Water Erosion:

Water erosion is judged to be the more serious of the two types and it has been estimated that:

Worldwide up to 75 billion tones of topsoil are eroded every year equating to:

i 9 million ha. of productive land lost

ii 80 % of world's agricultural soils are affected by erosion.

Mechanism of water erosion:

Soil erosion by water is a complex process and is dependent on many interrelated factors. The process is essentially the detachment of particles from the soil, their transport and subsequent deposition. The rate of erosion depends on the climate, soil topography, plant cover and land use. Water erosion process usually begins when raindrops strike unprotected soil on the surface and detach soil particles. The potential ability of rainfall to cause erosion is referred as its erosivity and is a function of the kinetic energy of the rain. The impact of a single raindrop on a wet soil surface is like a bomb blast. Soil aggregates are disrupted and broken into constituent particles by force of the impact. Detachment of soil particles is a function of the erosive forces of raindrop impact and flowing water, the susceptibility of the soil to detachment, the presence of material that reduces the magnitude of eroding forces and the management of the soil that makes it less susceptible to erosion. Detachment occurs when the erosive forces of raindrop impact or flowing water exceed the soil's resistance to erosion.

There is considerable interaction between two major erosion processes of raindrop impact and overland flow. Raindrop impact seals the soil surface and increases the rate of runoff.

The impact of raindrops into runoff water increases its turbulence and the capacity of the flow to transport soil particles. Raindrop impact acting in conjunction with overland flow causes more erosion than when either acts alone.

Major types of water erosion:

Several forms of erosion can be identified based on the processes involved and the relative importance of the effects of detachment and transport by overland flow. The major types/stages of soil erosion by water are as under:

iii. **Raindrop or splash erosion:** It is the first stage of water erosion. Raindrops strike soil surface with great force. Aggregates and clods are broken into smaller particles which are splashed into the air and the surface layer of the soil is compacted and puddle.

iv. **Sheet erosion:** The removal of a fairly uniform layer of soil from the land surface by runoff water is called sheet erosion. So, it is the removal of a thin layer of soil by water acting over the whole surface. Sheet erosion has damaged very fertile lands located on slopes, some of which have been eroded to a depth of about 15 cm. This causes great economic loss because it results in the loss of the most fertile soil layer and diminished soil productivity. Hence, sheet erosion is the removal of a fairly uniform layer of soil from the land surface by raindrop splash and/or runoff. The term sheet erosion has often been used to include all erosions that can be obliterated by tillage. The sheet erosion is a relatively uniform removal of soil and is, therefore, not as visible as rill or gully erosion. The land which is not protected by surface cover, soil is lost from most of the land surface by sheet erosion. The erosion is not greatly affected by the slope of the land or the location on the slope as raindrop impact is relatively uniform over the area of the land.

to wear/remove out

v. **Rill erosion:** It is the process in which numerous small channels of only several centimeters in depth are formed and it occurs mainly on recently cultivated soils. Appearance of small rivulets (depressions/water channels) on the soil surface is called rill erosion. This is transitional phase between sheet erosion and gullying. These small channels can be smoothed out with suitable tillage practices and proper management. Rill erosion is visible on uneven and neglected lands in Pothwar and western hilly areas.

Rill erosion is numerous small channels which can be obliterated by normal tillage. A depth of less than 300 mm may be used as a criterion to distinguish rills from gullies. Such distinction between rills and gullies is useful during erosion survey. For studies of erosion processes, flow characteristics rather than rill depth or size determine whether a set of channels are rills or gullies. Rill erosion results primarily from soil detachment by concentrated runoff. It usually affects only a small proportion of the land surface but is much more visible than inter rill erosion. Rill may develop where runoff is concentrated due to topographic variations or tillage marks. Once rilling begins, it increases rapidly with greater

flow accumulations, so rill erosion increases with the slope length. It also increases with slope steepness.

vi. **Gully erosion:** It is the last stage of water erosion and is the result of constant neglecting of land. Gullies are active as long as their sides are bare. They become inactive when they have been stabilized by vegetation. It causes much more soil loss than any other form of erosion. It may be defined as the process whereby water accumulates in narrow channels and over short periods removes the soil from this narrow area to considerable depths, ranging from 1-2 feet to as much as 75-100 feet.

Gully erosion is the removal of soil by running water resulting in the formation of channels sufficiently large that they disrupt normal farming operations and are too large to be filled during normal cultivation. This distinction between rills and gullies and gullies and streams is arbitrary. The most common gullies are deeper than 300 mm and the gullies are upland drainage ways, continuous or discontinuous, with steep sides and often with headward eroding scarps, usually conveying temporary runoff and drainage areas smaller than 2.6 square kilometers.

Gully erosion involves several interacting processes depending on soil type, landform, land use and climate. Gullies initiate when equilibrium within a minor drainage line is upset by either increased discharge or decreased soil resistance to detachment and transport. Once the equilibrium is disturbed and gullies start forming, much more effort is required to regain stability.

vii. **Tunnel Erosion:** Tunnel erosion may be considered a special type of gully erosion and is sometimes called piping. It is the removal of subsurface soil by water while the surface soil remains relatively intact. This produces long cavities beneath the soil surface which enlarge until the surface soil is no longer supported and collapses forming circular holes from the cavity to the surface. If this process is not checked, further surface collapse converts the cavity into an open gully which continues to grow.

Erosion tunnels range in size from a few centimeters to several meters in diameter and occur under conditions ranging from equatorial rainforest to semi-arid rangelands. Dispersible soil is particularly susceptible to tunnel erosion because it breaks down readily into transportable particles which are moved at low threshold velocity. Clay movement and deposition block soil pores, thus reducing the rate of water movement through the soil body and promoting flow along soil cracks, root holes and rodent burrows. There are 3 main factors that affect tunnel initiation and development.

- Water entry to the soil or a positive head of water
- Water movement within the soil or hydraulic conductivity to allow water movement through the soil
- Soil stability or soil that is unstable to wetting and allows soil particles to be transported in the water flowing through the soil.

The above factors must be considered when developing erosion control techniques for tunnel eroded areas and assessing the potential site susceptibility to tunnel erosion.

viii. **Streambank Erosion:** Streambank erosion is the removal of soil from streambanks by the direct action of stream flow, wind or wave action. It is associated with large water flows such as rivers. Erosion of sediments occurs in the stream channel when the stress applied by stream flow energy exceeds the resistance of the local materials. A number of factors affect the rate at which sediment erosion may occur.

Movement of nutrients and chemicals on sediments moved by water erosion:

Pollution in runoff, seepage or percolation resulting from land management activities has a major impact on water quality. Sources of such pollution include soil erosion and sedimentation on rural and urban land and eroding streambanks, nutrients and organic materials from livestock wastes and agricultural land and storm water from urban areas. Nutrients such as phosphorus are strongly adsorbed on clay particles and transported by soil erosion processes. Phosphorus is a major contributor to blue green algae outbreaks in rivers and storages.

Mechanics of Water Erosion:

Soil erosion by water is fundamentally a three step process.

I. Detachment of soil particles from the soil mass.
II. Transportation of the detached particles downhill by floating, rolling, dragging and splashing.
III. Deposition of the transported particles at some place lower in elevation.

On comparatively smooth soil surfaces, beating action of raindrops causes most of the detachment. Where water is concentrated into channels, the cutting action of turbulent flowing water detaches soil particles. In some situations, freezing-thawing action also contributes to soil detachment.

Influence of Raindrops:

A raindrop accelerates as it falls until it reaches terminal velocity (the speed at which friction between the drop and the air balances the force of gravity). Larger raindrops fall faster, reaching a terminal velocity of about 30 km/h, or about as fast as a person can run. As the speeding raindrops impact soil with explosive force, they transfer their high kinetic energy to the soil particles.

Raindrop impact exerts three important detrimental effects:

a) It detaches soil
b) It destroys granulation
c) Its splash, under certain conditions, causes an appreciable transportation of soil.

So great is the force exerted by raindrops that they not only loosen and detach soil granules but may even beat granules to pieces. Hence, most of erosion is initiated by the impact of raindrops rather than the flow of running water.

Prevention of water erosion:

1) Reduce run off onto fields from farm roads, tracks and areas of concrete by provision of adequate drains and ditches.
2) Maintain land drains, ditches and outlets to ensure effective field drainage.
3) Remove sediment that has deposited in ditches and drains and if possible place it back form where it came (i.e. in the field).
4) Develop stable topsoil's by using bulky organic manures.
5) Protect soil in winter by early sowing or use of cover crops.
6) Take care when irrigating to avoid run off.
7) Work across slopes whenever possible, complex slope patterns may cause run off and formation of gullies.
8) Minimum or non inversion tillage will incorporate straw residues into the surface of the soil and help prevent erosion.
9) Do not roll seedbeds as this will lead to run off and erosion.
10) Avoid surface compaction, rectify any problems before drilling.

If there is still a problem further action could be taken:

i. Introduce grass into rotation, possibly on set aside areas.
ii. Plant hedges, build new ditches, divert water away from vulnerable areas.
iii. Create permanent strips of grass or rough vegetation as buffer zones to slow down run off and trap soil at critical places on a slope or at the bottom of a field.