

Soil Erosion and Its Control Measures

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INTRODUCTION

Soil erosion is one of the most serious forms of land degradation affecting agricultural productivity and environmental sustainability across the world. It refers to the detachment, transportation, and deposition of soil particles by natural forces such as water and wind, or through anthropogenic activities like deforestation, overgrazing, and improper land management. Topsoil, which is the most fertile layer rich in organic matter and nutrients, is the first to be lost during erosion. Since soil formation is an extremely slow process, the loss of even a few millimetres of topsoil can take decades or centuries to recover. Soil erosion not only reduces crop yields but also causes sedimentation in rivers and reservoirs, lowers water quality, and contributes to climate change through the loss of soil organic carbon. Therefore, understanding its types, causes, and control measures is essential for sustainable agriculture and environmental conservation.

2. Types of Soil Erosion

Soil erosion occurs in several forms depending on the agent responsible and the manner in which soil is removed.

2.1 Water Erosion

Water erosion is the most common and destructive form of soil erosion, especially in regions with high rainfall or improper drainage systems. It occurs when raindrops strike bare soil with force, dislodging soil particles, which are then carried away by surface runoff. Water erosion is further classified into sheet, rill, and gully erosion.

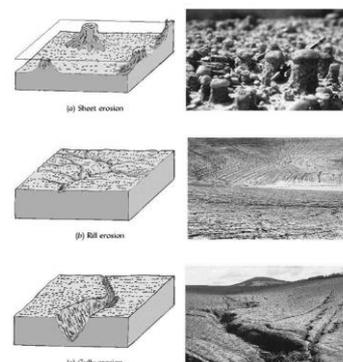


Figure 1: Types of Soil Erosion (Sheet, Rill and Gully).

Sheet Erosion

Sheet erosion is the uniform removal of a thin layer of soil over a large area. It is often unnoticed because it does not create visible channels, yet it gradually removes fertile topsoil and reduces soil productivity. Farmers may not realize its severity until crop yields begin to decline.

Rill Erosion

Rill erosion occurs when small channels or rivulets form on the soil surface due to flowing water. These channels are shallow and can often be removed by normal tillage, but repeated occurrence leads to significant soil loss and nutrient depletion.

Gully Erosion

Gully erosion is an advanced stage of rill erosion where deep and wide channels are formed due to continuous runoff. Gullies are difficult to reclaim and may render agricultural land unusable. This type of erosion is common in sloping lands and areas with poor vegetation cover.

2.2 Wind Erosion

Wind erosion is predominant in arid and semi-arid regions where vegetation cover is sparse and soils are dry, loose, and sandy. Strong winds lift and transport fine soil particles over long distances, leading to loss of soil fertility and air pollution.

Wind erosion occurs through three main processes: suspension, saltation, and surface creep. It is particularly harmful because it removes nutrient-rich fine particles and organic matter, leaving behind coarse and less productive soil.

3. Causes and Contributing Factors of Soil Erosion

3.1 Natural Factors

Natural environmental conditions play a major role in initiating soil erosion. Heavy rainfall, steep slopes, and high wind velocity increase the kinetic energy acting on soil particles, making

them more vulnerable to detachment and transport. Regions with intense storms or prolonged dry winds experience faster soil degradation.

3.2 Anthropogenic (Human-Induced) Factors

Human activities significantly accelerate soil erosion beyond natural limits. Practices such as deforestation, intensive and frequent tillage, monocropping, overgrazing, mining, and unplanned urbanization disturb soil structure and reduce vegetation cover, leading to rapid soil loss and land degradation.

3.3 Vegetation Removal

The removal of natural plant cover exposes the soil surface directly to raindrop impact and wind forces. Vegetation normally acts as a protective shield by binding soil with roots and reducing runoff velocity. Without it, erosion risk increases drastically.

3.4 Improper Irrigation and Water Management

Unsuitable irrigation practices, such as excessive flooding or poor drainage systems, may create surface runoff, waterlogging, and channel formation. These conditions weaken soil aggregates and enhance erosion processes.

3.5 Soil Texture and Structure

The inherent physical characteristics of soil also influence erosion susceptibility. Sandy soils are loose and easily carried away by wind, whereas silty soils are more vulnerable to water erosion due to weak aggregation. Well-structured clay soils generally resist erosion better when organic matter is adequate.

4. Control Measures and Conservation Practices

Effective soil conservation requires a combination of mechanical, biological, and agronomic measures designed to reduce soil detachment and runoff velocity while improving soil structure and vegetation cover.

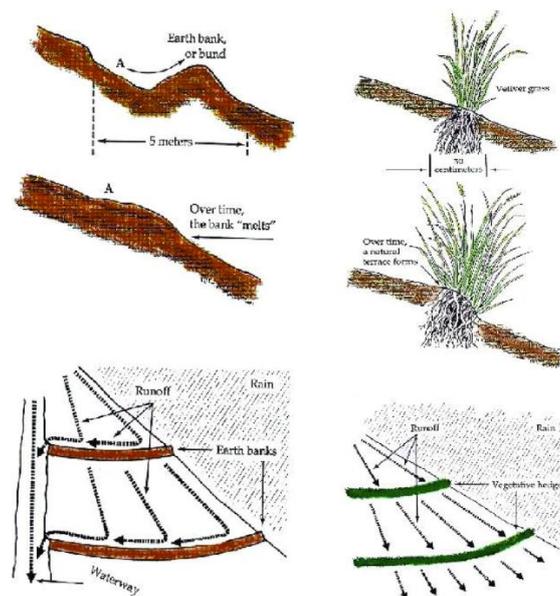


Figure 2: Contour Bunding and Vegetative Barriers.

4.1 Contour Bunding

Contour bunding involves constructing embankments or ridges along the natural contours of sloping land. These bunds slow down water flow, promote infiltration, and prevent the formation of rills and gullies. Contour farming also encourages uniform distribution of moisture and nutrients, enhancing crop productivity in rainfed regions.

4.2 Terracing

Terracing is a mechanical method commonly practiced in hilly and mountainous areas. It converts steep slopes into a series of flat steps or platforms, reducing slope length and runoff speed. Terraces not only control erosion but also improve water retention and allow cultivation on otherwise unproductive slopes.

4.3 Cover Crops

Cover crops such as legumes, grasses, and green manure crops protect the soil surface from direct raindrop impact and wind forces. Their roots bind soil particles together, increase organic matter, and enhance microbial activity. Cover cropping also suppresses weeds, improves soil structure, and contributes to nutrient cycling, making it a cost-effective conservation practice.

4.4 Additional Measures

Other effective practices include strip cropping, mulching, agroforestry, windbreaks, conservation tillage, and afforestation. Mulching

reduces evaporation and surface runoff, while windbreaks consisting of tree rows reduce wind speed and protect large fields from erosion. Conservation tillage minimizes soil disturbance, preserving soil aggregates and organic matter.

5. Link with Climate Change

Soil erosion and climate change are closely interconnected. Climate change increases the frequency and intensity of extreme weather events such as heavy rainfall, droughts, and storms, all of which accelerate soil erosion. Intense rainfall events lead to severe runoff and gully formation, while prolonged droughts dry the soil, making it vulnerable to wind erosion. Conversely, soil erosion contributes to climate change by releasing stored soil organic carbon into the atmosphere as carbon dioxide. Loss of vegetation and soil degradation reduce the land's capacity to sequester carbon, thereby intensifying greenhouse gas concentrations. Sustainable soil management practices such as conservation agriculture, afforestation, and residue retention help mitigate climate change by reducing erosion and enhancing carbon storage.

6. Environmental and Agricultural Impacts

The consequences of soil erosion extend beyond reduced crop yields. Sedimentation of rivers and reservoirs decreases water storage capacity and increases flood risks. Nutrient-laden sediments may lead to eutrophication of water bodies,

affecting aquatic ecosystems. Loss of soil fertility forces farmers to rely heavily on chemical fertilizers, raising production costs and environmental pollution. Biodiversity also declines as soil organisms lose their habitat and food sources.

CONCLUSION

Soil erosion is a silent but severe threat to global food security and environmental sustainability. Its various forms - wind, sheet, rill, and gully erosion gradually degrade fertile land and disrupt ecological balance. However, through integrated conservation practices such as contour bunding, terracing, cover cropping, agroforestry, and conservation tillage, soil loss can be effectively minimized. Addressing soil erosion is not only essential for maintaining agricultural productivity but also for combating climate change and preserving natural resources for future generations. Sustainable land management and farmer awareness are key to ensuring long-term soil health and environmental resilience.

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