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Editorial

Soil Quality vis-à-vis Soil Organic Carbon and Food Security

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Every 5 December, we are celebrating as a soil day throughout the world to create awareness about the issues of soils since 2015 (declared as decade of soils-2015-2025 by UN). Soil quality (SQ) is the capacity of a specific kind of a soil to function, within natural and managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality and support human health and habitation [4]. In the mid sixteen due to introduction of dwarf verities, which need high input in term of fertilizers, water, pesticides increased agricultural production but discriminate and imbalance use of fertilizer deteriorate inheherent capacity of soil to supply plant nutrient. Soil health (SH) refers to the fitness of soil for any specific purpose determined by the factors chosen for soil classification, soil suitability and land capability. It examines spatial and temporal variations induced by land use policy or management. Soil organic carbon (SOC) is the most reliable, versatile and easily assessable indicator, encompassing interactive effect of several factors. Plateuing or decreasing trends of crop yields at current level of management indicates declining SH. Erosion, drought and desertification, irrigation induced salinity and sodicity, paradigm shift in land use, nutrient depletion and intensive cultivation are the cause of SH deterioration. Erratic rainfall and exploitation of land, water and vegetation resources by ever increasing human and livestock population further accentuate the problem of SH. Increasing salinity, residual carbonate, alkalinity and contamination of surface and ground water through heavy metals, nitrates, fluoride and arsenic are the reflection of deteriorating SH.

The SH is an indicator of good soil physical, biological and chemical properties for maximum production. The challenges of growing population, industrialization and urbanization on qualities of diminishing resources are quite daunting especially in Asia, Africa and other developing nations. Soil, water and biodiversity are integral part of sustainable production system in the era of resource degradation and heavy input depended agriculture. In the mid sixteen our natural resources were not exploited, now have been reached up to high level of exploitation, needed immediate attentions. Enhancing productivity by input intensive agriculture consolidated food and nutritional securities of developing nations with limited per capita availability of land, water, and bio resources [6]. As per recommendations made in proceedings of International Conference on Soil, Water and Environmental Quality-Issues and Strategies (ICSWEQ) January 28 to February 1, 2005 held at New Delhi "The shrinking capacity of soils to absorb any more abuse must be impressed in the public mind through appropriate changes in educational curriculum, mind set, awareness, mass media and it is the time for individual countries to act on the "World Soil Charter of FAO" and press for "UN Soils Convention" to accord the same high priority to soil preservation as is being currently given to climate change, biodiversity etc. Soil organic matter (SOM) is the mainstay of soil quality. While balanced fertilization may meet crop productivity and maintain SOM. It is an urgent imperative to improve the sequestration of carbon in all the soils by all available resources including recycling of crop residues, green manuring, composting, zero tillage, resource conserving technologies (RCTs) and other soil agro techniques.

Challenges of Soil Quality

The mother earth day celebrated every year on 22 April world wide for creating awareness about the challenges of land degradation, soil pollution, and climate change impact and for earth preservation. Against an annual depletion of 28 million tonnes (mt) of nutrients, against addition of 20 mt, leaving a net gap of 8 mt per annum, a deficiency which accumulating year after year, depleting SQ. A Fact Finding Committee constituted by the Government of India in 1997 with the objective of analyzing in-depth the trend of productivity of important crops in Haryana and Punjab reported that there is decline in the organic-carbon content of the soils due to continuous cultivation of cereal based cropping system for instance rice-wheat, rice-rice and rice-maize etc. The continuous nutrients depletion from the agriculture field is the severe threat to the SH. Sub-optimal nutrient application together with poor quality water results in sparse plant cover and low vegetative inputs into the soils. In arid and rain-fed areas removal by crop was far more than the added through fertilizers [6]. Alfisols, ultisols and oxisols with low cation exchange capacity (CEC) were the heaviest looser. Soil organic carbon loss ranged from 0.22 to 6.0 % over the initial in different cropping sequences of India due to inadequate fertilization, whereas depletion of SOC was far less 0.22 to 2.92 % under balanced fertilization [1].

Inadequate fertilization with high RSC (residual sodium carbonate) depleted phosphorus and potassium by 7.7 and 13.4 %, respectively in arid soils of India from 1975 to 2002 [9]. The abrupt change in land use by introducing high water requiring crops further heighten the problem of nutrient depletion. Traditional farming system was extensive with low yields, which was sustainable in harmony with the carrying capacity set by the nature. Low productivity system has lost relevance in view of increasing demand of food, fiber and wood. Since 1951- 52 there has been an increase of 36, 22 and 54 million hectare irrigated, net sown and double-cropped area respectively on the cost of fallow, pastures and grazing lands and tree grooves. High intensity farming system supports high productivity, they appear non-sustainable in absence of holistic land management which satisfies needs of stakeholders in an economically favorable way and simultaneously contains curative action for preserving the SH and prevents further soil degradation.

Due to concerns with soil degradation and the need for sustainable soil management in agro ecosystem, there has been much scientific attention to characterize soil quality. The Soil Science Society of America (SSSA, 1995) defines SQ as "*it is the capacity of a specific kind of soil to function within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance soil and water quality, and support human health and habitation*. In simplest terms, SQ or SH can be defined as "*the fitness of soil for use*". In agricultural systems, high quality soil provides for the sustained and productive growth of crops with minimal impacts on the environment. There are two components of SQ viz. inherent and dynamic. Inherent SQ refers to the characteristics that define a soil's inherent capacity for plant production. These are usually static, changing little over short time frames (years to decades). Soil texture and soil mineralogy are commonly included as properties of inherent SQ. Other soil properties such as total soil carbon, CEC and exchangeable sodium percentage (ESP) may also be defined as inherent properties where broad soil type or regional comparisons are of interest at one point of time, even though they may be altered by management over longer time frame. Inherent soil properties are the basis of many land use capability or suitability assessments that are key components of land use planning and policy development in many regions. Most were undertaken with the primary aim of evaluating potential soil productivity. Thus, the inherent quality of a soil should be viewed in light of its intended agricultural use. Properties of dynamic SQ are those that change in response to human use and management normally over relatively short time frame (years to decades). Agricultural soils of high dynamic SQ maintain high nutrient availability, permit adequate infiltration of water and air, have relatively stable structure and maintain a functionally diverse community of soil organisms that support a relatively high level of plant productivity. These processes are reflected in specific physical, chemical and biological properties of soils. The terms "dynamic soil quality" and "soil health" are often used interchangeably. Two soils may be equally "healthy" but achieve different levels of plant productivity because of differences in their inherent quality.

Challenges of Food Security

Food an individual eats fundamentally affects his health, strength, stamina, nervous condition, moral and mental functioning. It is of paramount importance in the normal growth, development and health of humans. The access to food by all is still unachieved but cherished goal. A widely accepted food security comprises of three parts. Every individual has a physical, economic, social and environmental access to balanced diet that includes necessary macro and micro-nutrients, safe drinking water, sanitation, environmental hygiene, primary health care and education so as to lead a healthy life. Food is produced from efficient and environmental friendly technologies that conserve and enhance the natural resource base of crops, animal husbandry, forestry, inland and marine fisheries etc. The ultimate composition of a food is expressed in terms of nineteen chemical elements. Every human being has fundamental rights of balanced and nutritious diets in required quantity every day for sustaining their lives. Food security is a distance goal but achievable. Projections made by the Food and Agriculture Organization (FAO) on Trends in Agriculture, Food and Forestry (*World Agriculture: Towards 2015/2030*) indicated that low income countries with high dependence on agriculture will encounter challenges of, food security, sustainability and rural poverty. In the past, the increasing needs of expanding population for food, fuel and fiber were met from cultivating progressively larger areas of land and by intensifying the use of existing cultivated land. Under the circumstances when no more additional good quality land is available and the crop yields are stagnated, the food requirement of added population in future has to come from the reclamation and management of degraded lands which include salt affected ones also. India has world's 2.4 % of land and 4% of fresh water resources of which nearly 6.73 million hectares lands are salt affected and a sizeable area is underlain by poor quality water. With these limited resources we have to support 16% of the global population. Owing to higher allocation of good quality water to other remunerative sectors the availability of fresh water to agriculture which is the largest user, is diminishing rapidly and has to largely depend upon the low quality water resources. Therefore, another important component to achieve higher productivity could be the optimum utilization of surface waters as well as low quality groundwater and waste waters, which are still usable. The injudicious use of water is often associated with the development of water logging, salinity, sodicity and many other environmental problems. Adequate knowledge in diagnosis and management technologies for saline and alkali lands/waters and wastewater generated from municipalities and industries is essential to obtain maximum crop production from these resources for achieving goal of 300 million tones food grains by 2020 from 145 mha Indian arable lands.

Enhancing Soil Organic Carbon (SOC) Stock – A Ultimate Solution

The SOM consisted of living organisms (bacteria, fungi, earthworms, nematodes, insects, and plant roots), active organic matter (fresh/partially decomposed, labile) and humus (well decomposed and relatively stable). The source of organic matter (OM) in soil is plant and animal residues and the products synthesized by them and microorganisms. The OM and humus serve as reservoirs of living organisms and these living organisms participate in the mobilization of plant nutrients and facilitate to build soil structure besides providing other benefits. Nutritional value of organic matter lies in its dynamic nature. Organic carbon is the energy source for soil organisms, and it is the activity of these organisms and the processes they are involved in rather than the absolute-organic matter level, which is most important. Increasing SOC in tropical climate is not easy. However, continuous application of lingocellulotic crop residue helps in building soil organic matter temporarily. There are evidences in literature, as shown through long term experiments, that application of farm yard manure (FYM) + Mineral nutrient (Nitrogen, Phosphorus, Potash and Sulphur)and micronutrient increases the crop yield as well as built the organic carbon in soils. Integrated use of manures and fertilizers help in building SOC residues have a major role in maintaining soil organic matter content. Soil microorganisms grow rapidly during early phases of decomposition when plant materials are subjected to the transformation and decomposition processes by the heterotrophic microflora immediately after incorporation into the soil, and as a result, the population of bacteria fungi and actinomycetes increased with application of plant residues and FYM. It was also observed that exhaustion of the available carbon led to decrease in microbial biomass. Many crop management practices such as manuring including green manuring, crop residue application, mulching have shown improvement in soil organic matter and microbial population.

Land use systems	Material added	Organic carbon (%)
Maize-wheat (25 yrs)	Control	0.51
	FYM	2.49
Cotton-sorghum (45 yrs)	Control	0.56
	FYM	1.14
Ragi-cowpea-maize (3 yrs)	Control	0.30
	FYM	0.64
Rice-rice (10 yrs)	Control	0.43
	50% from inorganic + 50% through green manuring (*Sesbania aculeate*)	0.90
Rice -wheat (3 yrs)	Control	0.44
	FYM	0.54
Rice -wheat (7 yrs)	Fellow	0.23
	Green Manuring (*Sesbania aculeate*)	0.37

Table 1: Post harvest buildup of SOC by uses of different organic residues under different cropping sequences [8].

Soil carbon sequestration refers to the storage of carbon into stable solid form. It occurs through direct and indirect fixation of atmospheric CO_2. Direct soil carbon sequestration occurs by inorganic chemical reaction that converts CO_2 into soil inorganic carbon compounds such as Ca and Mg carbonates. Indirect plant carbon sequestration occurs as plants photosynthesise atmospheric CO_2 into plant biomass; subsequently some of the plant biomass is indirectly sequestered as soil organic carbon during decomposition process. The amount of carbon sequestered at a site reflects the long term balance between carbon uptake and release mechanism. Many best management practices have been proven to help in sequestering soil carbon like: Restoration of degraded soils and ecosystems. The adoption of recommended agricultural practices on prime land and retiring marginal agricultural lands to restorative land uses or converting to natural ecosystems. With rapidly increasing population restoration of degraded soils and ecosystems is an important strategy. This strategy of restoration of degraded soils and ecosystems can enhance biomass production improves soil quality and increases the SOC pool. Many soils of the tropics especially those in densely populated regions of Asia have lost a large proportion of their original SOC pool because of practices of mining soil fertility. There is a large potential of restoration of degraded soils in South East Asia which ranges from 18.3 to 35.0 Teragram carbons per year (TgC/yr). These estimates are attainable potentials provided that regional governments adopt appropriate polices and implement plans to restore degraded soils through forestation, establishing planted fellows and improving grazing lands. It is a major challenge that must be addressed in a coordinated and planned manner.

The SOM is extremely important for productivity, and particularly so for the poorer soils of arid and semi-arid areas. Its direct contributions to nitrogen and sulphur nutrition of crops, and its role in stabilizing soil aggregates and supporting the soil biota responsible for creating pores through which air and water move cannot be ignored. In addition, soil organic matter plays a major role in the retention of cationic nutrients by dominant soils of these areas which have clays composed of kaolinite, and low activity iron and aluminium oxides clays with only a weak ability to hold nutrient cations. Furthermore, under acid conditions, some of the organic compounds present in soil form complexes with aluminium which would otherwise be toxic to plants. In addition to physical and chemical effects, organic matter provides substrate for supporting biological life in the soil.

Land use system	*Organic carbon (%)*	*Available N (kg ha^{-1})*
Crop based system	+0.07	+10
Eucalyptus based	+0.12	+21
Acacia based	+0.20	+31
Populus based	+0.17	+25

Table 2: The changes in soil properties (0-30 cm) under different tree-crop combinations in 5 years [8].

Under natural vegetation the amount of organic matter in the soil tends to be established at a relatively high level but under cultivation, addition is usually much less than from the natural vegetation, and consequently the OM level tends to fall. If good crops are grown and all residues returned to the soil, the level established after cropping may be different than under grassland. A general principle of sustainable SH management systems is that return as much organic material as possible to arable upland soils but it should be free from toxic contaminants, and the costs and problems of collecting and spreading should be socially and economically acceptable.

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