BOTANY (H) 5^{TH} SEMESTER

Date : 05.11.2020

DSE 1 : NATURAL RESOURCE MANAGEMENT

UNIT – 3

Land

(Part – 9)

Soil degradation and management

Soil degradation refers to declination of soil's productivity through adverse changes in nutrient status, soil organic matter, structural attributes, and concentrations of electrolytes and toxic chemicals. Soil degradation is a process, which lowers the current and/or future capacity of the soil to produce goods or services. Soil degradation is among serious prevailing issues in our modern era. It is badly affecting soil's natural fertility to enhance our economic values along with ecological issues.

It is estimated that out of 329 M ha of total geographical area (TGA) of India, the area under agriculture is 179.9 M ha area is degraded through one or more degradation types, which in turn, is affecting the country's productive resource base.

Causes of Soil Degradation

The cause of land degradation for a particular area can be one or combined effects of many. The causes can be classified into two categories –

i. Proximate causes (biophysical) and
ii. Overlying causes (anthropogenic).

Biophysical have direct effect on all ecosystems like drought, soil salinity, soil acidity, metal contamination, related to extreme climatic conditions while on the other hand anthropogenic causes have indirect effect on ecosystem like intensive cropping, deforestation, overgrazing or poverty, urbanization and industrialization.

Major Threats and Management Options

1. **Soil Erosion**

Soil erosion is the detachment of soil particles by the action of wind or water. So, it is mainly caused by two agents, water and wind and thus soils erosion is divided into main categories –

i. Water erosion and
ii. Wind erosion.

Though soil erosion is a natural process but is accelerated by anthropogenic activities like deforestation, overgrazing, improper agricultural practices and cultivation techniques.

A major factor responsible for the degradation of the natural resources is soil erosion. In general, soil erosion is more severe in mountainous than in undulating and plain areas. Soil erosion by water is one of the most serious degradation in the Indian context.

Mulching, vegetation, riprap, matting, terracing, retaining walls and reforestation are common treatments to overcome soil erosion. Biomass mulches, crop rotations, no-till, ridge-till, added grass strips, shelterbelts, contour row-crop plantation are suitable techniques for soil conservation. All these strategies mainly focus on preventing the land from erosion by wind and water force by covering the surface layer with some sort of coverage. Not leaving the land open is the best remedy to prevent soil erosion.

The land degradation due to wind erosion is limited to arid and semiarid regions of India, including the states of Rajasthan, Haryana, Gujarat and Punjab. Removal of natural vegetative cover resulting from excessive grazing and the extension of agriculture to the marginal areas is the major human-induced factors leading to accelerated wind erosion. NBSS & LUP and the Central Soil Water Conservation Research and Training Institute (CSWCRTI) have jointly initiated the preparation of soil erosion maps of different states using the components of Universal Soil Loss Equation obtained from field data available in soil resource maps generated by NBSS.

2. Salinization and Alkalization

Land Degradation occurs due to high concentration of soluble salts, exchangeable sodium or both in such amount that decline the plant growth and soil productivity. Salt-affected soils can be divided into three different categories depending upon the physiochemical properties and nature of salts. The soils are classified into –

i. Saline soil – Soils with excessive soluble salts that retard seed germination and plant growth.
ii. Sodic soil – Soils having high exchangeable sodium concentration but low total soluble salts are called sodic soils.
iii. Saline-sodic soil – Soil contains both excessive soluble salts and high exchangeable sodium content to adversely affect plant growth.

There are two main causes of salilinity –

i. Primary salinity – Primary salinity is a naturally occurring process mostly occur in arid and semi-arid regions where rainfall is low while evapo-transpiration rate is high, thus there is not availability of sufficient water to leach salts down to avoid salinization. Primary salinity is also caused by natural release of some soluble salts in soil by weathering of parent material during soil development process.

ii. Secondary salinity – Secondary salinity is mainly due to disruption in hydrological cycle through the excessive utilization or ineffective supply of water. Various anthropogenic practices such as improper irrigation system and use of poor quality water are the main causes of disruption of hydrological cycle.

Severe salt affected soils have influential role on plant growth both chemically like nutritional effect or toxicity and physically like osmotic effect. Thus due to the effect on plant growth, the quality of agricultural production is reduced. There are three main reasons of soil salinization which can effect plant growth adversely –

i. Osmotic effect hinders water uptake into the plants,
ii. Specific ion effect causes nutritional imbalance in the plants,
iii. Destruction of soil structure and reduction in permeability

Strategies for management of salt affected soil are –

i. **Leaching :** Salt affected soils can be reclaimed by removing the salts from the root zone area of plants either with heavy irrigation or with the drainage.

ii. **Mulching :** It is recommended that the salinity problem become less when process of evaporation will be lowered by mulching or covering the soil. Thus after the fallowing of land mulching will be helpful in controlling the salinity problem.

iii. **Tillage and Amendments :** Tillage practice is considered as the physical practice in reclaiming the problem of sodicity. Tillage cause the fragmentation of the big soil colloids having the high concentration of the sodium and amendments will become the part of the soil and reclaiming process become faster.

iv. **Supplying Calcium to Improve Water Infiltration :** Refining water infiltration property of soil requires lowering of the exchangeable sodium percentage (ESP) along with raising the electrical conductivity (EC). Calcium is basic need in the reclamation process of the sodic soils as it can replace the sodium and that lowering the ESP.

v. **Salt Tolerant Plants :** To choose the plants that have the tolerance against the salinity is the major step in reclamation of the salt affected soils.

3. Acidity

Acidic soils mostly have pH values less than 7 on the pH scale. Acidic soil is observed to have low fertility rates, poor in physical, biological and chemical properties. It is reported that in India, about 6.98 M ha area is affected by acid soils. Based on the range of pH values, the acidic soils have been classified as –

i. Strongly acidic (pH < 4.5);
ii. Moderately acidic (pH 4.5–5.5);
iii. Slightly acidic (pH 5.5–6.5) and
iv. Non-acidic (pH > 6.5).

There are three main causes of soil acidity –

i. **Weathering and Leaching :** The soil form is more acidic in nature if the parent rock and material is acidic.

ii. **Acid Rain :** Rainfall is basically acid due to deposition of oxides of sulphur and nitrogen found in atmosphere due to combustion, burning of coal/petroleum products.

iii. **Application of Acid Forming Fertilizers :** Mostly used chemical fertilizers are ammonium sulphate (AS), urea, muriate of potash and tri-superphosphate, etc. Usage of these chemical fertilizers results in enhanced crop yield, along with this; these chemical fertilizers significantly increase the soil acidification.

The management of acid soils includes –

i. **Liming :** Addition of lime and/or other chemical amendments to correct the acidity and manipulate the agricultural practices so as to obtain optimum crop yields.
ii. **Use of Acid Tolerant Crops : G**row acid tolerant crops and cultivars/varieties and to supplement nutrients through suitable carriers.
iii. **Agroforestry : W**ater management and other agronomic practices.

4. **Soil Organic Carbon Losses**

Alfisols, Ultisols and Oxisols are prone to chemical deterioration owing to nutrient depletion due to pedogenic processes for soil development. In India, nearly 3.7 M ha is deteriorated due to depletion of organic matter. These areas are widely distributed across the country ranging from cultivated areas of subtropical belt to the areas under shifting cultivation. Removal or in-situ burning of crop residues, no or least addition of organic manures, and intensive cultivation are the major reasons for the depletion of soil organic carbon.

Balanced and integrated use of inorganic and organics, management of crop residues, etc. are desirable options for sequestering organic carbon in soils.

5. **Nutrient Imbalance**

Balanced nutrient supply is essential for achieving high crop yields, but excessive and/or imbalanced nutrient inputs may pose risk pressure on the environment, human health and ecosystems. Nutrient losses could occur in many ways, i.e., via emission to the air as NH3, N2O, NO, and N2, and discharge to the water through runoff, leaching and erosion. The nutrient inputs largely vary between regions/states of India. After 1980s, fertilizer was more widely used than manure in agriculturally developed states such as Punjab, Haryana and Orissa. The wide use of fertilizer and booming developed of the livestock production contributed to the vast N losses to the environment.

Both of the N imbalance and the N losses can be improved greatly, without sacrificing the crop yield, such as balanced and integrated use of fertilizers and organic manures, which are effective in increasing crop yields, nutrient use efficiency and minimizing environmental impacts.

6. **Pollution/Contamination by Toxic Substances**

Both geogenic and anthropogenic factors cause pollution/contamination of soil and water resources. There are naturally occurring minerals in aquitards in different regions, which control the concentration of geogenic pollutants, such as arsenic (As), uranium (Ur), fluoride (F), boron (B) and selenium (Se) in alluvial aquifers.

i. People are exposed to arsenic (As) most of the time through drinking groundwater, usually unknowingly. Arsenic contamination in the Gangetic alluvium of West Bengal has assumed the proportion of drinking water related health hazards for millions of people.
ii. In India, the average reported range of uranium (U) in groundwater is from 0.01 to 19.6 μg. Uranium in groundwater drawn from hand pumps and shallow tube-wells (up to the depth of 45 m) was first reported in Punjab State in 1995.
iii. High concentrations of fluoride (F), often significantly above the safe limit of 1 mg, constitute a severe problem in some semi-arid areas. In Punjab, an area of about 1000 ha is affected by selenium (Se) toxicity.

Management strategies are –

i. For arsenic (As) : Under natural conditions, oxi-hydroxides of iron control the concentrations of arsenic in aquifers or surface waters. Under oxidized conditions, iron precipitates as hematite and gets deposited on the surface of particulate suspensions or on the surface of the reservoirs.
ii. For Uranium (U) : Surface water (canal water) has very negligible concentration of Ur and is safe from uranium point of view.
iii. For selenium (Se) : Gypsum application resulted in substantial reduction in Se content in wheat, maize, oats and sugarcane crops grown on such soils.

7. **Soil Sealing and Capping**

Continuous expansions of cities, industries, cantonments and other infrastructures have been usurping fertile and productive soils. Drastic and often irreversible land use changes such as the conversion of forest to agro-industrial land, extractive mining activities, as well as extensive horizontal expansion of cities have been resulting in the soil sealing and capping.

Thus, better management of expanding cities, such as vertical expansion instead of horizontal expansion, adoption of apartment concept instead of individual bungalows, etc, establishment of new cities and industries on waste and unproductive soils would be desirable to protect productive agricultural soils.