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Soil Erosion: Processes, Causes, Effects and Preventable measures

Soil Erosion

Soil erosion is, at its core, a natural process. Put simply, it is when topsoil, which is the upper-most layer of the ground, is moved from one spot to another. Why this matters is because topsoil is the part of the land that is highest in organic matter and best suited for farming and other fertile activities, which is why soil erosion can have the greatest impact on farmers and agricultural land. In other words, soil erosion is a naturally occurring and slow process that refers to loss of field's top soil by water and wind or through conversion of natural vegetation to agricultural land.

When farming activities are carried out, the top soil is exposed and is often blown away by wind or washed away by rain. When soil erosion occurs, the movement of the detached topsoil is typically facilitated by either a natural process – such as wind or water movement – or by the impact of man, such as through tilling farmland.

Processes of Soil Erosion

Rainfall and surface runoff

Rainfall, and the surface runoff which may result from rainfall, produces four main types of soil erosion: splash erosion, sheet erosion, rill erosion, and gully erosion. Splash erosion is generally seen as the first and least severe stage in the soil erosion process, which is followed by sheet erosion, then rill erosion and finally gully erosion (the most severe of the four).

In **splash erosion**, the impact of a falling raindrop creates a small crater in the soil, ejecting soil particles. The distance these soil particles travel can be as much as 0.6 m (two feet) vertically and 1.5 m (five feet) horizontally on level ground.

If the soil is saturated, or if the rainfall rate is greater than the rate at which water can infiltrate into the soil, surface runoff occurs. If the runoff has sufficient flow energy, it will transport loosened soil particles (sediment) down the slope. Sheet erosion is the transport of loosened soil particles by overland flow.

Rill erosion refers to the development of small, ephemeral concentrated flow paths which function as both sediment source and sediment delivery systems for erosion on hill slopes. Generally, where water erosion rates on disturbed upland areas are greatest, rills are active. Flow depths in rills are typically of the order of a few centimetres (about an inch) or less and along-channel slopes may be quite steep. This means that rills exhibit hydraulic physics very different from water flowing through the deeper, wider channels of streams and rivers.

Gully erosion occurs when runoff water accumulates and rapidly flows in narrow channels during or immediately after heavy rains or melting snow, removing soil to a considerable depth.

Rivers and streams

Valley or *stream erosion* occurs with continued water flow along a linear feature. The erosion is both downward, deepening the valley, and headword, extending the valley into the hillside, creating head cuts and steep banks. In the earliest stage of stream erosion, the erosive activity is dominantly vertical, the valleys have a typical **V** cross-section and the stream gradient is relatively steep. When some base level is reached, the erosive activity switches to lateral erosion, which widens the valley floor and creates a narrow floodplain. The stream gradient becomes nearly flat, and lateral deposition of sediments becomes important as the stream meanders across the valley floor. In all stages of stream erosion, by far the most erosion occurs during times of flood, when more and faster-moving water is available to carry a larger sediment load. In such processes, it is not the water alone that erodes: suspended abrasive particles, pebbles and boulders can also act erosively as they traverse a surface, in a process known as traction.

Bank erosion is the wearing away of the banks of a stream or river. This is distinguished from changes on the bed of the watercourse, which is referred to as scour. Erosion and changes in the form of river banks may be measured by inserting metal rods into the bank and marking the position of the bank surface along the rods at different times.

Thermal erosion is the result of melting and weakening permafrost due to moving water. It can occur both along rivers and at the coast. Rapid river channel migration observed in the Lena River of Siberia is due to thermal erosion, as these portions of the banks are composed of permafrost-cemented non-cohesive materials. Much of this erosion occurs as the weakened banks fail in large slumps. Thermal erosion also affects the Arctic coast, where wave action and near-shore temperatures combine to undercut permafrost bluffs along the shoreline and cause them to fail. Annual erosion rates along a 100-kilometre (62-mile) segment of the Beaufort Sea shoreline averaged 5.6 metres (18 feet) per year from 1955 to 2002.

Floods

At extremely high flows, kolks, or vortices are formed by large volumes of rapidly rushing water. Kolks cause extreme local erosion, plucking bedrock and creating pothole-type geographical features called Rock-cut basins. Examples can be seen in the flood regions result from glacial Lake Missoula, which created the channelled scablands in the Columbia Basin region of eastern Washington.

Wind erosion

Wind erosion is a major geomorphological force, especially in arid and semi-arid regions. It is also a major source of land degradation, evaporation, desertification, harmful airborne dust, and crop damage—especially after being increased far above natural rates by human activities such as deforestation, urbanization, and agriculture.

Wind erosion is of two primary varieties: deflation, where the wind picks up and carries away loose particles; and abrasion, where surfaces are worn down as they are struck by airborne particles carried by wind. Deflation is divided into three categories: (1) surface creep, where larger, heavier particles slide or roll along the ground; (2) saltation, where particles are lifted a short height into the air, and bounce and saltate across the surface of the soil; and (3) suspension, where very small and light particles are lifted into the air by the wind, and are often carried for long distances. Saltation is responsible for the majority (50–70%) of wind erosion, followed by suspension (30–40%), and then surface creep (5–25%). Silty soils tend to be the most affected by wind erosion; silt particles are relatively easily detached and carried away.

Wind erosion is much more severe in arid areas and during times of drought. For example, in the Great Plains, it is estimated that soil loss due to wind erosion can be as much as 6100 times greater in drought years than in wet years.

Mass movement

Mass movement is the downward and outward movement of rock and sediments on a sloped surface, mainly due to the force of gravity.

Mass movement is an important part of the erosional process, and is often the first stage in the breakdown and transport of weathered materials in mountainous areas. It moves material from higher elevations to lower elevations where other eroding agents such as streams and glaciers can then pick up the material and move it to even lower elevations. Mass-movement processes are always occurring continuously on all slopes; some mass-movement processes act very slowly; others occur very suddenly, often with disastrous results. Any perceptible down-slope movement of rock or sediment is often referred to in general terms as a landslide. However, landslides can be classified in a much more detailed way that reflects the mechanisms responsible for the movement and the velocity at which the movement occurs. One of the visible topographical manifestations of a very slow form of such activity is a scree slope.

Slumping happens on steep hillsides, occurring along distinct fracture zones, often within materials like clay that, once released, may move quite rapidly downhill. They will often show a spoon-shaped isostatic depression, in which the material has begun to slide downhill. In some cases, the slump is caused by water beneath the slope weakening it. In many cases it is simply the result of poor engineering along highways where it is a regular occurrence.

Surface creep is the slow movement of soil and rock debris by gravity which is usually not perceptible except through extended observation. However, the term can also describe the rolling of dislodged soil particles 0.5 to 1.0 mm (0.02 to 0.04 in) in diameter by wind along the soil surface.

Causes of Soil Erosion

All soils undergo soil erosion, but some are more vulnerable than others due to human activities and other natural causal factors. The severity of soil erosion is also dependent on the soil type and the presence of vegetation cover. Here are few of the major causes of soil erosion.

1. **Rainfall and Flooding**

Greater duration and intensity of rainstorm means greater potential for soil erosion. Rainstorm produces four major types of soil erosion including rill erosion, gully erosion, sheet erosion, and splash erosion. These types of erosions are caused by the impacts of raindrops on the soil surface that break down and disperse the soil particles, which are then washed away by the storm water runoff.

Over time, repeated rainfall can lead to significant amounts of soil loss. Rapidly moving storm water, flash floods, and flooding may also occur because of excess surface water runoff, thus, causing extreme local erosion by plucking bed rocks, forming rock cut-basins, creating potholes, and washing away the loosened soil particles.

2. **Rivers and Streams**

The flow of rivers and streams causes valley erosion. The water flowing in the rivers and streams tend to eat away the soils along the water systems leading to a V-shaped erosive activity. When the rivers and streams are full of soil deposits due to sedimentation and the valley levels up with the surface, the water ways begin to wash away the soils at the banks.

This erosive activity is termed as lateral erosion which extends the valley floor and brings about a narrow floodplain. This erosive activity is evident in most rivers or streams especially during heavy rainfall and rapid river channel movement.

2. **High Winds**

High winds can contribute to soil erosion, particularly in dry weather periods or in the arid and semi-arid (ASAL) regions. The wind picks up the loose soil particles with its natural force and carries them away to far lands, leaving the soil sculptured and denudated. It is severe during the times of drought in the ASAL regions. Hence, wind erosion is a major source of soil degradation and desertification.

4. **Overgrazing, Overstocking and Tillage Practices**

The transformation of natural ecosystems to pasture lands has largely contributed to increased rates of soil erosion and the loss of soil nutrients and the top soil. Overstocking and overgrazing has led to reduced ground cover and break down of the soil particles, giving room for erosion and accelerating the erosive effects by wind and rain. This reduces soil quality and agricultural productivity.

Agricultural tillage depending on the machinery used also breaks down the soil particles, making the soils vulnerable to erosion by water. Up and down field tillage practices as well create pathways for surface water runoff and can speed up the soil erosion process.

5. **Deforestation, Reduced Vegetation Cover, and Urbanization**

Deforestation and urbanization destroy the vegetation land cover. Agricultural practices such as burning and clearing of vegetation also reduce the overall vegetation cover. As a result, the lack of land cover causes increased rates of soil erosion.

Trees and vegetation cover help to hold the soil particles together thereby reduces the erosive effects of erosion caused by rainfall and flooding. Deforestation and urbanization are some of the human actions that have continued the cycle of soil loss.

6. **Mass Movements and Soil Structure/Composition**

The outward and downward movements of sediments and rocks on slanting or slope surfaces due to gravitational pull qualify as an important aspect of the erosion process. This is because mass movements aids in the breakdown of the soil particles that makes them venerable to water and wind erosion. Soil structure and composition is another factor that determines erosivity of wind or rainfall.

For instance, clay soils tend to be more resistant to soil erosion compared to sandy or loose silt soils. Soil moisture content and organic matter make up are some of the soil component aspects that determine erosivity of wind or rainfall.

Effects of Soil Erosion

The consequences of soil erosion are primarily cantered on reduced agricultural productivity as well as soil quality. Water ways may also be blocked, and it may affect water quality. This means most of the environmental problems the world face today arises from soil erosion. The effects of soil erosion include:

1. **Loss of Arable Land**

Lands used for crop production have been substantially affected by soil erosion. Soil erosion eats away the top soil which is the fertile layer of the land and also the component that supports the soil's essential microorganisms and organic matter. In this view, soil erosion has severely threatened the productivity of fertile cropping areas as they are continually degraded.

Because of soil erosion, most of the soil characteristics that support agriculture have been lost, causing ecological collapse and mass starvation. It is likely that most of the cultivated areas around the globe are vulnerable to soil erosion.

2. **Water Pollution and Clogging of Waterways**

Soils eroded from agricultural lands carry pesticides, heavy metals, and fertilizers which are washed into streams and major water ways. This leads to water pollution and damage to marine and freshwater habitats. Accumulated sediments can also cause clogging of water ways and raises the water level leading to flooding.

The water quality of various streams, rivers, and coastal areas has also been deteriorated as a result of soil erosion, eventually affecting the health of the local communities.

3. **Sedimentation and Threat to Aquatic Systems**

Apart from polluting the water systems, high soil sedimentation can be catastrophic to the survival of aquatic life forms. Silt can smother the breeding grounds of fish and equally lessens their food supply since the siltation reduces the biodiversity of algal life and beneficial aquatic plants.Sediments may also enter the fish gills, affecting their respiratory functions.

4. **Air Pollution**

Wind erosion picks up dust particles of the soil and throws them into the air, causing air pollution. Some of the dust particles may contain harmful and toxic particles such as petroleum and pesticides that can pose a severe health hazard when inhaled or ingested.

Dust plumes from the deserts or dry areas can cause large and widespread air pollution as the winds move. Such a case is evident in North America where dust winds from the Gobi desert have recurrently been a serious problem.

5. **Destruction of Infrastructure**

Soil erosion can affect infrastructural projects such as dams, drainages, and embankments. The accumulation of soil sediments in dams/drainages and along embankments can reduce their operational lifetime and efficiency. Also, the silt up can support plant life that can, in turn, cause cracks and weaken the structures. Soil erosion from surface water runoff often causes serious damage to roads and tracks, especially if stabilizing techniques are not used.

6. **Desertification**

Soil erosion is a major driver of desertification. It gradually transforms a habitable land and the ASAL regions into deserts. The transformations are worsened by the destructive use of the land and deforestation that leaves the soil naked and open to erosion. This usually leads to loss of biodiversity, alteration of ecosystems, land degradation, and huge economic losses.

Ways to Prevent Soil Erosion

1. Planting Vegetation as ground cover: Farmers plant trees and grass to cover and bind the soil. Plants prevent wind and water erosion by covering the soil and binding the soil with their roots. The best choice of plants to prevent soil erosion is herbs, wild flowers and small trees. Some excellent plants that help to prevent soil erosion are creepers because instead of growing straight up, they spread on the ground by crawling around.

2. Applying Mulches: Mulching soil, greatly help in soil erosion control. Mulching is done by putting dead leaves and shredded wood on the soil. Mulching acts as a protective covering for the tree and plants against extreme weathers. Mulching allows water to reach the soil slowly, and thus reduce the impact of rainfall or heavy watering. Mulches help to prevent the soil from turning acidic and suppresses weeds from growing. Over time, mulches made from organic materials break down and increase soil's structure and fertility.

3. Matting the soil: Matting is the process of covering the soil with biodegradable materials that include mulch, straw, coconut fibre and wood chips. These are held together with biodegradable netting made from coco coir. It is like covering the soil with a biodegradable carpet. Biodegradable spikes are used to hold the matting material in place. Biodegradable means it can decompose or decay and turn to soil fertilizer. Plastic in non biodegradable that is why it is not good for the environment.

4. Contour farming and terracing: The practice of tilling sloped land along lines of consistent elevation in order to conserve rainwater and to reduce soil losses from surface erosion. Contour farming act as reservoirs to catch and retain rainwater, thus permitting increased infiltration and more uniform distribution of the water.

5. Creation of windbreakers by planting evergreen trees around gardens or farmland, to prevent the wind blowing away the soil. Windbreakers helps in protecting crops from damage caused by strong & severe wind and improve plant health, quality and yield. Crop protected from wind are able to retain significantly more moisture.