 (Lal 2015), to maintain the sustainability of soil productivity as well as soil health, is putting an unavoidable pressure on human body and the remaining productive land to innovate strategies in the direction of land reforming.

The land reformation process is not affected in one day or one year; it takes years and years. It needs attention on all the levels of agriculture, such as maintenance of soil structure, microbial biodiversity, level of soil organic carbon, balanced availability of nutrients with their cycles, positive effect of pesticides on soil quality, etc. These are some blank spaces, which are required to be filled to compile the process of land-reforming system (Fig. 2.2).

The phenomenon of coalescing should be avoided by keeping the soil's moisture level high, which maintains the soil structure and increases the porosity of the soil.

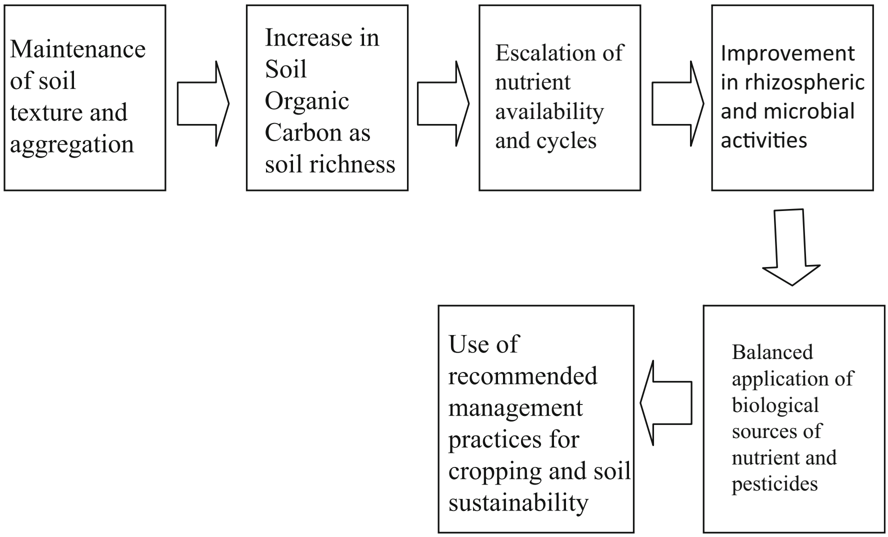

Fig. 2.2 Lining framework of soil degradation form soil to ecosystem

Therefore, proper irrigation technology should be taken into priority. Incorporation of high-quality organic matter in soil requires increasing soil porosity, soil biological activities, microbial diversity, etc. Organic supplements or vermin compost, farmyard manures can be used here to enrich soil organic carbon, close nutrient cycles, and slow release of fertilizers for full-time availability of nutrients in the soil. The rate of mineralization also determines the availability of nutrients to plants (Bi et al. 2010). Therefore, the process of reclamation mainly depends upon the used recommended management practice for farming besides other factors. It also depends upon the type of soil and its specific recommended practice.

2.7 Role of Organic Supplements in Soil Restoration

The use of organic supplements in organic farming is not a recent technique to exploit; it had its scope from a very ancient time when agriculture had started and no compost or any type of fertilizer were in use – only cow dung was in use. That's why it doesn't lose its capacity to maintain the fertility level/health of the soil. Organic supplements are usually the derivative of animals and plant residues (Gaskell and Smith 2007; Bi et al. 2010) such as poultry manure, farmyard manure, vermi compost, hair and wool waste, cow dung with rice, wheat straw, sorghum stalks, pigeon pea, chickpea, sugarcane trash, etc.

On the basis of the quantity of nutrients available to the crops, manures are categorized into two parts: bulky organic manure and concentrated organic nutrients. As its name indicates, bulky organic manure has less quantity of nutrients, so a large quantity is needed to apply. However, they increase the nutrient availability of soil, recover the structural factors of soil, increase carbon content in soil, and maintain the balance of microbial quantity in soil. Farmyard manure, compost, and green manure are its best examples. In comparison to bulky, concentrated organic manure has a high quantity of nutrients, is rich in nitrogen fertilizers, and converted into ammonium nitrogen and nitrate nitrogen through mineralization. Oil cakes, fish manure, blood meals are some of the best types of concentrate organic manure (Reddy 2005). Organic manures are not immediately available to the soil, but they retain always in some amount. They release slowly as its requirement through mineralization by microbes; thus, its surplus requirement is not needed. Organic manure also maintains microbial diversity. Thus, they led to developing a nutrient and microbial-rich, structurally maintained, pollution-free soil covered land as the high demand for land reclamation.

2.8 Status of Organic Supplements in India

The nature of the soil is a key factor of sustainable agriculture (Tscharntke et al. 2012; Paustian et al. 2016). The role of organic supplements totally depends upon its high organic matter development in soil, minimizing food chain–associated health hazards and attaining closed nutrient cycles.

India has a large potential to produce various organic supplements due to its different agro-climatic regions, agriculture, and livestock-based economy. In livestock population, India achieved a remarkable position in the world with the largest cattle population in 2018 (63%) followed by Brazil & China (Livestock census 2012). On the other hand, it is estimated that about 300 million tons per annum of municipal solid waste will be generated by 1823 million urban populations until 2051. It contains 40–60% compostable waste having approximately 0.64% Nitrogen, 0.67% Phosphorus, 0.68% Potassium and 26% C/N ratio. The largest vermincompost plant was founded in Bengaluru (100 million tons per day capacity), besides Hyderabad, Mumbai and Faridabad (Joshi and Ahmad 2016).

Livestock itself is a major source of farmyard manure, cow dung, poultry manure, meat meal, bone meal, etc. (Table 2.1), which has a significant fertility-promoting supplement on sterile soil. In addition, its trampling process and removal and addition of nutrients through grazing and dung with the urine process are very important to maintain the soil health (Qu et al. 2016).

Municipal solid waste is also a rich source of various types of compost. Thus, the fast-booming population of humans and livestock can also play a positive role in the direction of land reformation indirectly, besides its hazardous effects on reducing the natural resources process. Besides animal refuse, plant refuse also indicates its rich availability for land reformation process as 60% of India's population relies upon agriculture for its livelihood.

Thus, India has a strong potential for the availability of organic supplements not only in the farming sector but also in the land reformation sector. However, it needs some steps and policies and its proper implementation through the Indian government.

2.9 Subsidies and Support of Indian Economy to Encourage Organic Farmers

As of 31st March 2018, the total area under organic certification process (registered under National Programme for Organic Production) is 3.56 million Hectare (2017–2018). This includes 1.78 million ha (50%) cultivable area and another 1.78 million Hectare (50%) for wild harvest collection (Sruthy and Vibini 2019). Among all the states, Madhya Pradesh has covered the largest area under organic certification followed by Rajasthan, Maharashtra, and Uttar Pradesh. During 2016, Sikkim had achieved a remarkable distinction of converting its entire cultivable land (more than 76,000 ha) under organic certification.

In the 14th Conference of Parties (COP-14) to the United Nations Convention to Combat Desertification (UNCCD), organized in Greater Noida, Prime Minister had launched a central scheme of Rs. 13,500 crore to control the livestock diseases, especially foot and mouth disease (FMD) and brucellosis, from the Mathura district in Uttar Pradesh. To improve soil health and fertility, soil status such as nutrients value should be known. For this purpose, Soil Health Card has been issued, which provides the nutrient status of their soil along with recommendations on

Table 2.1 Average nutrient composition of NPK in various organic supplements

Organic Supplements	Nutrient concentrations, %		
Plant refuse			
	N	P_2O_5	K_2O
Rice straw	0.58	0.23	1.66
Wheat straw	0.49	0.25	1.28
Sorghum stalks	0.40	0.23	2.17
Pearl millet stalks	0.65	0.75	2.50
Maize stalks	0.59	0.31	1.31
Average pulses	1.60	0.15	2.00
Pigeon pea	1.10	0.58	1.28
Chick pea	1.19		1.25
Sugar cane trash	0.35	0.04	0.50
Edible/nonedible oil seed			
Ground nut	7.29	1.65	1.33
Mustard	4.52	1.78	1.40
Rapeseed	5.21	1.84	1.19
Linseed	5.56	1.44	1.28
Sesame	6.22	2.09	1.26
Cotton seed (decorticated)	6.41	2.89	1.72
Cotton seed (undecorticated)	3.99	1.89	1.62
Neem (Azadirachta indica)	5.22	1.08	1.48
Castor	4.37	1.85	1.39
Mahua (Madhuca indica)	3.11	0.89	1.85
Kusum (Schleichera oleosa)	5.23	2.56	1.37
Animal refuse			
Cattle dung	0.3	0.10	0.15
Sheep/goat dung	0.65	0.5	0.03
Human excreta	1.2–1.5	0.8	0.5
Hair and wool waste	12.3	0.1	0.2
Farmyard manure	0.5	0.15	0.5
Poultry manure	2.87	2.90	2.35
Town urban compost	1.5	1.0	1.5
Rural compost	0.5	0.2	0.5
Vermicompost	0.6	1.5	0.4
Meat meal	10.5	2.5	0.5
Bonemeal (raw)	3–4	20–25	–
Bonemeal (steamed)	2–5	26–28	–
Fishmeal	4–10	3–9	1.8

the appropriate dosage of nutrients to be applied for improving soil health and its fertility. To promote sustainable agriculture, through climate change adaptation measures, enhancing agriculture productivity, especially in rainfed areas focusing on integrated farming, soil health management, and synergizing resource conservation, National Mission for Sustainable Agriculture was launched under National

Action Plan for Climate Change (NAPCC). To focus on the irrigation systems in agriculture, micro-irrigation was promoted under Pradhanmantri Krishi Sinchai Yojana from July 2015 implemented by the Ministry of Water Resources and Department of Land resources. For this purpose, micro-irrigation fund (MIF) created with NABARD (National Bank for Agriculture and Rural Development) has been approved with an initial corpus of Rs. 5000 crores (Rs. 2000 crores for 2018–2019 & Rs. 3000 crores for 2019–2020) for encouraging public and private investments in Microirrigation. In the field of organic farming, to improve soil health and organic matter content and increase the net income of the farmer so as to realize premium prices, an area of 5 lakh acre is targeted to be covered through 10,000 clusters of 50 acres each, from the year 2015–2016 to 2017–2018 (The Economic Times 2019).

To bring in transparency and competition to enable farmers to get improved remuneration for their produce moving toward ‘One Nation One Market’, National Agriculture Market (e-NAM) program was launched, which provides an e-marketing platform at the national level and support creation of infrastructure to enable e-marketing. To tackle aberrant monsoon situations leading to drought and floods, extreme events (heat waves, cold waves, frost, hailstorms, cyclone) adversely affecting crops, livestock and fisheries (including horticulture), Central Research Institute for Dryland Agriculture (CRIDA) and Indian Council of Agriculture Research (ICAR) have prepared a district-level agriculture contingency plan in collaboration with state agricultural universities using a standard template. For the development of rainfed-area farmers, Rainfed Area Development Programme (RADP) and National Watershed Development Project for Rainfed Areas (NWDPRA) have launched under Rashtriya Krishi Vikas Yojna.

To protect our harvested crop before marketing, Pradhan Mantri Fasal Bima Yojana (PMFBY) is started, which is an actuarial premium-based scheme under which farmers have to pay the maximum premium of 2% for Kharif, 1.5% for Rabi food & oilseed crops and 5% for annual commercial/horticultural crops and the remaining part of the actuarial/bidded premium is shared equally by the Centre and State Government. To protect the Livestock from diseases, The livestock insurance scheme was started to provide a protection mechanisms to the farmers and cattle rearers against any eventual loss of animals due to death. Therefore, there are so many schemes and insurances, which benefit the Indian farmers if they implement properly.

2.10 Recommendations/Suggestions and Follow-Up

In India, soil/land degradation has reached roots in great depth and created a very critical image in both rainfed and irrigated areas of India. It creates very dangerous conditions because it is attached to major issues such as economic losses, food security, degraded soil health, insufficient food production, etc. In the case of India, it becomes more significant as it supports 18% of the world’s human population, 15% of the world’s livestock population with only 2.4% of global land area in which 29% of land is degraded.

The land reformation process is not only possible with a single effort but also requires a mixed action of government policies, farmers' hard work, and support of local communities. All the policies announced by the government should be consumed until the lowest level of farmers, their importance should be in their knowledge, and workshops and conferences, play, and discussions should be organized at the panchayat/village level to create awareness in each category of people about its importance. Besides all these efforts, some major steps can be started:

- Focus on proper irrigation technology, promotion of afforesting process, to maintain the soil moisture, to maintain the vegetative cover as well as prevent soil, water, and other land degradation.
- If land becomes adequately moist, land should be prepared and allowed for grazing, which promotes the nutrient cycle efficiently.
- Recommended management practices should be used to prepare the land for farming using the organic supplement, no-tillage practice but after properly investigating the basic need of that particular land.
- Government organized seed banks should use to start farming because, initially the main focus should be on land regeneration, not food production.
- When the land physico chemical and biological properties can be maintained, the land takes under proper farming.

These steps are not possible without the financial support of the government and their implementation schemes and local bodies. Some NGOs should also come in front of this demanding issue. Organic farming is the earliest government-authorized and government-supported farming technology. The higher profitability of organic farming was due to minor labour requirement and to a greater market appreciation for organic products that granted a premium price respect to conventional prices (Sgroi et al. 2015; Akshu and Hooda 2017). The demand for Indian organic food products is on the constant increase worldwide as India exported organic products worth $ 515 million in the financial year 2017–2018, from $ 370 million in 2016–2017, by officials from Agricultural and Processed Food Products Export Development Authority (APEDA). Registering an increase of 39%, the total volume of export during 2017–18 was 4.58 lakh tones, they added. So this established agriculture technology plays a vital role not only in improving and maintaining the soil fertility stability, sustainable agriculture, food demand, and security but also in increasing the value of organic export, certified organic farms, use of livestock population, the human population as workers and reforming land as well as the country economy.

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Chapter

Humic Substances: Its Toxicology, Chemistry and Biology Associated with Soil, Plants and Environment

Rajneesh Kumar Gautam, Dimuth Navaratna, Shobha Muthukumaran, Amarendra Singh, Islamuddin and Nandkishor More

Abstract

In recent decades, scientists in different disciplines have been increasingly concerned about the fate of natural organic matter, and in particular of humic substances (HS). The term humic substances (HS) incorporates refractory autochthonous and terrestrial organic matter in the soil and aquatic ecosystem, and are one of the key fractions of natural organic matter. These substances are important chelators of trace elements constituting complex class of molecular structures that occur naturally, consisting of aggregation and assembly processes in which biomolecules derived from plant and animal residues are gradually transformed through biotic and abiotic tracts. Since these organic compounds are bound by or linked with soil mineral fractions, they must be physically or chemically separated from the inorganic components by an extraction method before their physico-chemical study. This chapter focuses on the chemo-toxicological, molecular aspects of humic compounds and their derivatives such as humins, fulvic acids, humic acids etc., with their agricultural, biomedical, environmental and biochemical applications. In addition to studying their impact on plant physiology and soil microstructure to expand our understanding about humic compounds.

Keywords: humic compounds, Humins, fulvic acids, humic acids

1. Introduction

Humic substances are a structurally specified fraction of soil organic matter that are thought to be an important component of the biosphere, as they are responsible for many physical and chemical processes in soil. Organic carbon accounts for approximately 62 percent of global soil carbon, with at least half of this carbon classified as the chemically resistant portion known as humic substances (HS) [1–3]. Plant and microbial biomass are the primary sources of organic matter production in soil, and their composition and properties are important major constraints for humification processes. When looking at the structural aspects of HS, we must understand the contributions of the different compound groups that make up those tissues. These compound types include intracellular (i.e. protein) and structural (for example, polysaccharides, lignin and aliphatic) compounds that shape membranes and cell walls, including membrane lipids and plant cuticles [4]. Due to their intimate relationships with soil mineral phases, they cannot be easily decomposed and are chemically complex to be used by microbes. One of the most notable properties of HS in soil is their ability to interact with metal ions, oxides, hydroxides, mineral and organic compounds [5], including toxic contaminants [3], to form water-soluble and water-insoluble complexes [4, 5].

Humic substances (HS) are important elements of natural organic matter (NOM) in soil, water, as well as geological organic substances including shales, brown coals, peat and lake sediments. They contribute to the brown or black color of surface soils and make up much of the characteristic brown color of rotting plant waste. They are major components of NOM in surface waters and can impart a dark color at higher concentrations, especially in brown fresh water ponds, lakes, and streams. The color of composts due to leaf-litter can range from yellowish-brown to black, depending on the degree of decay and concentration. It is well understood that HS are the most significant source of transient refractory organic carbon in the earth's crust. Conventionally, the mixtures are processed into humic acids (HA), fulvic acids (FA), and humin (Hu). HA is recognized as the fraction precipitated from an aqueous solution at pH < 2 (under acidic conditions), FA residues in solution after HA precipitation, and the Hu fraction is insoluble in aqueous solvents [6] .

2. Nature and origin of humic substances

Humic substances are soil complexes produced during humification phase, are responsible for fossil coal, oil deposits, and other geological deposits. It is the Earth's second most important organic phase, after photosynthesis. It is estimated that photosynthesis binds more than 5000 tons of atmospheric carbon per year, while the transformation of dead living organisms results in the creation of approximately 4000 tons of carbon [7], which is deposited annually on the Earth's surface. Humic substances are naturally occurring organic material that are formed due to biochemical, chemical, and physical changes in dead plants, microbial residues, and fauna debris. Humic material formation is linked to the behavior of microorganisms, resulting in the accumulation of recalcitrant macromolecular compounds with unique properties [7]. Due to death of microbes a recalcitrant humic mass is created due to their assimilation. These progressive decay leads to biotic and abiotic transformation processes which ultimately produces diverse and heterogeneous mixtures of polydisperse materials, which are a major component of natural soil organic matter. Humic material can take hundreds or thousands of years for their formation, resulting in a wide range of humic substances. Humic substances are extremely heterogeneous in composition, structure, and are derived from a variety of organic matter sources. This sets them apart from naturally occurring biomolecules such as proteins, carbohydrates, lipids, and others.

Humic substances happens to be the most common of the various organic substances found in nature. They account for approximately 25% of total organic carbon on Earth and can also be found in a variety of ecosystems such as lakes, rivers, sea sediments, soil, and coal composites. Humic substances influence the chemistry, cycling, and bioavailability of chemical elements in terrestrial and aquatic environments, as well as the distribution and degradation of xenobiotic and organic chemicals of natural origin [7]. For decades, scientists have discussed the formation mechanisms of HS [8, 9]. The lack of repeated sequences, as well as the variety of chemical and biological reactions involved in their formation, render HS very complex and multifaceted molecules capable of important signaling and nutritional functions in the soil–plant system. The polymeric origin of HS has a high molecular mass (100–300 kDa) [10], derived from lignin decomposition and abiotic catalysts such as primary minerals and layer silicates. Humic compounds are classified into three categories: (1) Humin, (2) Humic Acids (HAs), and (3) Fulvic Acids (FAs) [11]. **Figure 1** summarizes several of the major chemical characteristics of humic compounds.

Figure 2, illustrates the hypothetical model structure of fulvic acid (Buffle's model) [13], which contains aromatic and aliphatic structures, both extensively substituted with oxygen containing functional groups [15, 16].

2.1 Humus

Humus is generally brownish or black colored complex variable of carbon-containing compounds that does not show cellular organization in the form of animal bodies or plant under a light microscope. Humus is distinguished from non-humic substances such as carbohydrates (a primary component of carbon), fats, waxes, alkanes, peptides, amino acids, proteins, lipids, and organic acids by the fact that distinct chemical formulae for these non-humic substances can be published. The majority of small molecules of non-humic compounds are easily destroyed by soil microbes. Soil humus, on the other hand, decay slowly under natural soil conditions. When combined with soil minerals, soil humus can survive in the soil for centuries. Humus is the primary component of soil organic matter, accounting for 65 to 75 percent of the total. Humus plays an important role as a fertility factor in all soils, far outweighing its percentage contribution to total soil mass.

2.2 Humins

Humins are derived from humic compounds that are not soluble in alkali, not soluble in acids, and are insoluble at neutral pH ranges. However, the physical and

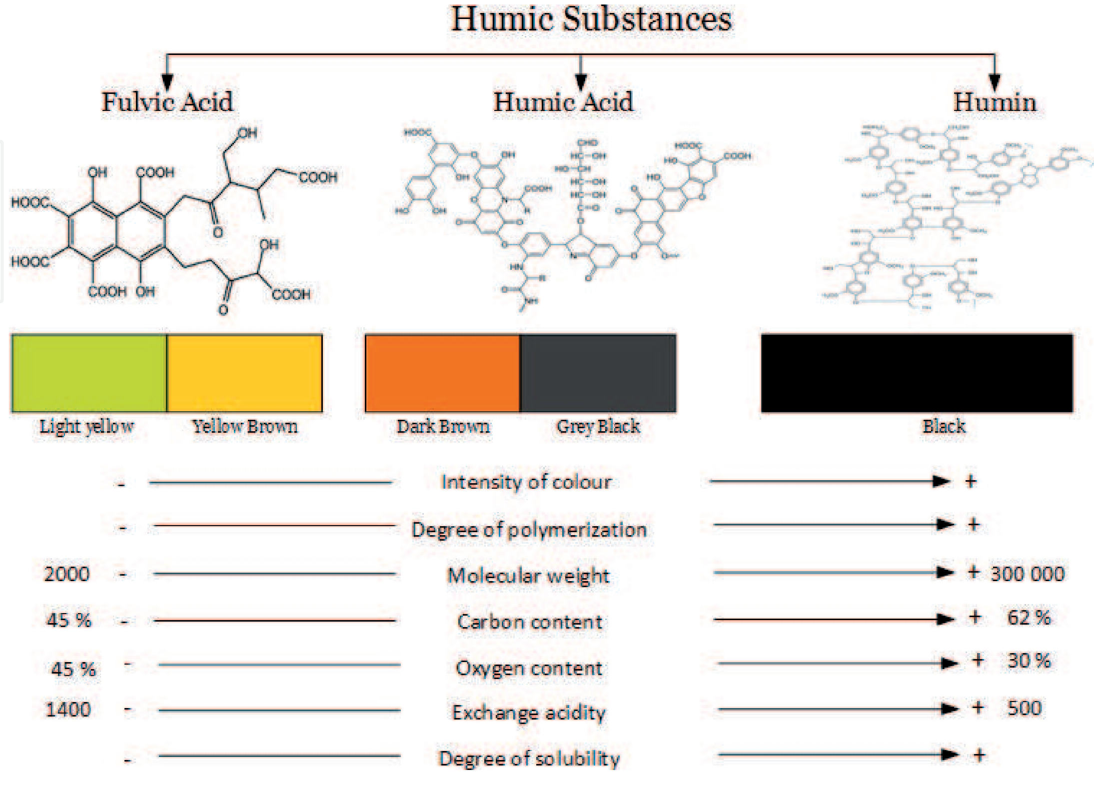

Figure 1.
Chemical characteristics of humic compounds (modified and adapted from [12–14]).

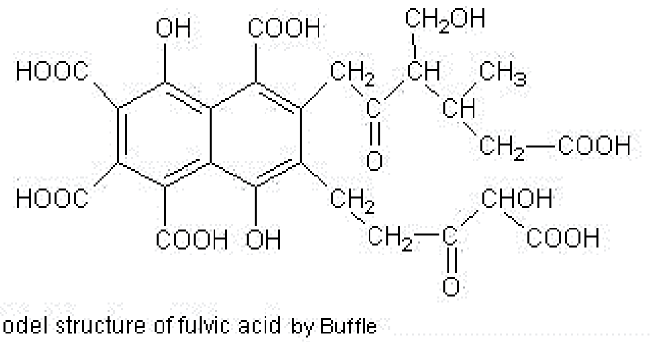

Figure 2.
Model structure of fulvic acid [13].

chemical properties of humins are partly known. Humin complexes are also recognized as macro organic substances due to their large molecular weights (MW) ranging from $1\,x\,10^5$ to $1\,x\,10^7$. Conversely, the molecular weights of carbohydrates range between $5\,x\,10^2$ and $1\,x\,10^5$ [17]. The humins are highly resistant to decomposition of all humic substances found in soil. Humins are known for enhancing the soil's water holding capacity, improving the soil fertility, taming soil structure, retaining soil stability, and acting as a cation exchanger.

2.3 Humic acids

Humic acids (HA) are organic acids that are a combination of weak aliphatic (carbon chains) and aromatic (carbon rings) organic acids that are insoluble in acidic water but soluble in alkaline water [18]. Humic acids are composed of humic compounds that precipitate from aqueous medium when the pH drops below 2. Due to their variable chemical composition, humic acids (HA) are also known as polydisperse. These complicated carbon-containing compounds are assumed to be 3-dimensionally flexible linear polymers that reside in the form of random coils with cross-linked bonds. On average, 35 percent of humic acid (HA) molecules are aromatic (carbon rings), with the remaining components being aliphatic (carbon chains) [17]. Humic acids (HAs) have molecular sizes ranging from $1\,x\,10^4$ to $1\,x\,10^5$. Clay minerals readily bind to humic acid (HA) polymers, forming stable organic clay complexes. Natural and synthetic-organic chemicals can be accommodated in the polymer's peripheral pores in a lattice (clathrate) arrangement. Humic acids (HAs) readily combine with trace inorganic mineral elements to form salts. It is reported in the literature that there exists more than 60 distinct mineral elements in naturally occurring humic acids (HAs). These trace elements are bound to humic acid molecules in a form that is easily assimilated by a variety of living organisms. As a result, humic acids (HAs) play an important role in ion exchange and metal complexing (chelating) [19].

2.4 Fulvic acids

The proportion of humic substances that are soluble in water at all pH levels. They are known as fulvic acids because they remain in solution after humic acid has been removed by acidification (FA). Fulvic acids range in color from light yellow to yellow-brown. The elemental composition of various FA and HA reveals that C, H, O, N, and S are the main elements in their composition. These major elements are always present, regardless of their birth, country of origin, or continent of origin. An examination of a broad range of HS reveals that the percentage composition of C, O, H, and N varies as follows: C (45–60),

Substances	% Dry ash-free basis			
	C	H	N	O
Lignin	62–69	5.0–6.5	—	26–33
Proteins	50–55	6.5–7.3	15.0–19.0	19–24
Humic acids	52–62	3.0–5.5	3.5–5.0	30–33
Fulvic acids	44–49	3.5–5.0	2.0–4.0	44–49

Table 1.
Composition of several plant material and humic substances (by Kononova) [16, 21].

O (25–45), H (4–7), N (10–13) and inorganic elements (ash) 0.5–5 **Table 1** [20]. summaries the composition of humic substances.

3. Preparation of fulvic and humic acids: a toxicological evaluation

The general properties for HA, and FA relate to their basic constituents (carbon, hydrogen, nitrogen and sulfur) and their oxygen-containing functional groups (hydroxyl, carboxyl, carbone and phenolic) which give rise to their overall chemical properties, including their ability to react with ionic particles in solution. Because of their properties, HAs and FAs have been used in a variety of agricultural applications, including improving nutrient and water use, soil quality, and carbon sequestration [11]. Although a variety of mechanisms have been proposed and/or studied for the effects on humic substances on plant life, much can be learned from the imperfect understanding of these mechanisms. One such process is ion exchange, which allows the use of plant minerals by prevention of the development of insoluble mineral complexes in the soil and then enhances humic substances in exchange for hydrogen and carbonic acid, which can produce absorbable mineral ions for plant roots. In sequestration of radioactive metals in soil, the ion-exchange process also works [22]. As humic substances play a role in maintaining plant life and their ability to attach or sequester potentially harmful environmental toxicants, they can also easily be extrapolated such that they can improve human nutrition and provide some protection from unintended ingestion of dietary toxic elements.

Two active New Dietary Ingredient Notices (NDIN) for use in a dietary supplement containing additional minerals to improve the status of minerals and trace elements were subjected to a specific preparation of HA and FA derived from Hungarian peat [20]. The NDIN has recorded 9 unpublished and one published clinical evaluations in which mineral status in humans has been improved and/or absorption is inhibited and toxic element excreted [23]. However, it is not clear if these effects can generally be extrapolated to humic substances due to the possible variations between this and other humic preparations as well as the inclusion of exogenous minerals. The use of clinical or mechanical research on other humic preparations, important for humans, is restricted and there are no other studies of the above-mentioned results, although it was shown that the addition of a humic extract to the broiler feed was intended to improve the growth of chickens. Due to the heterogeneous existence of the humic substances, an extrapolation for the whole community has not been deemed sufficient toxicological evaluation of one particular unique material, while attempts have been made for the identification of an appropriate model. As a result, a number of toxicological studies have been reported on humic materials of diverse origin even though many of them have been performed to examine the mutagenic potential of byproducts produced during water disinfection because of the normal occurrence of low levels of humic material in surface waters. Chlorination of organic non-volatile substances found in HA and FA is known to lead to the development in bacterial mutation tests of compounds (such as mucochlorine acid and 2, three, three-trichloropropenal) under conditions of decreasing pH and sufficient chlorine and HA and chlorine.

4. Plant physiology and humic substances

Various authors have assumed that even though high molecular weight (HMW) and small molecular weight fractions (LMW) appear to be behaving differently, HS may be adsorbed by the root plant [24]. The mechanisms by which HS interacts with the root cells affecting the plant physiology and growth have not been significantly researched until today. Changes in size and growth were the first to be analyzed among the modifications caused by HS on treated plants. HS will promote plant growth with a view to increasing plant length and dry and fresh weight under specific conditions. These effects are apparently dependent on the dosage and source of the drug, the plant species and age and the conditions of the trial cultivation [25]. Many studies have recently confirmed the assumption that HS has direct effect on plant physiology, especially in regard to the development of root hair and side root [26, 27]. The impact of HS has been thoroughly evaluated on metabolic processes in plants. For example, several studies have shown that HS affects breathing, protein synthesis and the function of the enzyme in higher plants [28, 29]. With regard to the photosynthesis process, few reports are available which focus on the contents of chlorophyll and transport of electrons.

4.1 Humic substances and abiotic stress regulation in plants

The productivity of crop plants will benefit significantly from regulation that mitigates the impact of abiotic stress on the growth and production of crops during ontogenesis. There are insufficient information currently available on control mechanisms and techniques. Optimizing plant growth conditions and providing regulators for water, nutrients and plant growth will help in avoiding abiotic pressure [30]. Bio-stimulants such as HS are also used in production systems with the aim to regulate physiological events in plants in order to improve productivity as well as these traditional strategies.

In the last two decades, scientists have increasingly utilized HS from natural materials [31]. In addition, HS provides new methods to alter physiological activity in plants to increase plant growth and abiotic stress tolerance. A number of examples show the ability of HS to improve plant abiotic stress tolerance. Treatment with hydrated leaves, anti-oxidants, radical growth and shooting under dry conditions, increased hydration of the leaves (*Agrostis palustris*) and increased fescue (*Festuca arundinacea*) [32]. Recent studies have shown that the blocking of cell wall pores by fouling has been responsible for the effects induced by HS that could be related to temporary mild water stress (a beneficial stress, 'eustress') and the downstream effects of HS on hormonal signals and plant growth [33].

4.2 Humic substances and improved mineral nutrition in plants

HS in the soil promotes root and spring growth through the improvement of mineral nutrition below the soil surface. In terms of plant production and active development, the function of these substances can be assessed [34], by their complementary and possibly diverse effects. HS regulates plant growth and mineral assimilation. In general, these effects are classified as direct and indirect.

HS activities rely mainly on the structural features, functional groups and their inclination to associate with inorganic, organic and soil substratum molecules [35]. Furthermore, HS primarily affects the bioavailability of nutrients through its ability to form complexes containing metallic ions, thus enhancing micronutrient availability (zinc, manganese, copper and iron). On the other hand, HS targets plant cell membranes that can cause biochemical and molecular processes at post-transcriptional levels in the roots and shoot [32]. Targeted HS typically increase macronutrient and micronutrient consumption in plants.

Jackson [36], used ^{14}C HS-listed substances, and found a small portion of them entering the root apoplastic pathway, especially those of low molecular weight. Therefore, the effect of HS to promote molecular systems and signal pathways of nutrient absorption present in cell membranes can be controlled. The full advantage of this direct influence is still unknown. Non-specific HS activity on the leaf and root can, however, be speculated on by controlling events at both the transcriptional and post-transcriptive stages, to modify molecular and biochemical processes.

5. Bimolecular fragments in soil humic substances

Humic soil fractions comprise bio-molecular fragments that were explicitly omitted from conventional humic concepts. Many of these bio-molecular movements are closely linked to the humic fraction by seven covalently and cannot be effectively isolated [37]. Why should a whole group of constituent molecules be excluded? Simply because it can be classified as biomolecules if we consider humic material as a super-molecular association of constituent molecules. It is inappropriate and deceptive for these nuanced, heterogeneous mixes to purge humic fractions of closely related, identifiable bimolecular components [38]. A description that is applicable to experimental studies of the humic component should include all molecules which are closely linked within a humic fraction, i.e. those which cannot be eliminated without substantial changes in the chemical characteristics of the fraction. That will necessarily include biomolecules that are identifiable and play important structural roles. Will this wider concept of humic molecules be contrary to the recognized refractory nature?

Soil humic compounds are typically aged between hundreds and thousands of years on average and many biomolecules easily decomposed by energy-seeking microbes and nutrients. However, it can lead to biomolecules being protected against microbial degradation by binding them with humic fractions, creating identifiable but refractory biological molecules [39], is alternatively a “two-part” view of the stability of humic substances. Although the majority of humic material is permanent, some humic elements may be transient. The persistent material contributes to ^{14}C, while the transitional components will contribute mainly to the C turnover rate. A significant portion of the transient, often refilled humic components may be made up of closely related, but easily degraded biomolecules. While most humic materials are permanent, some humic elements may be temporary. The continuous material contributes to ^{14}C, while the intermediate components are primarily responsible for the C turnover rate [40]. A large part of the frequently refilled transient humic components can consist of closely related, but easily degraded biomolecules.

6. Application of humic substances

Humus is one of the largest reserves of carbon in the world. To date, industrial uses of humus and goods extracted from humus have been rare. In the second half of the 19th century and the first half of the 20th century the use of coal was more abundant and, in addition, it was a foundation of chemical production. The application Petroleum was also considered the key raw material of 20th-century chemical industry. HS applications can now be broken down into four major categories: agricultural, industrial, environmental and biomedical.

6.1 Agriculture applications

From an agronomic and agricultural point of view, HS plays a significant role as they have a huge impact on soil quality and productivity. HS also shows a high Base Exchange potential, which is essential to soil fertility, in addition to enhancing the soil's physical properties and humidity. Many researchers and humates have observed the growth-promoting effect of humic substances in various preparations for plant growth improvement. Soil productivity in the presence of humic materials can be improved by various methods. However, in some case the consistency and fertility of the soil is greatly affected. In addition to the improvement of physical properties and moisture of the soil, HS shows a high Base Exchange potential, which is important for soil fertility. In various preparations for plant growth enhancement, several investigators have studied the growth-promoting effects of humic substances.

6.2 Environmental applications

Natural organic colloids are important because they form water solutions with a large number of metals, including radionuclides. It is well known that the humic substances affects the absorption of natural solids into the surface and ground waters of radionuclides. Thus, these organics may be essential as a transport agents in the environment for radionuclides. In environmental chemistry, the key role of humic substances is to extract radioactive metals, organic chemical substances of anthropogenic nature and other contaminants from water [18]. Calcium humate ion exchange products were considered suitable for the extract from the water and removal of radioactive elements from water discharges from nuclear power plants for heavy metals such as iron, nickel, mercury and cadmium and copper [11]. They also use their selective bonds to destroy ammunition and chemical warfare agents [41]. For the last 30 years, interactions between humic and micro-organic materials has been widely studied and researched. Fermenting bacteria have been found capable of reducing humic materials. Many investigators have been studying the use of humics as energy source for various bacteria, fungi and higher microorganisms, but they have not exploited them. Many researchers including [42, 43], investigated the use of humic as an energy source for specific bacteria, mushrooms and higher micro-organisms but pointed out that humic materials cannot be exploited as a source of food.

6.3 Biomedical applications

Veterinary and human medicine uses humic substances manufactured on a commercial scale. Various studies have been published on the medicinal properties of humic materials. The proliferation of gastric damage caused by ethanol was greatly reduced by humic acids administered prophylactically to rats [44]. TPP given to rats with gastric and duodenal ulcers improved the healing process considerably [44]. The interest in the use of humic materials in medicine and biology has developed in the past few decades. There is an investigation into the possibility that soil humus extract could be an applicant for cosmetic and pharmaceutical products with amino acid complexes and vitamin B analogues [11]. Anti-virals, profibrinolytic, anti-inflammatory and estrogenic activities are the primary explanation for the increased attention given to humic acids [45].

6.4 Chelate balneotherapy capacity of humic substances

In many mammalian cells, humic acid was, on the other hand, shown to be a toxic factor, although its precise cytotoxicity mechanism remains uncertain. Humic acid can be reduced from Fe (III) to Fe (II) under the wide range of pH values in aqueous conditions (4.0 to 9.0) and iron from ferritin reduction and release, but the process is partially inhibited by superoxide scavengers. It was shown that iron released from ferritin accelerates the lipid peroxidation caused by humic acid. Humic acids are also capable of reducing, releasing and supporting lipid peroxidation from ferritin storage. HAs coupled to freed iron can therefore disrupt the redox balance of the biological system and evoke oxidative stress. This may be one of the main pathways for cytotoxicity caused by HA [46]. Now is the time for new applications for humic substances, particularly in biomedicine, in less conventional areas.

7. Conclusions

HS has been widely studied in different fields of agriculture, such as ground chemistry, fertility and plant physiology as the major component of organic soil content. HS plays an important role in the regulation of pollutants' activity and mobility in the atmosphere and makes a major contribution to improving the status of global soil fertility. Together with a strong demand for safe food and sustainable agriculture, these features have led to increasing the environmental importance of

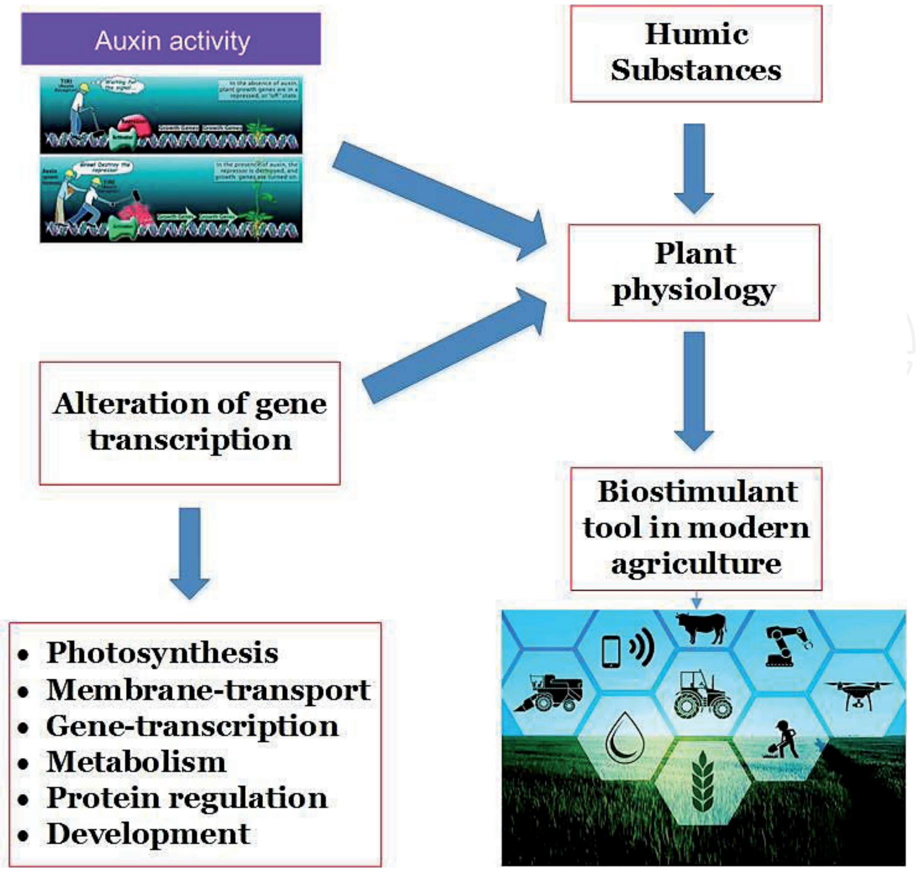

Figure 3.
Schematic representation of impact of humic substances on plant biology.

HS, recently recognized as a potential tool in facing global environmental problems. Many of its positive effects on soil structure and plant growth have been shown to depend on their chemical composition, but progress in HS research is known to be regulated by auxin. In addition, physiological and molecular evidence indicate that brassinosteroids may have a possible additional impact on the growth of plants. A critical review of literature shows that HS requires an auxin transduction pathway in order to determine its action in plant physiology but also show that the various signaling cascades in the global physiological response of plants to these substances (**Figure 3**). This could be used as a starting point for the clarification of mechanisms in the molecular response to HS in the plant. Further studies are required to evaluate the molecular goals and signaling trajectories involved in the intersection of the HS and the plant cells.

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APPENDICES

International/National Conferences, Trainings, Workshops etc. participated

1. International Scientific Conference (Pre CoP) on Our Common Future under Climate Change CFCC-2015 from 5th to 10th July 2015 at UNESCO, HQ, Paris, **France.**
2. 8 th European Conference on Ecological Modelling Beyond boundaries: Next generation modeling held from Oct 27-30, 2015 at Caddi Ayyad University, Marrakech, **Morocco.**
3. National Seminar on International Current trends in Society, Science and Technology organized by Academy of Administrative Careers, Mumbai University, Mumbai, India. held from 25th to 27th March 2016.
4. National Workshop "Recent Trends in Environmental Science and Carbon Management'' (RTCM-15) organized by School of Earth and Environmental Sciences, Central University of Himachal Pradesh, Dharamshala on November 19-20, 2015.
5. National Seminar on Rejuvenation of River Gomati: Past Present and Future organized by Babasaheb Bhimrao Ambedkar University, Lucknow on 9th- 11th May 2015.
6. National Conference on "Climate Change and Sustainable Development: Emerging Issues and Mitigation Strategies (CCSD-2015)" (www.ccsd2015.org) November 23rd-24th, 2015 organized by Babasaheb Bhimrao Ambedkar University, Lucknow.
7. 6 th International Conference on Natural Polymers (ICNP-2018) Dec 7-9, 2018, by Centre of Nanoscience and Nanotechnology, Mahatma Gandhi University, Kottayam, Kerala.
8. National Seminar on Environmental Protection: An Interdisciplinary Trend for Sustainable Development on 11 th and 12 th Jan 2019 at Padmashri Vikhe Patil College of Arts, Science and Commerce, Pravaranagar affl. Savitribai Phule Pune University, Pune (M.S.).
9. International Conference on Energy, Functional Materials and Nanotechnology & Sustainable Environment Management (ICEFN&SEM-2019) May 24-26, 2019 Nanoscience and Nanotechnology Centre Department of Chemistry Kumaun University, Nainital-263001 Uttarakhand, India

10. National Conference on Recent Intelligence in Materials and Bio Medical Sciences (RIMBMS-2019) Jan 5th -6th 2019 at K. Narkhede College, Bhusawal affl. North Maharashtra University, Jalgaon (MS).
11. National Seminar on Horticulture: A Boon for Indian Economy on 3 1st October, 2019 organized by Department of Horticulture, School of Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University, Lucknow-226025, UP, India.
12. 8 th International Library and Information Professionals Summit on Empowering Libraries with Emerging Technologies on 22 nd to 24 th November 2019 organized by Department of Library and Information Science, Babasaheb Bhimrao Ambedkar University, Lucknow-226025, UP, India.
13. 1 st International Conference on Landslide Risk Reduction and Resilience 2019, on 28 th November 2019, at Hotel the Ashok, New Delhi, organized by National Instituted of Disaster Management, New Delhi
14. Academy of Environmental Biology Annual Conference on One Health and Ecosystem Services on 28 th and 30 th November 2019 organized by ICAR-NBFGR, Lucknow-226025, UP, India.
15. Global Symposium on & Disaster Resilient Smart Cities organized by Special Centre for Disaster Research, JNU, New Delhi., 4-6 December, 2019.
16. Delivered an invited talk in Two days Pre Conference Workshop on “New Urban Agenda, SDGs and Climate Change Initiatives: Issues and Alternatives” from December 3-4, 2019 of the International Conference on “Global Frameworks in the Local Context: Challenges and Way Forward” Organized by Centre for Research in Rural and Industrial Development (CRRID), Chandigarh from December 5-7, 2019 at CRRID Chandigarh.
17. International Conference on “Global Frameworks in the Local Context: Challenges and Way Forward” Organized by Centre for Research in Rural and Industrial Development (CRRID), Chandigarh from December 5-7,2019 at CRRID, Chandigarh.
18. International Conference on Environmental Sustainability: Innovations, Translational Dimensions and Way Forward on 11th – 12th February, 2020.
19. Training Workshop Cum FDP on Environment, Biodiversity And Disaster Risk Management From 2nd to 6th March 2020 sponsored by NIDM, New Delhi.
20. Integrated Workshop on ‘Publication Ethics and Patenting’ on 10th February, 2020; Venue- SES Conference Hall, BBA University.

21. National Workshop on Research Methodology for Social Science Professionals organized by Department of Social Work, Mumbai University on 23rd -24th Dec 2019
22. Participated in 3 days Training Program on Climate Change, Landslides and Safe Hill Area Development from 5^{th} to 7^{th} August 2020 organized by National Institute of Disaster Management, New Delhi, Ministry of Home Affairs, and Govt. of India in collaboration with R S T Uttarakhand Academy of Administration, Nainital, Uttarakhand.
23. Webinar on Sustainable Cities on 20^{th} September 2020 organized by Inclusive Human Resource Development Initiative, MDC, MGSIPA, Chandigarh, Punjab.
24. Webinar on Public Private Partnership-Issues, Challenges and Way Forward for on 11^{th} October 2020 organized by Inclusive Human Resource Development Initiative, MDC, MGSIPA, Chandigarh, Punjab Chandigarh, Punjab.
25. Webinar on Housing for All-Issues and Challenges on 18^{th} October 2020 organized by Inclusive Human Resource Development Initiative, MDC, MGSIPA, Chandigarh, Punjab.
26. Webinar on Behavioural Changes After Reopening of Education Institution on 26^{th} October 2020 organized by Child Centric Disaster Risk Reduction Centre, National Institute of Disaster Management, New Delhi, Ministry of Home Affairs, Govt. of India.
27. Webinar on Climate Action-United Nations Sustainable Development Goal 13 on 8^{th} November 2020 organized by Inclusive Human Resource Development Initiative, MDC, MGSIPA, Chandigarh, Punjab
28. Webinar on Early Warning and Communication on 17^{th} November 2020 organized by National Institute of Disaster Management, New Delhi, Ministry of Home Affairs, Govt. of India in collaboration with Manipur State Disaster Management Authority, Govt. of Manipur.
29. Webinar on Gender Equality- United Nations Sustainable Development Goal 5 on 29^{th} November 2020 organized by Inclusive Human Resource Development Initiative, MDC, MGSIPA, Chandigarh, Punjab.
30. Webinar on Good Health and well Being - United Nations Sustainable Development Goal 3 on 27^{th} December 2020 organized by Inclusive Human Resource Development Initiative, MDC, MGSIPA, Chandigarh, Punjab.

31. Webinar on Safe School Operation on 8th January 2021 organized by Child Centric Disaster Risk Reduction Centre, National Institute of Disaster Management, New Delhi, Ministry of Home Affairs, Govt. of India.
32. Webinar on Right to information- United Nations Sustainable Development Goal 16 on 10th January 2021 organized by Inclusive Human Resource Development Initiative, MDC, MGSIPA, Chandigarh, Punjab.
33. Webinar on The Art and Science of Negotiations on 31st January 2021 organized by Inclusive Human Resource Development Initiative, MDC, MGSIPA, Chandigarh, Punjab.
34. Webinar on Envisioning Indian Higher Education- United Nations Sustainable Development Goal 4 on 7th March 2021 organized by Inclusive Human Resource Development Initiative, MDC, MGSIPA, Chandigarh, Punjab.

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