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IMPACTS OF CLIMATE CHANGE TOWARDS THE SOIL HEALTH (Soil Physical, Chemical and Biological Properties)

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When we are starting to talk about soil health, it is not just a single property of soil. It includes the holistic property of soil which are soil physical, chemical and biological properties the most prominent features towards the sustainable soil health. The most recent report of the Intergovernmental Panel on Climate Change (IPCC) visualised that the average global temperature will probably rise between 1.1 and 6.4°C by 2090 – 2099, as compared to 1980–1999 temperatures, with the most likely rise being between 1.8 and 4.0°C (IPCC, 2007). The idea that the Earth's climate is changing and its effects on our daily life are now almost universally accepted in the scientific community (Cooney, 2010; Corfee- Morlot *et al.*, 2007). The CO2 concentration reached a level of 386 ppm in 2009 and increased further to 389 ppm. This is an increase of about 110 ppm (+38%) compared to the pre-industrial levels (i.e. before 1750) (NOAA, 2011). The Nitrous oxide (N2O) concentration in 2009 was 322 ppm, up 0.6 ppb from the year before (Encyclopaedia Britannica). In the last century, considerable changes took place in the gas composition of the atmosphere due to natural processes and anthropogenic activities, such as increasing energy consumption, industrialization, and intensive agriculture, urban and rural development. As a result, led to arise in global temperature and high spatial and temporal variability. The changing the temperature regime would result in considerable changes in the precipitation pattern there for Soil water regimes are considerable changes which effects on microbial activity, salt concentration, soil structure (aggregate) that's are intricately linked to the atmospheric–climate system through the carbon, nitrogen, and hydrologic cycles.

Effects on soil physical properties

Soil structure and Aggregate stability

The arrangement and organization of primary and secondary particles in a soil mass are known as soil structure where the amount of water and air present in the soil. Aggregate stability, the resistance of soil aggregates from the high intensity of rainfall and cultivation is determined by soil structure. It is also being used to measure soil erosion and management changes. The behaviour and quality of the structure is strongly influenced by the amount and quality of organic matter present, inorganic constituents of the soil matrix, cultivation methods and natural physical processes such as shrink-swell and freeze-thaw behaviour. Due to the variation of rainfall distribution and higher or lower temperature which decline in soil organic matter levels lead to a decrease in soil aggregate stability, infiltration rates and increase in susceptibility to compaction, runoff furthermore susceptibility to erosion

Porosity

Porosity a measure of the void spaces in material as a fraction (volume of voids to that of total volume) and pore size distribution provides the ability of soil to store root zone water and air necessary for plant growth. Pore size distribution is strongly linked to soil physical quality, bulk density, microporosity and functions of the pore volume. Soil porosity and water release pattern or amount of water release are directly influenced a range of soil physical properties which are soil aeration capacity, plant available water capacity and relative field capacity. Since root development and soil enzyme activities are closely related to soil porosity and pore size distribution. Climate change scenarios which are elevated CO2 and temperature, variable and extreme rainfall events that may alter root development and soil biological activities; as a result soil porosity and pore size distribution consequently soil functions are likely to be affected in a wrong way or lethal directions. It will lead to poor crop emergence, growth and increases chances of surface runoff

Bulk density

Bulk density is the most important feature of the soil physical property, which characterizes the state of soil compactness in response to land use and management. It has, in general, negatively correlated with soil organic matter (SOM) or soil organic carbon (SOC)

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content. Due to elevated temperature may lead to increase in bulk density because the losses of organic carbon which leads to making soil more prone to compaction viz. land management activities and climate change stresses from variable and high-intensity rainfall and drought events (Birkas *et al*., 2009)

Effects on Soil Chemical properties

Soil pH

Soil pH characteristic is depending on the parent material, time of weathering, vegetation and climate. It is an important indicator of soil health. Soil pH is an integral part of soil health tests to assess impacts of land-use change and agricultural practices. These drivers of climate change (variation of rainfall intensity and temperature) which will affect organic matter status, C and nutrient cycling, plant available water and hence plant productivity, which in turn will affect soil pH (Reth *et al*., 2005)

Electrical conductivity

Soil electrical conductivity (EC) is another important feature of soil chemical property which is the measure of salt concentration. It can inform trends of soil salinity, crop performance, nutrient cycling and biological activity. Due to the Increasing temperatures and decreasing precipitation increase the electrical conductivity under climate change scenarios. The dynamics of soluble salts concentration in soils from four climatic regions (Mediterranean, Semi-arid, Mildly arid and Arid) are found a non-linear relationship between the soluble salts content and rainfall intensity.

Sorption and Cation exchange capacity

Sorption(Adsorption and absorption) and cation exchange capacity (CEC) are considered important properties, particularly the retention of major nutrient cations Ca2+, Mg2+, K+ and immobilization of potentially toxic cations Al3+ and Mn3+. These properties are useful indicators of soil health that is inform the soil's capacity to absorb nutrients. Due to the pore size variation of coarse-textured soils have low CEC and low-activity clay that is attributed to the SOM, the increasing decomposition and loss of SOM due to elevated temperatures may lead to decreasing the CEC of these soils. It may results in increased leaching of base cations in response to high and intense rainfall events.

Plant available nutrients

Measurement of extractable nutrients may provide the indication of a soil's capacity to support plant growth that may identify critical or threshold values for environmental hazard assessment (Dalal and Moloney, 2000). Nutrient cycling, especially N is intimately linked with soil organic carbon cycling . The drivers of climate change such as elevated temperatures, variable precipitation and atmospheric N deposition are likely to impact on N cycling and the cycling of other plants available nutrients such as phosphorus and sulphur. It's may also create some hazardous effect of some of the micro and beneficial element through the process of sorption and desorption due to variability of elevated temperature and high rainfall intensity

Effects on Soil Biological properties

Soil organic matter

Soil organic matter is originated from an extensive range of living and non-living components. It is one of the most complex and heterogeneous components of soils which vary in their properties, functions and turnover rates. It possesses the ability to form a complex with multivalent ions (cations and anions) and organic compounds. It provides microbial and faunal habitat and substrates, as well as affecting aggregate stability, water retention and hydraulic properties of soil. SOM contribute the vital and core function where, decreases in SOM can lead to a decrease in fertility and biodiversity, as well as a loss of soil structure, that resulting in reduced water holding capacity, increased risk of erosion and increased bulk density and soil compaction. The drivers of climate change such as elevated temperatures, variable precipitation which leads to decrease SOM by oxidised the organic matter as a result deteriorated the soil quality

Light fraction and Macro organic matter (Labile organic matter)

Light (low-density) fraction and macro organic components of SOM consist mainly of mineral-free particulate plant and animal residues, which serve as readily decomposable with the variation of temperature and oxidised easily, therefore, labile nutrient reservoir are decline inversely. Since light fraction and macro organic matter are responsive to management practices, which act as early indicators to measure the effectiveness of changing management practice in the adaptive response to climate change (Knorr *et al*., 2005)

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Potentially mineralisable C and N

Mineral sable organic matter acts as an interface between autotrophic and heterotrophic organisms during the nutrient cycling process. Mineral sable organic matter may be a useful indicator to assess soil health under climate change because of its affects nutrient dynamics within single growing seasons. Due to the variation of climate change which leads to change the quantity of organic matter through the oxidation.

Soil respiration

Soil respiration is used as a biological indicator for soil health, and it is positively correlated with SOM content. It has a critical link between climate change and the global C cycle. It is relatively responsive to changes in the seasonal timing of rainfall.

Enzyme activity

Soil enzyme activities may serve to indicate change within the plant-soil system due to its close association of rhizosphere. It is closely linked to the cycling of nutrients and soil biology; however, the elevated of CO2 may stimulate microbial enzyme activities, an abundance of microbial enzymes and C turnover possibly affecting microbial community functioning in soil.

Conclusion

The quantitative and qualitative evaluation of predicted climate change effect on soil health is a difficult task due to uncertainties in the weather forecast. Conservation farming has shown positive results in minimizing land degradation. It is advisable to adopt the conservation tillage and residue management, which is essential that complete package of practices may be identified based on intensive research for each agro-ecological region. The site-specific management practices for soil and water conservation, crop improvement and integrated nutrient management needs to be implemented to overcome the impact of climate change on physical, chemical and biological properties of soil. It is also advisable that increase of afforestation and reduces the deforestation to mitigate the climate change and also take the initiative to bring the problematic zones of soils into the form of some extends to cultivable form so that the intensive pressure of already cultivable land can some extend minimized. Govt should take some awareness programme regarding the effect of climate change towards

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the soil health with the help of extension worker. Lastly, not least the most important factors to mitigate climate change towards soil health is a public awareness and public responsibility towards the environment.

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