Lecture No.2 - Factors affecting soil erosion by water

Erosion by water is known as water erosion. It is the removal of soil from the land's surface by water in motion (runoff). Water erosion is due to the dispersive action and transporting power of water. There is a direct relationship between total runoff and soil loss from agricultural lands. The major factors affecting water erosion are climate, topography, vegetation and soil. It may be expressed as follows:

$$E = f(C,T,V,S)$$

in which E represents the rate of erosion and C,T,V and S stand for climate, topography, vegetation and soil respectively. Climate, the degree of the land and certain physical characteristics of the soil cannot be directly controlled. Their effects, however, may be modified indirectly. For example, the use of bunds and terraces reduce the length of slope.

Climate

The major climatic factors influencing runoff and erosion are rainfall, temperature and wind. Of these rainfall is the most important one. Rainfall and runoff are the two erosive agents for soil erosion by water. The principal effect of raindrops is to detach the soil particles, while the principal effect of surface flow of water (runoff) is to transport the detached soil particles.
The following are the processes in soil erosion.
i. The detaching capacity of the erosive agent.
ii. The detachability of the soil
iii. The transporting capacity of the erosive agent.
iv. The transportability of the soil.

Raindrop impact on a soil surface has a pronounced effect on erosion. Raindrops cause soil splash, detach soil particles and make them available for transportation. When the rate of rainfall exceeds the infiltration rate of the soil, the rain starts moving over the land as surface runoff. The amount, intensity, frequency and duration of rainfall have very definite effects on the amount and the rate of the resultant runoff. A large total rainfall may not cause excessive erosion, if the intensity is low. Likewise, an intense rain of short duration may not produce sufficient runoff to cause erosion. When both amount and intensity factors are high in a given storm runoff, erosion will be serious. The rainfall in monsoon Asia, including India is poorly distributed and falls within a short period.

Topography

The degree of slope and the length of slope are the two main features of topography affecting erosion. The velocity of the runoff water is influenced mainly by the degree of slope. If the land slope is increased four times, the velocity of water flowing over it is doubled. When the velocity is doubled the erosive capacity, as represented by the kinetic energy of the flowing water, is increased about four times. The amount of material of a given size that can be carried is increased about 32 times and the size of particle that can be transported by pushing or rolling is increased about 64 times. On the other hand, any reduction in velocity will result in a deposition of the suspended soil load.

The length of slope is another important factor. Water accumulates over the entire length of the slope, unless the soil and land covers are such as to absorb rain as fast as it falls. The additional volume of water accumulation increases the depth and the velocity. Control of accumulated water at the base of a long slope is difficult.

Vegetation

The following are the major effects of vegetation on soil erosion:

1. Interception of rainfall

A part of rainfall intercepted by the canopy of vegetation never reaches the soil but is evaporated directly from the leaves and stems. The vegetative canopy absorbs the impact of the raindrop and thereby minimizes the dispersion of soil by the rain drops

2. Decreasing runoff velocities

Any vegetative cover is a hindrance to runoff water. A well distributed close growing vegetation not only slows down the rate at which water travels down the slope but also tends to prevent the concentration of water. These two effects greatly reduce the erosive capacity of the runoff water.

3. Root effects

The knitting and binding effect of roots systems in the surface layer of soils aggregates the soil into granules and increases its resistance to erosion. The roots die and decay and leave numerous cavities which increase the pore space and consequently the absorption of water. Studies have shown that a cubic meter of soil has several kilometers of root fibre.

4. Biological influences

The soil fauna are most active in soils having ample vegetative cover. The soil under a thick forest is permeated with the channels of earthworms, beetles and other animals. These channels increase the permeability of the soil. In addition, vegetation increases soil aeration which provides a better environment for the activity of beneficial bacteria.

5. Transportation effects

Vegetation increase the storage capacity of the soil for rainfall by the transpiration of large quantities of moisture from the soil.

Soil

The soil properties influencing erosion by water are the infiltration rate of soil and the resistance of soil to dispersion and erosion. When the rainfall intensity is less than the infiltration capacity of the soil, then there is no runoff. On the other hand, if rain drops could not beat the soil into a state of dispersion, then soil suspension is prevented and there would be no erosion.

The infiltration rate declines with the increase in soil moisture content. The soil structure play a dominant role in determining the infiltration capacity of soils. A coarse sandy soil has very high infiltration rate and permits little runoff from a normal rainfall. Clay and clay loams are fine textured soils with minute pores resulting very slow infiltration. Silt loams, loams and fine sandy loams are the more desirable soils from the point of view of minimizing soil erosion.

Evil effects of soil erosion

Soil erosion is the result of poor management of land. Some of the damages caused by water erosion are given below:

1. Loss of productive soil

The surface soil lost with runoff water consists of rich productive soil and active organic matter. The coarser material is usually deposited on river beds or plains when the velocity of water reduces with the reduction of slope of the riverbed. The deposited soil is transported to the field by the farmers. The colloidal matter, clay, silt and the finest grades of sand are carried into the ocean.

In the plains, fertile lands become unfertile due to deposition of coarser material brought down from the hills by streams and rivers. The deposition of soil in the lakes and reservoirs reduces their storage capacity and shortening their useful life. The deposition of silt in drainage ditches reduces their depth and capacity to handle runoff. As a result, overflow and flooding of downstream area increases, with damage to crops and disaster to man made structures.

2. Lowering of water table

With the increase in runoff, the quantity of water available for entering the soil is decreased. This reduces the supply of water to replenish the groundwater in wells and the yield of the well is reduced.

3. Fragmentations of land

Gullies may divide the farm into many valleys and ridges. Field thus become smaller and more numerous. Crop rows are shortened, movement from field to field is obstructed and the farm value is decreased. Roads, bridges, buildings and fences are often damaged by gully development.