Chapter 11

Climate Change and Carbon Sequestration

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Abstract

Climate change has adverse impact on all the spheres of life and is the most serious issue among all the global environmental challenges for human beings. Irregular rainfalls, severe droughts and seasonal disturbances in many areas of the world are the major consequences of climate change. The climate change has significant impact on agriculture and it is assumed that it will further impact the food production directly and indirectly. There is a diverse range of options to tackle emerging climate change related issues. The carbon sequestration is considered as the most suitable option, as a natural remedy to overcome the climate change. Soil carbon turnover is a predominantly weak link in our thoughtful of ecosystem reactions to climate change, such as the probable for carbon sequestration or release. One way to manage carbon is to use energy further professionally to decrease our need for main energy and carbon source-fossil fuel incineration. Additional way is to raise our use of low-carbon and carbon free fuels and machineries. A third way, is carbon sequestration, in which carbon is seized and stockpiled, thus alleviating carbon emanations. We can quickly and voluntarily amend prevailing management practices to raise carbon sequestration in our widespread forest, range, and croplands. Additionally, any measure that raises soil organic carbon content is probable to have helpful impacts on soil properties and functioning, along with mitigating climate changes.

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11.1. Introduction

Climate of the Earth is of great concern for mankind as it is directly related to the mankind's prosperity (Florides et al. 2013). Climate change is the most serious issue among all the global environmental challenges for the inhabitants of this planet, especially the human beings. The climate changes severally affect all the spheres of life (FAO 2008). Pakistan is highly vulnerable to the adverse impacts of climate change but has done little to contribute to the problem. Pakistan is ranked 16th out of 170 countries in a recent Climate Change Vulnerability Index (Maplecroft 2011). The world food security, ecosystem balance and health of the people are at risk by the climate change. The irregular rainfalls, severe droughts and disturbance in the duration of summer and winter in many parts of the world are the major adverse consequences of climate change. The climate change is badly affecting agricultural productivity all over the world and poses a severe threat to world's food security (Zia 2011). The extreme climate events in the form of elevated temperature and uncertain rainfall patterns are directly affecting social life. Droughts in Pakistan, Middle East and the Swahel region in Africa and intense flooding of low lying plains in Bangladesh, East Asia, Far East and present flooding in Pakistan provide the recent examples of climate change (Bhatti and Khan 2012). There is a diverse range of options to tackle the fast emerging climate change related issues. The carbon (C) sequestration is considered as the most effective option, as a natural remedy to overcome the climate change (Stephens 2006). Soil carbon sequestration is getting attention around the globe as the rapidly increasing CO_2 concentration in the atmosphere needs to be reduced (IPCC 2011). The carbon in the atmosphere (mainly in the form of CO_2) can be transformed into the stored soil carbon through the process of carbon sequestration. Plants have the ability to transform the carbon in the atmosphere through the process of photosynthesis into the relatively stable form and ultimately enhancing the soil organic carbon (SOC). The main advantage of carbon sequestration is the reduction of atmospheric concentration of carbon along with improvement in the quality and productivity of the soil (Stephens 2006). The goal of carbon sequestration can be accompanied by efficient utilization of natural resources in a manner which is less destructive to the environment and agricultural productivity (Raman et al. 2012).

11.2. Climate Change

The United Nations Framework on Conventions on Climate Change (UNFCCC) precisely defined the climate change as "A change of climate which is attributed, directly or indirectly to human activity that alters the composition of global atmosphere and which is in addition to natural climate variability observed over comparable time periods". Simply the change in average weather conditions of a region or the changes in distribution of weather is termed as climate change (IPCC 2007).

The climate change has significant impact on agriculture (Lobell et al. 2011) and it is assumed that it will further impact the food production directly and/or indirectly. The changing climatic conditions like the change in rainfall sequence, hydrological cycle, rising sea levels and increased frequency of droughts have significant effects on agriculture, forestry and fisheries (Gornall 2010; IPCC 2007; Beddington et al. 2012). The intensity and periodicity of these factors determine their intensity. The uncertainty in rainfall patterns increases the chances of crop failure and threatens the raising of crops and livestock rearing. It is evident in many dryland areas where the climate change affects the delicate ecosystem balance. The magnitude of overall rainfall has declined as a result of climate change leading to more frequent and intense periods of drought. The climatic zones are shifting due to temperature extremes both hot and cold and this result in decreased length of growing seasons and a shift in the prevalence of pests and diseases in different areas. Climate models predict about $4^{\circ}C$ rise in atmospheric temperature at the end of this century that will result in shortening of growing periods up to 20%. The dry land areas of the world are more threatened by climate change, posing severe threat to food security in these areas.

11.2.1. Causes of climate change

An important cause of climate change is the emission of greenhouse gasses which are directly or indirectly influencing the climate. The causes of climate change can be categorized into human induced and natural causes. The human induced causes may include the burning of fossil fuels, deforestation, agricultural practices and urban and industrial developmental activities. These all lead to the emission of greenhouse gasses which ultimately alter the natural climate. Among the natural causes, the changes in Earth orbital, intensity of sun and circulation of ocean and atmosphere are mainly responsible for climate change. The greenhouse gasses vary in their capability to cause the climate change. The most devastating effect on climate is caused by CO_2, methane, nitrous oxide and chlorofluorocarbons. The aerosols and changes in land use patterns are also responsible for climate change. The extent and lifetime of clouds is also affected by changes in their physical and chemical properties resulting in unpredicted rains and heavy storms or severe droughts. The aerosols are produced by many anthropogenic activities like burning of fuels, exhaust emissions from auto mobiles and from various industrial processes. The agricultural sector being an important producer of greenhouse gasses is also responsible for climate change. The major greenhouse gasses in agricultural emissions are carbon dioxide, methane and nitrous oxide.

11.2.1. Global warming and greenhouse gases

The greenhouse gasses act as a blanket and trap heat energy, resulting in an increase in global atmospheric temperature. Global warming is the result of greenhouse effect and is directly related to the emission of greenhouse gasses. Only the carbon dioxide contributes around 50% to the total greenhouse effect. So the net increase in the concentration of carbon dioxide in the atmosphere is the main cause of global warming. If by any mean the concentration of greenhouse gasses particularly the concentration of carbon dioxide is controlled in the atmosphere, the present global warming trend can be reduced.

11.2.2. Ozone depletion

Ozone depletion is an environmental issue and is directly related to global warming which, in turn, leads to climate change. As a result of ozone depletion, the global climate is more exposed to UV radiations. The ozone is known as the protective layer of Earth or sun screen that saves the Earth from the UV radiations. Ozone is present in stratosphere, about 15-20 km above the Earth surface. Ozone depletion is the breakdown of ozone molecules (O_3) into O_2 and atomic oxygen due to a number of compounds, like chloroflourocarbon (CFCs), carbon tetrachloride, methyl chloroform and Halons (brominated fluorocarbons) which are commonly known as ozone depleting substances (ODS). These ozone depleting substances are very stable for years in the troposphere and are transported to stratosphere where these substances are broken down by intense UV radiations resulting in the release of chlorine atoms which react with ozone and destroy ozone molecules. Approximately, one chlorine atom can destroy 100,000 ozone molecules. As a consequence of these reactions, there may be the holes in ozone layer or thinning of ozone layer. As a result, harmful radiations come to Earth and pose severe threat to environment and health related issues like reduction in efficiency of immune system, skin cancer and blindness due to damaging of eyes. Ozone depletion and climate change works side by side. The Montreal Protocol is the successful agreement in the last century and had a marked effect on climate change. Due to Montreal Protocol the radiative forcing of chlorofluorocarbons (CFCs) has been markedly reduced as these have been gradually phased out.

11.3. Factors affecting global climate change

11.3.1. Physical factors

11.3.1.1. Solar activity

The ultimate source of energy is sun that affects the weather and climate. The climate of Earth is ever changing and it is evident from geological and historical records. Any phenomenon that changes the incident radiations coming from sun can cause climate change. Under normal conditions the balance exists between the radiations coming from the sun and the radiations that the Earth reflects back into space. The radiations are mostly reflected in the form of long wave radiations attributing to the average temperature of the Earth. The increasing concentration of GHGs serves as a blanket and trap heat resulting in increased global temperature. The change in total irradiance of the sun is major cause of climate change. A change in solar activity, cloud cover and ocean circulation also affect global temperatures (Florides et al. 2013).

11.3.1.2. Orbital Variation

Earth's orbit is the principle factor which is responsible for seasonal distribution, affecting the falling of sunlight on Earth and its distribution across the globe. A small change in Earth's orbit results in significant change in seasonal and geographical distribution of sun light as a consequence of which the climate of the globe changes. The Earth's eccentricity, angle of Earth's axis of rotation and precession of Earth's axis are the major orbital variations responsible for Milankovitch cycles which have direct relation to glacial and interglacial periods (NASA, 2012). Florides et al. (2013) have argued that Earth's orbital variation and the Milankovitch cycles have great effect on the Earth's climate. The Milankovitch cycles also affect the glacial cycles followed by temperature change leading to the formation of deep oceans and rise in ocean temperature which increases the solubility of CO_2 and also affects exchange of CO_2 between the ocean and the atmosphere.

11.3.1.3. Solar output

The sun is the prime source of energy to this planet. The global climate may be affected by the variation in solar intensity and this has been extensively reviewed by Haigh (2007). Around four billion years ago, sun's emitting power was 70% than today. Thus, here is a gradual increase in solar energy. The concentration of greenhouse gasses and atmospheric composition vary widely. It is assumed that approximately after five billion years, the emitting power of sun will become too high to make it a red giant and ultimately will lead to its destruction. For shorter periods of time, the solar output varies over the 11 years cycle and this variation is also contributing to climate change.

11.3.1.4. Atmospheric circulation

The radiations coming from the sun are the sole source of light and heat to Earth and the regions which are more exposed to these radiations are warmer than the regions receiving less exposure to these radiations. Obviously, it is true for the tropical regions which are more exposed to solar radiations and experience less seasonal variations. High moisture contents and warm air are the major characteristics of the tropical regions due to high temperature of these regions. The moist warm air rises up due to its less density, when it reaches the upper atmosphere it becomes cool and the moisture is transformed into clouds which ultimately fall back as rain. Due to high temperature at the equator the moist warmed air moves away, i.e., towards the poles, leaving behind its moisture in the form of rainfall.

11.3.2. Chemical factors

The greenhouse gases as chemical factors are among the primary causes of climate change. Consequent to rapid industrialization in different parts of the world, there has been a significant increase in the global atmospheric concentration of the greenhouse gases. There is a marked increase in the concentrations of carbon dioxide, methane and nitrous oxide in the global atmosphere due to different human activities. These concentrations are far higher than the pre-industrial atmospheric concentrations of these gases. The CO_2 concentration has increased from 290 ppm at the beginning of 20^{th} century to 385 ppm in 2009 (Ciattaglia et al. 2010). The increase in carbon dioxide concentration in the atmosphere is the consequence of burning of fossil fuels and changed land use, whereas higher concentrations of methane and nitrous oxide are due to agricultural activities.

11.3.3. Biological factors

The major biological factors affecting global climate change are the deforestation and modern crop production systems. Deforestation has led to less carbon storage in the soil which ultimately increases carbon level in the atmosphere in the form of CO_2, which is a major greenhouse gas contributing in the global warming. Computer simulation studies show that a doubling of the atmospheric CO_2 concentration will increase the temperature by about 1.5 to 4.5°C (IPCC, 2001). Deforestation not only decreases the carbon sequestration but also changes the land use systems leading to urbanization or industrialization. The urbanization or industrialization results in more utilization of fossil fuels which is the major contributor of greenhouse gasses. The radiations which are being absorbed by the plants and converted into biomass by the process of photosynthesis are reflected back as a result of deforestation and trapped by the greenhouse gases resultantly increases the global atmospheric temperature. Crop production is very vital activity to feed the ever increasing world population but it is also considered as major contributor of greenhouse gasses which are responsible for global warming. The carbon dioxide releases from combustion of fossil fuels, during land preparation and during transportation of agricultural goods while the methane is produced during the decaying of organic materials and due to anoxic conditions especially from rice fields. On the other hand, the nitrous oxide is produced by the fertilization of agricultural crops.

11.3.4. Social factors

The human activities have a considerable impact on Earth's climate particularly through an increase in the greenhouse gases mainly as a result of the burning of fossil fuels in transportation, building heating and cooling and the manufacture of cement and other goods. The balance of the incoming solar radiation and the outgoing radiation has been disturbed by the greenhouse gases and aerosols which in turn have led to changed climatic conditions. A change in the atmospheric abundance of the greenhouse gases and aerosols as a result of different human activities either leads to warming or cooling of climate.

11.4. Global Carbon Cycle

Being most important constituent of all living things, carbon is the very definition of life, along with nitrogen, calcium, oxygen, hydrogen and phosphorus. Among these elements, carbon is the vital part of those compounds obligatory for life, such as fats, sugars, proteins, and starches. Overall, carbon accounts for approximately half of the total dry mass of living creatures. The movement of carbon, in its many forms, between the atmosphere, plants, soil and oceans, is described in the carbon cycle, illustrated in Fig. 11.1.

The carbon cycle, like every biogeochemical cycle, is a complex cycle consisting of different pools and stocks. Global C cycle can be divided into two components, inorganic and organic C cycle. Inorganic carbon cycle mainly consisted of dissolution of CO_2 in rainwater forming carbonic acid which then reacts with basic cations to form secondary carbonates, or with calcium–magnesium silicate minerals during the weathering process to release basic cations that then precipitate as carbonates (Hester and Harrison, 2010). This inorganic C cycle is mainly important in alkaline and sodic soils. Both organic and inorganic C cycle components are connected together via different fluxes like plant photosynthesis and soil respiration. The strong link between global C cycle and world climate is the reason why global C cycle gets such important attention from world's scientific community.

In order to simulate C cycling and future changes in atmospheric CO_2, it is important to know major carbon pools and the mechanisms for C storage and transformation from one pool to another, as shown in Fig. 11.1.

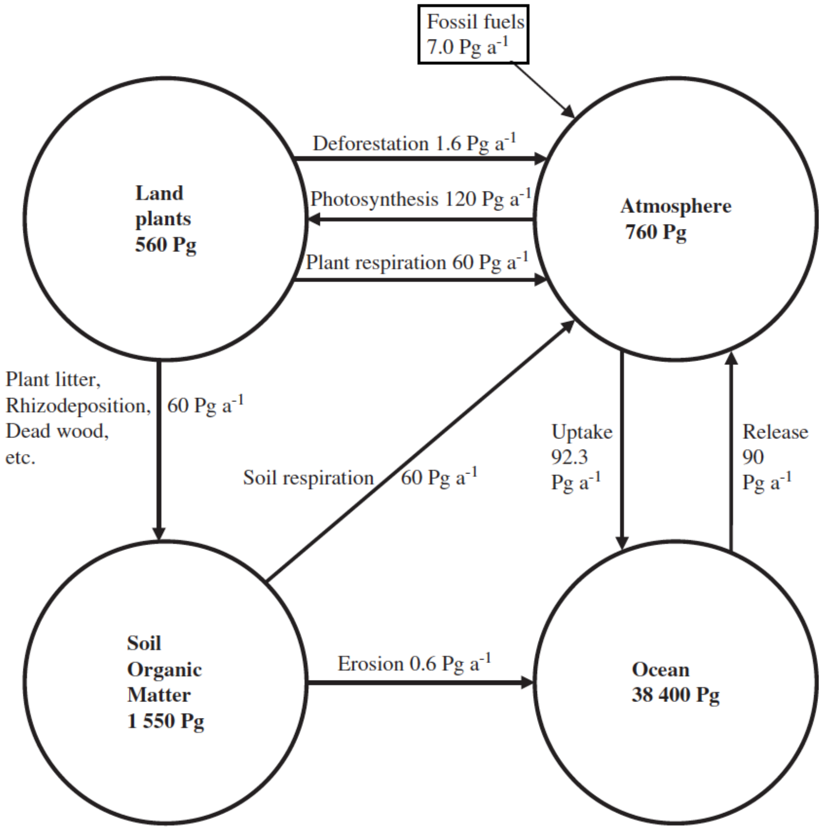

Fig. 11.1 Global Carbon Cycle (adapted from Hester and Harrison 2010)

Major C pools in global carbon cycle are:

11.4.1. Atmosphere

The atmosphere contains approximately 760 Pg C (1 Pg = 10^{15} g = Gt; t = tone; a = annum, or year), most of which is mainly in the form of CO_2, with much smaller amounts of methane (CH_4) and several other complexes. Atmospheric carbon is of dynamic rank because of its greenhouse effect and ultimately on climate. This C in the atmosphere is mainly exchanged with all other carbon pools like plants, soil, oceans as well as fossil fuels which contribute 7.0 pg C a^{-1} to the atmosphere.

11.4.2. Land plants

Land plants contain 560 pg C which is mainly taken up by plants from the atmosphere through photosynthesis (120 pg C a^{-1}) and is release back into the atmosphere via respiration (60 pg C a^{-1}). Deforestation also adds C to the atmosphere, and is contributing approximately 1.6 pg C a^{-1}.

11.4.3. Soil organic matter

Carbon from land plant material (60 pg C a^{-1}) in the form of plant litter, root exudates, dead roots, etc. can be transferred into soils, where it is stabilized in the form of soil organic matter (SOM). This carbon pool contains 1550 pg C which is two third C of total terrestrial ecosystem. Soil organic matter stocks are the result of balance between the inputs and outputs of carbon in the environment. This SOM is stabilized in the soil until being fragmented by soil microbes and released back to the atmosphere in the form of soil respiration (60 pg C a^{-1}). Small part of SOM is eroded due to soil erosion and it contributes the transfer of 0.6 pg C a^{-1} towards oceans.

11.4.4. Oceans

Oceans are the major reservoir of global carbon, containing 38400 Pg C which is mainly in the form of highly recalcitrant dissolved inorganic carbon. Ocean carbon is in direct exchange with atmosphere through (i) physical processes, such as CO_2 gas absorbed into the water, and (ii) biological processes, such as the growth, death and deterioration of plankton. But oceans are mainly the sink for carbon as uptake by oceans is 92.3 pg C a^{-1} while release is 90 pg C a^{-1}.

11.4.5. Soil organic matter and terrestrial carbon cycle

In terrestrial ecosystems, carbon is present in the form of animals, plants, soils and microorganisms (bacteria and fungi etc.). Soils and plants are the main C reservoirs in terrestrial ecosystem, representing ~ 75% of the total land biosphere C. The word soil organic matter has been used in diverse ways to define the organic ingredients of soil. SOM is an innumerable of organic compounds made from organic material and resulting products after microbial decomposition.

Soil organic matter is not a single chemical entity but a complex range of compounds, of which the precise nature of many is unknown. Part of the SOM will consist of newly added plant material and in many environments this will be under seasonal control. As this plant material undergoes decomposition, the more readily available and simple constituents, sugars, amino acids, nucleic acids, proteins, etc., are broken down first (Fig. 10.2). The structural polymers, pectin, hemicellulose and cellulose are then more slowly degraded. Finally, lignin is attacked once most other constituents have been exhausted. However, in much plant material, these chemical entities are not present singly, but rather in varying degrees of physical and chemical complexity. Hence, cellulose is often complexed (intimately mixed, probably with some covalent bonding) with lignin, and the lignin component then offers some resistance to the cellulose against decay. Some proteinaceous material may also survive longer when closely associated with lignin. Other complex plant components of SOM, such as tannins and cutins (waxes), can also offer some protection to otherwise rapidly decomposable substrates.

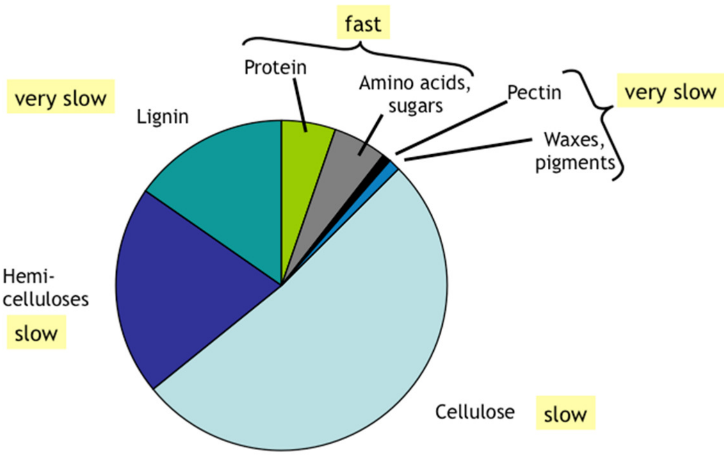

Fig. 11.2 Forms of carbon in plant residues and their decomposition rate

The soil microbes performing the mineralization of SOM use C as energy as well as assimilate it along with other nutrients as their DNA. The stabilization and mineralization of SOM is thus not exclusively dependent on inputs and outputs of C but on the availability of other nutrients as well.

11.5. Trends in Carbon Emission

Total CO_2 emissions are being increased with time and this increase is causing real threat to the environment. It has been recorded that in 2011, this threatening increase in CO_2 emission was highest, i.e., 3% increase and CO_2 reached 34 billion tones in 2011 (Olivier et al. 2012). Top global CO_2 emitting countries include China with 7.2 tones CO_2, European Union with 7.5 tones and United States with 17.3 tones per capita emissions. Russian Federation and Japan are also included in top five CO_2 emitting countries of the world. Continuous economic growth rate and expansion of infrastructure are the main reasons for this increase in CO_2 emissions due to increased fossil fuel consumption. Human activities including deforestation have been estimated for 420 billion tones of CO_2 emissions. There is also small share of renewable energy sources including biofuels and solar and wind energy.

11.6. Carbon Capture and Storage

Carbon capture and storage (CCS) is the process of preventing the release of large quantities of CO_2 into the atmosphere, mainly produced from large point sources, such as fossil fuels. These fossil fuels are mainly hydrocarbons and release CO_2 on incineration. This CO_2 and other greenhouse gases production is the major source of global warming (Anderson and Newell 2004; IPCC 2011).

11.7. Carbon Biosequestration

11.7.1. Introduction and concepts

As mentioned earlier, carbon sequestration in soils is the process whereby atmospheric carbon dioxide can be fixed into soil such that it is held there in a relatively permanent form. Biosequestration mentions to a kind of biological processes that absorb carbon dioxide, the primary greenhouse gas, from the atmosphere and encompass it in living organic matter, soil, or aquatic ecosystems. The prospects for growing biosequestration by fluctuating management and land-use practices are making debate among landowners, policy makers and the media. Other possibilities of enhancing natural carbon seizing processes may exist, but more study is desirable to regulate their probable for climate change modification (Bird et al. 1999; Bruce et al. 1999). Biosequestration occurs naturally in the global carbon cycle.

11.7.2. Terrestrial biosequestration

Terrestrial biosequestration is the fixing and storage of atmospheric CO_2 by terrestrial vegetation in soil on long-term basis. Such kind of C sequestration is possible either by decreasing atmospheric CO_2 or by reducing CO_2 emissions from terrestrial ecosystems. Thus sequestration can be enhanced by decreasing decomposition of organic matter, increasing photosynthetic carbon fixation by vegetation and generating energy offsets using biomass for fuels and other products. The terrestrial biosphere is projected to sequester about 2 billion tones of carbon yearly.

In count to increasing plant carbon contributions, approaches for improving soil carbon sequestration consist of decreasing organic matter turnover and increasing its residence time in soils. Chemical alteration and physico-chemical protection can help in stabilizing soil organic carbon (SOC) and reduce SOC turnover (Hungate et al. 1997; Koch and Roy 1995). Stabilization of SOC can happen by its sorption to mineral or its physical protection in soil pores where decomposers and extracellular enzymes have not easy access. Soil structure is also very important variable that both controls and indicates the soil organic carbon maintenance status of a soil (Read and Moreno 2003).

11.7.3. Role of soil enzymes and plants in C biosequestration

Soil carbon turnover is a predominantly weak link in our thoughtful of ecosystem reactions to climate change, such as the probable for carbon sequestration or release. Soil extra-cellular enzymes are specialized proteins produced by plants and/or microorganisms that combine with a specific substrate and act as catalysts in a biochemical reaction. These soil enzymes are very important drivers for nutrient cycling such as in carbon and other nutrient cycles.

Microbes take up simple forms of nutrients (C, N and P), which are used for their biomass growth or to produce extracellular enzymes in order to decay multifarious resources into available nutrients. The microbes enhance the magnitudes of diverse biomass mechanisms and enzyme assembly to exploit their growth rate. So, microorganisms release extracellular enzymes to decay organic materials (e.g., dead plants) into available nutrient elements: C, N and P. Extracellular enzymes are the tackles that microbes use to accomplish their roles as material recyclers in the global carbon and nutrient cycles. Increased N and P concentrations in plant materials stimulates enzyme production, which in turn escalate decay of organic materials and nutrient recycling. Addition of available carbon to microbes growing on new plant litter quashes enzyme production and decay. Addition of reachable carbon to old intractable material increases enzymatic decay, liberating nutrients and carbon through a grooming effect.

Following are the major factors which can influence enzyme activities in soil:

11.7.3.1. Soil Temperature

Soil enzymes are very specific to temperature and are only efficient at a certain optimum temperature range. Increase in temperature until optimum level can provide kinetic energy to the molecules and can increase the reaction rate of soil enzymes. Any increase in temperature above optimum can cause denaturing of soil enzymes. Denaturing of enzymes may result in the breakage of enzyme bonds holding molecules and enzyme active sites lose their shapes.

11.7.3.2. Soil pH

Similar to temperature, enzymes have an optimum pH requirement. Any change in soil pH can modify the chemical nature of the amino acids of enzymes which will result in a change in enzyme structures. The active site may be denatured resulting in denaturing of soil enzymes.

11.7.3.3. Change in concentration

Both enzyme and substrate concentrations can affect enzyme activities in soil.

i. Enzyme concentration

When enzyme concentrations are low, rate of reaction is low because of competition for the active sites. While with increasing enzyme concentration, more free active sites are available which enhance reaction rate. Ultimately, increase in enzyme concentration above certain point may have no effect because at this point, substrate concentration becomes the limiting factor.

ii. Substrate concentration:

Similar to enzyme concentration, low substrate concentration will result in low reaction rate because there are many unoccupied active sites. With increase in substrate concentration up to a certain limit will result in higher reaction rates because enzyme-substrate complexes can be increased with the availability of active sites. Above that concentration limit, there will be no effect because active sites will be saturated so no more enzyme-substrate complexes can be formed.

11.8. Factors Influencing Carbon Sequestration in Soil

Soil and crop management strategies that improve soil organic carbon pool in soil and thus carbon sequestration comprise of the following:

11.8.1. Climate

Climate plays a major role in determining C sequestration in soil and temperature and moisture are major determinants of the rate of decomposition since they directly affect the activity of the microbial biomass. Microbial activity and ultimately SOM decomposition is increased with increasing temperature which can cause reduction in C sequestration in soil. Soil moisture has also significant role in carbon sequestration, as under optimum moisture conditions, there will be less C sequestration in soil due to favorable conditions for microbial activity. While high moisture in the form of saturations may decrease decomposition rates due to anaerobic conditions and limited availability of oxygen. Such wet conditions help in the accumulation of C stocks in soils especially, peats and organic soils. Similarly, drought stress inhibits SOM decomposition (Sanaullah et al. 2011& 2012) and can help to increase C sequestration, although primary productivity tends to be very low.

11.8.2. Plant input

As mentioned in global C cycle, plant input has direct contribution towards increase in C stock in soil. However, this increase in C sequestration in soil due to plant input is highly dependent on type of vegetation, plant species and strains. Different type of plants input having different initial biochemical composition have different role in C sequestration in soil. Because plant material with higher N contents and lower recalcitrant phenolic compounds may have tendency for higher decomposition rates as compared with plant litter having higher recalcitrant compounds (Sanaullah et al. 2010).

11.8.3. Organic inputs and manuring

Regular application of livestock manure can induce substantial changes in soil organic carbon over the course of few years. And it was reported that continuous application of animal manure, soil organic carbon contents were increased. The reality of smallholder resource availability indicates that the movement in soil organic matter contents lead to offset losses for soil organic carbon accumulated prior to land management rather than to lead to a net increase in soil carbon (Bajracharya et al. 1997; Dormaar and Carefoot 1998).

11.8.4. Soil tillage

Overall, conventional tillage practices can cause losses in soil organic carbon pools. Disturbance of the soil exposes SOM that may have been physically protected, particularly by the soil mineral components, against further decomposition. Better soil aeration due to tillage operations and changes in temperature and moisture may also result in C loss because of stimulation of microbial biomass activity in soil. Though, the welfares of no till on soil organic carbon sequestration may be soil or site specific, and the development in soil organic carbon may be unpredictable in fine textured and poorly drained soils (Compton and Boone 2000).

11.8.5. Soil erosion

Soil carbon loss occurs both as a result of mineralization as well as through soil erosion and makes it often more difficult to interpret soil carbon responses to management practices in long term basis. However, the disruptive forces of soil erosion are similar to those of tillage and will probably promote increased decomposition. However, the deposited C after soil erosion may be protected from decomposition when eroded SOM becomes part of ocean sediments. Indirectly, decrease in plant yields and biomass due to soil erosion can cause decrease in plant return to soil and ultimately, to lower carbon sequestration.

11.9. Role of Carbon Sequestration in Climate Change Mitigation

Human deeds, particularly the scorching of fossil fuels such as coal, oil, and gas, have initiated a considerable proliferation in the absorption of carbon dioxide in the atmosphere. This intensification in atmospheric CO_2 from about 280 to more than 380 ppm over the last 250 years is producing quantifiable global warming. Probable antagonistic effects contain sea-level rise; enlarged incidence and strength of wildfires, floods, droughts, tropical storms; fluctuations in the extent, timing, and circulation of rain, snow and runoff and disruption of coastal marine and other ecologies (Marland et al. 2003; Olivier et al. 2012).

According to the Inter-governmental Panel on Climate Change (IPCC) agriculture presently accounts for 10-12% of global greenhouse gas (GHG) releases and is predictable to increase further. GHGs ascribed to agriculture by the IPCC comprise releases from soils, enteric fermentation, rice production, biomass scorching and manure management (Houghton 1996). There are additional unintended sources of GHG releases that are not accounted for by the IPCC under agriculture such as those made from land-use changes, use of fossil fuels for modernization, transport and agro-chemical and fertilizer production.

Carbon releases and atmospheric concentrations are predictable to continue throughout the next century if main changes are made in the way carbon is coped. Managing carbon has arisen as a persistent national energy and environmental need that will drive national policies and treaties through the coming decades. One way to manage carbon is to use energy further professionally to decrease our need for main energy and carbon source-fossil fuel incineration (Houghton 1996). Additional way is to raise our use of low-carbon and carbon free fuels and machineries. A third way, is carbon sequestration, in which carbon is seized and stockpiled, thus alleviating carbon emanations.

Sequestration of carbon in the terrestrial biosphere has arisen as the standard means by which the world will meet its near-term economic necessities for dropping net carbon releases. Terrestrial carbon pools and fluxes are of adequate extent to efficiently mitigate global carbon emanations (Lal and Bruce 1999; Liang et al. 2008). We can quickly and voluntarily amend prevailing management practices to raise carbon sequestration in our widespread forest, range, and croplands. Additionally, any measure that raises soil organic carbon content is probable to have helpful impacts on soil properties and functioning, along with mitigating climate changes.

11.10. Conclusion

Climate change has adverse impact on all the spheres of life and is the most serious issue among all the global environmental challenges for human beings. Irregular rainfalls, severe droughts and seasonal disturbances in many areas of the world are the major consequences of climate change. The climate change has significant impact on agriculture and it is assumed that it will further impact the food production directly and indirectly. There is a diverse range of options to tackle emerging climate change related issues. The carbon sequestration is considered as the most suitable option, as a natural remedy to overcome the climate change. Soil carbon turnover is a predominantly weak link in our thoughtful of ecosystem reactions to climate change, such as the probable for carbon sequestration or release. One way to manage carbon is to use energy further professionally to decrease our need for main energy and carbon source-fossil fuel incineration. Additional way is to raise our use of low-carbon and carbon free fuels and machineries. A third way, is carbon sequestration, in which carbon is seized and stockpiled, thus alleviating carbon emanations. We can quickly and voluntarily amend prevailing management practices to raise carbon sequestration in our widespread forest, range, and croplands. Additionally, any measure that raises soil organic carbon content is probable to have helpful impacts on soil properties and functioning, along with mitigating climate changes.

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