CLIMATE CHANGE AND SOIL POLLUTION

Abdul Haris A., Nihad K., and Jeena Mathew
Corresponding author's email: aabdulharis@gmail.com

Climate change is experienced from the time immemorial to the present. With progressing earth history, the parameters of climate such as temperatures and precipitation have globally, regionally and locally changed. We had ice ages and warmer periods, ice ages have occurred in a hundred thousand year cycle for the last 700 thousand years, and there have been previous periods that appear to have been warmer than the present despite CO_2 levels being lower than they are now. Climate change in Intergovernmental Panel on Climate Change (IPCC) usage refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the Framework Convention on Climate Change (FCCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

A reduced water evaporation from agricultural land in contrast to natural forest, emissions of warmth and carbon dioxide especially in urban-industrial agglomerations and the release of methane and nitrous oxide in agriculture are the most important impacts. It is assumed that in the 21st century the global mean temperature will rise by another 2-3°C, mainly caused by a higher use of fossil fuels and an intensified conventional agriculture.

Geological reasons: The earth's climate is dynamic and always changing through a natural cycle. The climate changes are being studied by scientists all over the world who are finding evidence from tree rings, pollen samples, ice cores and sea sediments. There are a number of natural factors responsible for climate change. Some of the more prominent ones are continental drift, volcanoes, ocean currents, the earth's tilt, comets and meteorites.

Human causes: Apart from geological cycles, leading to climate change over the ages, human activities are a major contributor in the recent past, affecting climate. Human-caused global warming is often called anthropogenic climate change. Industrialization, deforestation and pollution have greatly increased atmospheric concentrations of water vapor, carbon dioxide, methane and nitrous oxide, all greenhouse gases that help trap heat near earth's surface. Humans are pouring carbon dioxide into the atmosphere much faster than plants and oceans can absorb it. These gases persist in the atmosphere for years, meaning that even if such emissions were eliminated today, it would not immediately stop global warming.

Our planet is made habitable by the presence of certain gases which trap long-wave radiation emitted from the earth's surface, giving a global mean temperature of 15°C as opposed to an estimated -18°C in the absence of an atmosphere (Rakshit et.al, 2009). This phenomenon is popularly known as the "Greenhouse" effect.

Effect of climate change on Soils:

Direct effects: Organic matter content, which is already quite low in Indian soils, would become still lower. Quality of soil organic matter may be affected. The residues of crops under the elevated CO_2 concentrations will have higher C:N ratio, and this may reduce their rate of decomposition and nutrient supply. Rise in soil temperature will increase N mineralization, but its availability may decrease due to increased gaseous losses through processes such as volatilization and denitrification. There may be a change in rainfall volume and frequency, and wind may alter the severity, frequency and extent of soil erosion. Rise in sea level may lead to salt-water ingression in the coastal lands, turning them less suitable for conventional agriculture

Indirect effects: Indirect effects are soil erosion, increased leaching of nutrients, insect-pest-pathogen, increased reproduction rate, severity of infestation, extension of geographical range, outbreak of new pests, salinization of fresh water, ground water depletion, land use change, deforestation, land degradation and shifting of cropping zone etc.

Soil contamination or soil pollution : It is a type of land degradation caused by the presence of xenobiotic (human-made) chemicals or other alteration in the natural soil environment. It is typically caused by industrial activity, agricultural chemicals, or improper disposal of waste. Soil pollution due to climate change is manifested due to direct and indirect changes in natural soil environment.

Direct effects of climate change leading to soil pollution

Soil pollution refers to the presence of chemicals in soils that are either out of place or at higher-than-normal concentrations. Such contamination may be produced by mining and industrial activity or by sewer and waste mismanagement. In some cases, pollutants are spread over large areas by wind and rain. Agricultural inputs such as fertilizers, herbicides and pesticides and even antibiotics contained in animal manure are also major potential pollutants. Soil pollution is an insidious risk because it is harder to observe than some other soil degradation processes, such as erosion. The hazards posed depend on how soil properties affect the behaviour of chemicals and the speed with which they enter ecosystems. Excessive amount of nitrogen and trace metals such as arsenic, cadmium, lead and mercury can impair plant metabolism and reduce crop productivity. When they enter the food chain, these pollutants pose risk to food security, water resources, rural livelihoods and human health.

Sea-level rise will be a key issue for many coastal areas as rich agricultural lands may be submerged and taken out of production (Wassmann et al., 2009). Sea level rise will inundate low lying areas and will especially affect rice growing regions. Increases in floods and droughts will exacerbate rural poverty in parts of Asia due to negative impacts on the rice crop and resulting increases in food prices and the cost of living (IPCC, 2014). Sea-level rise threatens coastal and deltaic rice production areas in Asia, such as those in Bangladesh and the Mekong River Delta (Wassmann et al., 2009). Agriculturally fertile coastal regions with paddy fields are vulnerable to inundation and salinization. Threat due to coastal inundation is likely in Orissa state which normally produces around five million tonnes of rice each year. The rice crop on the coast contributes about 40 per cent to the total rice grown in the state.

Indirect changes leading to soil pollution

The most rapid processes of chemical or mineralogical change under changing external conditions would be loss of salts and nutrient cations where leaching increases and salinization where net upward water movement occurs because of increased evapotranspiration or decreased rainfall or irrigation water supply (Brinkman, and Sombroek, 1996)

Soil nutrient quantity is often affected by climatic factor. Change in temperature and precipitation could affect soil nutrient levels in numerous manners. Increasing temperatures could act to assert nutrients within the soil because of raised evaporative forces and abbreviate leaching (Dent., 1986). Moreover, decrease in rainfall may cause upward movements of nutrients and thus leads to Stalinization. Downward movement of water in soil leads to loss of soil nutrient; hence movement of water to a great extent affects the soil nutrient level. In tropical and subtropical countries, loss of soil nutrient is an increasing problem (Bullock et al., 1995, Smaling, 1990). Soil erosion threatens agricultural productivity and sustainability. There are several ways that soil erosion could increase in the future due to climate change. Wind and water erosion of agricultural soils are strongly tied to extreme climatic events, such as drought and flooding, which are commonly projected to increase as a result of climate change and land use change could exacerbate these impacts. Warmer winters may result in a decrease in protective snow cover, which would increase the exposure of soils to wind erosion, whereas an increase in the frequency of freeze-thaw cycles would enhance the breakdown of soil particles. The risk of soil erosion would also increase if producers respond to drought conditions through increased use of tillage summer fallow. Around one-third of the world’s soils are degraded due to unsustainable soil management practices. Tens of billions of tonnes of soil are lost to farming each year, which in some countries affects as much as one-fifth of all croplands. Erosion and deposition may result in soil pollution based on its severity.

Direct and indirect land-use change can lead to additional environmental pressures on land and water resources, habitat destruction and loss of biodiversity and thus contribute to further food insecurity through the competition for land and resulting increases in food prices (van der Velde et al., 2009; Tilman et al., 2009).

Land degradation due to increase in extreme events, such as flash floods and droughts threatening food and energy securityplacing more pressure on natural resources. Land degradation caused by inadequate communal land tenure systems and uneven distribution of water. Degradation of land quality (contamination of soil, groundwater and surface waters, loss of soil fertility) occurs due to industrialisation, urbanisation and unsustainable farming practices and causes soil erosion, soil infertility and reduced crop yields.

Land degradation is also a major problem in India. According to the State of India’s Environment 2017, India's total geographical area of 328.72 million hectares 96.4mha is under desertification. In nine states, around 40 to 70 per cent of land has undergone desertification.Healthy soils are vital for food security. Of the 17 sustainable development goals (SDG) and 169 targets, four contain targets related to soils and sustainable soil management.

Climate change adaptation measures related to agricultural soils

- Decision making regarding the timing of agricultural operations, the type of operations used (e.g., minimum tillage) and by erosion control measures such as buffer strips could help reduce negative impacts on soil structure, erosion and runoff
- Soil moisture conservation measures such as mulching and minimum tillage could help minimise increased crop irrigation needs in summer. The possibilities and potential methods (technologies) for an efficient soil moisture control are summarized latter
- Careful planning of the amounts and timing of applications of fertilisers and pesticides
- Land management practices to increase SOM content (e.g., addition of cereal straw, animal manure, rotations etc.) could help maintain SOM contents and avoid increased CO_2 fluxes from soils. Correct farming techniques can sequester carbon into the soil and reverse the greenhouse gases created by Agriculture. The processes to increase soil carbon can be divided into three steps

Use plants for carbon sequestration : It is estimated that between 30-60% of the atmospheric carbon dioxide (CO_2) absorbed by plants is deposited into the soil as organic matter in the form of bud sheaths that protect the delicate root tips and as a range of other root excretions

Use microorganisms to convert soil carbon into stable forms: The stable forms of soil carbon such as humus and glomalin are manufactured by microorganisms. The continuous application of carbon as composts, manures, mulches and via plant growth will not increase soil carbon levels if farming practices destroy soil carbon. The following are some of the practices that result in a decline in carbon and alternatives that prevent this loss,

- *Reduce nitrogen applications:* Synthetic nitrogen fertilisers are one of the major causes of the decline of soil carbon. This is because it stimulates a range of bacteria that feed on nitrogen and carbon to form amino acids for their growth and reproduction. These bacteria have a carbon to nitrogen ratio of around 30-1. In other words every ton of nitrogen applied results in the bacteria consuming 30 t of carbon. The quick addition of these nitrogen fertilisers causes the nitrogen feeding bacteria to rapidly multiply, consuming the soil carbon to build their cells

- *Carbon eaters rather than carbon builders:* The use of synthetic nitrogen fertilisers changes the soil biota to favour microorganisms that consume carbon, rather than the species that build humus and other stable forms of carbon. By stimulating high levels of species that consume soil carbon, the carbon never gets to increase and usually continues to slowly decline

- *Reduce herbicides, pesticides and fungicides:* Research shows that the use of biocides (Herbicides, Pesticides and Fungicides) causes a decline in beneficial microorganisms. Dr Elaine Ingham has shown that these chemicals cause a significant decline in the beneficial microorganisms that build humus, suppress diseases and make nutrients available to plants. Many of the herbicides and fungicides have been shown to kill off beneficial soil fungi112

- *Use correct tillage methods:* Tillage is one of the oldest and most effective methods to prepare planting beds and to control weeds. Unfortunately it is also one of the most abused methods resulting in soil loss, damage to the soil structure and carbon loss through oxidation when used incorrectly

- *Control weeds without soil damage:* A large range of tillage methods can be used to control weeds in crops without damaging the soil and losing carbon. Various spring tynes, some types of harrows, star weeders, knives and brushes can be used to pull out young weeds with only minimal soil disturbance

- *Prevent Soil erosion:* Erosion is one significant ways that soil carbon is lost. The top few centimetres of soil is the area richest in carbon. When this thin layer of soil is lost due to rain or wind, the carbon is lost as well.
- *Avoid burning stubble:* Practices such as burning stubble should be avoided. Burning creates greenhouses gases as well as exposing the soil to damage from erosion and oxidation.
- *Encourage vegatative cover:* Vegatative cover is the best way to prevent soil and carbon loss. As stated in the previous section 'Managing weeds to increase soil Carbon', it is not always necessary to eradicate weeds. Effective management tools such as grazing or mowing can achieve better long term results.
- *Bare soils should be avoided as much as possible:* Research shows that bare soils lose organic matter through oxidation, the killing of micro organisms and through wind and rain erosion. Cultivated soils should be planted with a cover crop as quickly as possible. The cover crop will protect the soil from damage and add carbon and other nutrients as it grows. The correct choice of species can increase soil nitrogen, conserve soil moisture through mulching and suppress weeds by out competing them.
- Careful planning of land management (e.g., timing and application of fertiliser applications) could help minimize potential increases in trace gas fluxes from soils.
- Conservation measures to maintain peatland moisture could help avoid drying out of peatlands and associated CO_2 fluxes.
- Coastal management options should consider measures to protect aquifers from saline intrusion due to sea level rise where appropriate.
- Conservation measures for low-lying vulnerable coastal habitats need to be planned carefully with consideration of possible impacts on trace gas fluxes.

Conclusion

Changes due to climate change are expected to be relatively well buffered by the mineral composition, the organic matter content or the structural stability of many soils. As a matter of fact, the impact of climate change on soil system should be monitored in different agroecological regions on regular basis. Climate change and land degradation are closely linked issues and conservation farming has shown promise in minimizing land degradation.

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