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1. Impact on Soil Erosion in Sustainable Agriculture

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Abstract

Soil erosion is agriculture's enemy: a major environmental threat to sustainability and productivity with knock-on effects on the climate crisis and food security. Soil is the most fundamental and basic natural resource for all life to survive. Water and wind erosion are two main agents that degrade soils. Runoff washes away the soil particles from sloping and bare lands while wind blows away loose and detached soil particles from flat and unprotected lands. Geologic erosion is a normal process of weathering that generally occurs at low rates in all soils as part of the natural soil-forming processes. Magnitude and the impacts of soil erosion on productivity depend on soil profile and horizonation, terrain, soil management, and climate characteristics. There are so many factors and processes are responsible for soil erosion. For sustainable agriculture and environment, it is pertinent to protect the soil resources against erosion. Different control measures should be adopted to protect the soil resources against erosion.

Keywords: Soil, Soil erosion, Conservation, Control measures.

1.1 Introduction:

Soil is the most fundamental and basic natural resource for all life to survive. Soil erosion, the removal of soil by water and wind, is the most common and extensive. Natural or geologic erosion ranges from very little in undisturbed lands to extensive in steep arid lands. Geological erosion takes place, as a result of the action of water, wind, gravity and glaciers and it takes place, at such slow rates that the loss of soil is compensated for the formation of new soil under natural weathering processes. It is sometimes referred to as normal erosion. Accelerated erosion caused by the disturbances of people (cutting forests, cultivating lands, constructing roads and buildings etc.) and is increasing as the population increases. In this erosion, the removal of soil takes place at a much faster rate than that of soil formation. It is also referred to as abnormal erosion.

It is impossible to stop all erosion completely, but can be minimized. Human activities have increased by 10–50 times the rate at which erosion is occurring globally. Excessive (or accelerated) erosion causes both "on-site" and "off-site" problems. On-site impacts include decreases in agricultural productivity and (on natural landscapes) ecological collapse, both because of loss of the nutrient-rich upper soil layers. In some cases, the eventual end result is desertification. Off-site effects include sedimentation of waterways and eutrophication of water bodies, as well as sediment-related damage to roads and houses.

Water and wind erosion are the two primary causes of land degradation; combined, they are responsible for about 84% of the global extent of degraded land, making excessive erosion one of the most significant environmental problems worldwide.

Intensive agriculture, deforestation, roads, anthropogenic climate change and urban sprawl are amongst the most significant human activities in regard to their effect on stimulating erosion. However, there are many prevention and remediation practices that can curtail or limit erosion of vulnerable soils.

Techniques to control water and wind erosion usually result in maintaining or increasing soil productivity also.

1.2 Gravity Erosion:

Mass-Wasting is the down-slope movement of rock and sediments, mainly due to the force of gravity. Mass-wasting is an important part of the erosional process, as it moves material from higher elevations to lower elevations where transporting agents like streams and glaciers can then pick up the material and move it to even lower elevations. Mass-wasting processes are occurring continuously on all slopes; some mass-wasting processes act very slowly. Slumping happens on steep hillsides, occurring along distinct fracture zones, often within materials like clay that, once released, may move quite rapidly downhill. Surface creep is the slow movement of soil and rock debris by gravity which is usually not perceptible except through extended observation.

1.3 Water Borne Soil Erosion:

Water erosion of soil starts when raindrops strike bare soil peds and clods, resulting the finer particles to move with the flowing water as suspended sediments. The soil along with water moves downhill, scouring channels along the way. Each subsequent rain erodes further amounts of soil until erosion has transformed the area into barren soil.

- **Causes of Water Borne Soil Erosion:**

Water erosion is due to the dispersive action, and transporting power of water-water as it descends in the rain and leaves the land in the form of run-off.

Water erosion caused by people who remove protective plant covers by tillage operation, burning crop residues, overgrazing, over cutting forests etc. including loss of soil.

1.4 Forms of Water Soil Erosion:

The major forms of water-borne soil erosion are:

a. Raindrop splash erosion
b. Sheet erosion
c. Rill erosion

a. Gully erosion
b. Bank erosion
c. Stream channel erosion

a. Raindrop Splash Erosion:

Raindrop splash erosion results from soil splash caused by the impact of falling rain drops. There are four factors that determine the rate of rain drop erosion namely, climate (mostly rainfall and temperature), soil- (its inherent resistance to dispersion and its infiltration rate), topography particularly steepness and length of slope, and vegetative cover-either living or the residues of dead vegetation.

The continued impact of raindrops compacts the soil and further seals the surface- so that water cannot penetrate into the soil and as a result causing more surface run-off. The impact of the raindrops per unit area is determined by the number and size of the drops, and the velocity of the drops.

b. Sheet Erosion:

Sheet erosion is the movement of soil from raindrop splash and runoff water. It typically occurs evenly over a uniform slope and goes unnoticed until most of the productive topsoil has been lost.

It is common on lands having a gentle or mild slope, and results in the uniform "skimming off of the cream" of the top soil with every hard rain. Deposition of the eroded soil occurs at the bottom of the slope or in low areas. Lighter-coloured soils on knolls, changes in soil horizon thickness and low crop yields on shoulder slopes and knolls are other indicators. In this erosion, shallow soils suffer greater reduction in productivity than deep soils. Movement of soil by rain drop splash is the primary cause of sheet erosion.

c. Rill Erosion:

Rill erosion is the removal of soil by concentrated water running through little streamlets, or head cuts. Detachment in a rill occurs if the sediment in the flow is below the amount the load can transport and if the flow exceeds the soil's resistance to detachment. As detachment continues or flow increases, rills will become wider and deeper. Rill erosion mainly occurs as a result of concentrated overland flow of water leading to the development of small well-defined channels. These channels act as sediment sources and transport passages, leading to soil loss. Rill erosion is more apparent than sheet erosion. This type of soil erosion may be regarded as a transition stage between sheet and gully erosion.

d. Gully Erosion:

Gully erosion is an advanced stage of rill erosion. A gully is a distinct channel, carved into a hillslope or valley bottom by intermittent or ephemeral runoff. Such channels are carved where the force exerted by flowing water – a function of its mass.

During every rain, the rain water rushes down these gullies, increasing their width, depth and length. Gully erosion is more spectacular and therefore, more noticeable than any other erosion.

- **The Development of Gully Occurs Due to Following Four Stages:**

a. Formation stage- with channel erosion by a downward scour of the surface soil.
b. Development stage- consisting of upstream movement of the gully head and enlargement of the gully in width and depth.
c. Healing stage- beginning with the growing of vegetation in the gully.
d. Stabilization stage- the gully reaches a stable gradient, gully walls reach a stable slope, and vegetative cover spreads over the gully surface.

- **Classification of Gully Erosion:**

a. Very small gullies (G1) - deep up to 3m, width not greater than 18m, side slopes vary.
b. Small gullies (G2)- deep up to 3m, width greater than 18m, side slopes between 8 to 15%
c. Medium gullies (G3)- deep between 3 to 9m, width not less than 18m, side slopes between 8 to 15%
d. Deep and narrow gullies (G4) - deep 9m, width varies, side slopes mostly steep or even vertical with intricate and active branch gullies.

e. Bank Erosion:

Bank erosion is the wearing away of the banks of a stream or river. This is distinguished from erosion of the bed of the watercourse, which is referred to as scour. Natural streams and constructed drainage channels act as outlets for surface water runoff and subsurface drainage systems. Bank erosion is the progressive undercutting, scouring and slumping of these drainage ways. There are three main processes that cause bank erosion (scour, mass failure and slumping), and it is essential to determine which are operating at any particular site because the management required to slow or prevent them may differ. Bank scour is the direct removal of bank materials by the physical action of flowing water and is often dominant in smaller streams and the upper reaches of larger streams and rivers. Mass failure, which includes bank collapse and slumping, is where large chunks of bank material become unstable and topple into the stream or river in single events. Mass failure is often dominant in the lower reaches of large streams and often occurs in association with scouring of the lower banks.

f. Stream Channel Erosion:

Stream channel erosion is the scouring of material from the water channel and the cutting of banks by flowing or running water. This erosion occurs at the lower end of stream tributaries and to streams that have nearly continuous flow and relatively flat gradients. Stream but erode either by run-off flowing over the side of the stream bank, or by scouring or undercutting. Scouring is influenced by the velocity and direction of flow, depth and width of the channel and soil texture.

1.4.1 Effects of Water Erosion On- Site:

- The main on-site impact is the reduction in soil quality which results from the loss of the nutrient-rich upper layers of the soil, and the reduced water-holding capacity of many eroded soils. The breakdown of aggregates and the removal of smaller particles or entire layers of soil or organic matter can weaken the structure and even change the texture.
- Textural changes can in turn affect the water-holding capacity of the soil, making it more susceptible to extreme conditions such as drought. Crop emergence, growth and yield are directly affected by the loss of natural nutrients and applied fertilizers.
- Seeds and plants can be disturbed or completely removed by the erosion.
- Organic matter from the soil, residues and any applied manure, is relatively lightweight and can be readily transported off the field, particularly during spring thaw conditions.
- Pesticides may also be carried off the site with the eroded soil.
- Soil quality, structure, stability and texture can be affected by the loss of soil.

1.4.2 Effects of Water Erosion Off-Site:

In addition to its on-site effects, the soil that is detached by accelerated water or wind erosion may be transported considerable distances. This gives rise to 'off-site problems'.

- Water erosion’s main off-site effect is the movement of sediment and agricultural pollutants into watercourses. This can lead to the silting-up of dams, disruption of the ecosystems of lakes, and contamination of drinking water. In some cases, increased downstream flooding may also occur due to the reduced capacity of eroded soil to absorb water.
- Sediment can accumulate on down-slope and contribute to road damage. Sediment that reaches streams or watercourses can accelerate bank erosion, obstruct stream and drainage channels, fill in reservoirs, damage fish habitat and degrade downstream water quality.
- Pesticides and fertilizers, frequently transported along with the eroding soil, contaminate or pollute downstream water sources, wetlands and lakes.
- Rapid bank erosion leads to loss of valuable land, reduced water quality as sediment and nutrients enters the stream, as well as threatening infrastructure such as roads, bridges and buildings.
- Stream bank erosion is the dominant source of sediment in many river systems.

1.4.3 Harmful Effects of Water Erosion:

Water erosion causes various damages to the land as follows:

- Loss of top fertile soil.
- Accumulation of sand or other unproductive coarse soil materials on other productive lands.
- Silting of lakes and reservoirs.
- Silting of drainage and water channels.

- Decreases water table.
- Fragmentation of land.

1.4.4 Factors Affecting Water Erosion

The rate and magnitude of soil erosion by water is controlled by the following factors:

a. Rainfall and runoff
b. Soil Erodibility
c. Slope gradient and length
d. Cropping and vegetation
e. Tillage practices

a. Rainfall and Runoff:

The greater the intensity and duration of a rainstorm, the higher the erosion potential. The impact of raindrops on the soil surface can break down soil aggregates and disperse the aggregate material. Lighter aggregate materials such as very fine sand, silt, clay and organic matter are easily removed by the raindrop splash and runoff water. Soil movement by rainfall (raindrop splash) is usually greatest and most noticeable during short-duration, high-intensity thunderstorms. Surface water runoff occurs whenever there is excess water on a slope that cannot be absorbed into the soil. Reduced infiltration due to soil compaction, crusting or freezing increases the surface runoff and soil erosion. Runoff from agricultural land is greatest when compared with other land areas.

b. Soil Erodibility:

Soil Erodibility – susceptibility of soil to agent of erosion - is determined by inherent soil properties e.g., texture, structure, soil organic matter content, clay minerals, exchangeable cations and water retention and transmission properties. Climatic erosivity includes drop size distribution and intensity of rain, amount and frequency of rainfall, run-off amount and velocity, and wind velocity. Important terrain characteristics for studying soil erosion are slope gradient, length, aspect and shape.

Ground cover exerts a strong moderating impact on dissipating the energy supplied by agents of soil erosion. Soil Erodibility is an estimate of the ability of soils to resist erosion, based on the physical characteristics of each soil. Texture is the principal characteristic affecting Erodibility, but structure, organic matter and permeability also contribute. Generally, soils with faster infiltration rates, higher levels of organic matter and improved soil structure have a greater resistance to erosion.

Sand, sandy loam and loam-textured soils tend to be less erodible than silt, very fine sand and certain clay-textured soils. Tillage and cropping practices that reduce soil organic matter levels, cause poor soil structure, or result in soil compaction, contribute to increases in soil Erodibility. The formation of a soil crust, which tends to "seal" the surface, also decreases infiltration.

c. Slope Gradient and Length:

The steeper and longer the slope of a field, the higher the risk for erosion. Soil erosion by water increases as the slope length increases due to the greater accumulation of runoff. Consolidation of small fields into larger ones often results in longer slope lengths with increased erosion potential, due to increased velocity of water, which permits a greater degree of scouring (carrying capacity for sediment).

d. Cropping and Vegetation:

The potential for soil erosion increases if the soil has no or very little vegetative cover of plants and/or crop residues. Plant and residue cover protects the soil from raindrop impact and splash, tends to slow down the movement of runoff water and allows excess surface water to infiltrate.

The erosion-reducing effectiveness of plant and/or crop residues depends on the type, extent and quantity of cover. The effectiveness of any protective cover also depends on how much protection is available at various periods during the year, relative to the amount of erosive rainfall that falls during these periods.

Crops that provide a full protective cover for a major portion of the year (e.g., alfalfa or winter cover crops) can reduce erosion much more than can crops that leave the soil bare for a longer period of time (e.g., row crops), particularly during periods of highly erosive rainfall such as spring and summer.

e. Tillage Practices:

The potential for soil erosion by water is affected by tillage operations, depending on the depth, direction and timing of plowing, the type of tillage equipment and the number of passes. Minimum till or no-till practices are effective in reducing soil erosion by water.

Tillage and other practices performed up and down field slopes creates pathways for surface water runoff and can accelerate the soil erosion process.

1.4.5 Techniques for Control of Water Borne Soil Erosion:

Soil erosion caused by water is lessened by reducing either soil detachment or soil sediment transport or both.

a. Controlling Soil Detachment:

Soil detachment can be controlled by cropping or other vegetative cover practices that keep the soil covered as possible. As rain drops fall on the vegetation then the water gently slides off to be absorbed into the soil. The practice of using deep or subsurface tillage implements that leave much of the crop residues standing on the surface of the soil is stubble mulch farming, an effective techniques of wind erosion control.

b. Controlling Soil Sediment Transport:

Soil sediments transportation is hindered by slowing the eroding water, decreasing the steepness of slope, and by erecting barriers namely brush dams, terraces, contour cultivation and contour strip cropping. Terracing is generally recommended only for intensively used eroding crop land. Contour cultivation means tilling and planting at right angles to the natural slope of the land.

c. Wind-Borne Soil Erosion:

Wind erosion is the detachment and transportation of soil particles by wind when the airstream passing over a surface generates sufficient lift and drag to overcome the forces of gravity, friction and cohesion. Once a particle has been dislodged from the surface, it may be transported in suspension or by saltation or by surface creep. Loss of topsoil by wind erosion over a relatively short time period can significantly decrease soil fertility and crop yield.

d. Movement of Soil Particles by Wind

Movement of soil particles is caused by wind forces exerted against or parallel to the surface of the ground. Wind erodes the soil in three steps namely, saltation, suspension, surface creep.

- **Saltation:**

It is a process of soil movement in a series of bounces or jumps.

- **Suspension:**

It represents the floating of small sized particles in the air stream.

- **Surface Creep:**

It is the rolling or sliding of large soil particles along the ground surface.

The Rate and Magnitude of Soil Erosion by Wind is Controlled by The Following Factors:

a. Soil Erodibility
b. Soil surface roughness
c. Climate (wind patterns, precipitation, frost action)
d. Unsheltered distance
e. Vegetative cover
f. Topography (exposure, elevation, terrain roughness, localized funneling of wind)
g. Cultural practices (cultivation, vegetation depletion).

a. Soil Erodibility:

Very fine soil particles are carried high into the air by the wind and transported great distances (suspension). Fine-to-medium size soil particles are lifted a short distance into the air and drop back to the soil surface, damaging crops and dislodging more soil (saltation). Larger-sized soil particles that are too large to be lifted off the ground are dislodged by the wind and roll along the soil surface (surface creep). The abrasion that results from windblown particles breaks down stable surface aggregates and further increases the soil Erodibility.

b. Soil Surface Roughness:

Soil surfaces that are not rough offer little resistance to the wind. However, ridges left from tillage can dry out more quickly in a wind event, resulting in more loose, dry soil available to blow. Over time, soil surfaces become filled in, and the roughness is broken down by abrasion. This results in a smoother surface susceptible to the wind.

c. Climate:

The speed and duration of the wind have a direct relationship to the extent of soil erosion. Soil moisture levels are very low at the surface of excessively drained soils or during periods of drought, thus releasing the particles for transport by wind.

d. Unsheltered Distance:

A lack of windbreaks (trees, shrubs, crop residue, etc.) allows the wind to put soil particles into motion for greater distances, thus increasing abrasion and soil erosion. Knolls and hilltops are usually exposed and suffer the most.

e. Vegetative Cover:

The lack of permanent vegetative cover in certain locations results in extensive wind erosion. Loose, dry, bare soil is the most susceptible; however, crops that produce low levels of residue (e.g., soybeans and many vegetable crops) may not provide enough resistance. In severe cases, even crops that produce a lot of residue may not protect the soil.

Effects of Wind Erosion:

- Wind erosion damages crops through sandblasting of young seedlings or transplants, burial of plants or seed, and exposure of seed. Crops are ruined, resulting in costly delays and making reseeding necessary.
- Plants damaged by sandblasting are vulnerable to the entry of disease with a resulting decrease in yield, loss of quality and market value.
- Soil drifting is a fertility-depleting process that can lead to poor crop growth and yield reductions in areas of fields where wind erosion is a recurring problem.
- Continual drifting of an area gradually causes a textural change in the soil.

- Loss of fine sand, silt, clay and organic particles from sandy soils serves to lower the moisture-holding capacity of the soil. Also, soil nutrients and surface-applied chemicals can be carried along with the soil particles.

Control of Wind Erosion:

There are generally four basic methods that can control or reduce soil erosion caused by the wind.

- Protection of the soil surface with a vegetative cover or crop residues.
- Bringing aggregates or clods to the surface soil because aggregates or clods are larger enough to resist the wind force.
- By making surface roughness for the reduction of wind velocity.
- Establishment of barriers or trap strips and wind breaks at suitable intervals at right angles to the most erosive winds to reduce wind velocity and soil drifting.

1.5 Tillage Erosion:

Tillage erosion is the redistribution of soil through the action of tillage and gravity. It results in the progressive down-slope movement of soil, causing severe soil loss on upper-slope positions and accumulation in lower-slope positions. This form of erosion is a major delivery mechanism for water erosion. Tillage action moves soil to convergent areas of a field where surface water runoff concentrates. Also, exposed subsoil is highly erodible to the forces of water and wind. Tillage erosion has the greatest potential for the "on-site" movement of soil and in many cases can cause more erosion than water or wind.

The rate and magnitude of soil erosion by tillage is controlled by the following factors:

a. Type of Tillage Equipment
b. Direction
c. Speed and Depth
d. Number of Passes

a. Type of tillage equipment

Tillage equipment that lifts and carries will tend to move more soil. As an example, a chisel plow leaves far more crop residue on the soil surface than the conventional mold board plow but it can move as much soil as the mold board plow and move it to a greater distance. Using implements that do not move very much soil will help minimize the effects of tillage erosion.

b. Direction:

Tillage implements like a plow or disc throw soil either up or down slope, depending on the direction of tillage. Typically, more soil is moved while tilling in the down-slope direction than while tilling in the up-slope direction.

c. Speed and depth:

The speed and depth of tillage operations will influence the amount of soil moved. Deep tillage disturbs more soil, while increased speed moves soil further.

d. Number of passes:

Reducing the number of passes of tillage equipment reduces the movement of soil. It also leaves more crop residue on the soil surface and reduces pulverization of the soil aggregates, both of which can help resist water and wind erosion.

1.5.1 Effects of Tillage Erosion:

- Tillage erosion impacts crop development and yield.
- Crop growth on shoulder slopes and knolls is slow and stunted due to poor soil structure and loss.
- Of organic matter and is more susceptible to stress under adverse conditions.
- Changes in soil structure and texture can increase the Erodibility of the soil and expose the soil to further erosion by the forces of water and wind.

1.6 Conservation Measures:

Soil conservation is the preventing of soil loss from erosion or reduced fertility caused by over usage, acidification, salinization or other chemical soil contamination. Soil conservation is about solving the problems of land degradation, particularly soil erosion. Soil conservation is fundamentally a matter of determining a correct form of land use and management. Soil conservation can be defined as the combination of the appropriate land use and management practices that promote the productive and sustainable use of soils and, in the process, minimizes soil erosion and other forms of land degradation. Slash-and-burn and other unsustainable methods of subsistence farming are practiced in some lesser developed areas. A sequel to the deforestation is typically large-scale erosion, loss of soil nutrients and sometimes total desertification. Techniques for improved soil conservation include crop rotation, cover crops, conservation tillage and planted windbreaks and affect both erosion and fertility.

1.7 Notable Methods of Soil Erosion Control:

- Contour ploughing.
- Terracing or terrace farming.
- Keyline design.
- Perimeter runoff control.
- Windbreaks.
- Cover crops/crop rotation.
- Soil-conservation farming.
- Salinity management.

There are five main techniques that can be used in controlling soil erosion are.

They are as follows:

a. Contour bunding and Farming
b. Strip Cropping
c. Terracing
d. Gully Reclamation
e. Shelter Belts.

Soil erosion can be controlled by adopting land management practices and also by changing the pattern of some human activities which accelerate soil erosion. One such idea is to minimise disturbance.

1.8 Land Disturbing Activities:

The most effective form of erosion control is to minimize the area of disturbance. The land disturbing activities are the following:

a. Quarries: Quarries are places of naturally occurring hard rock that is mined for rock and gravels. The products from quarry operations are used for roading, building and in rock. Protections measures, i.e., rip-rap.

b. Trenching: Trenching (usually for installing utility services), often occurs at the end of bulk earthworks. Topsoil and sub-soils should be stockpiled separately adjacent to the trench so that at the completion of the operation these soils can be replaced in the appropriate order and vegetation established.

c. Clean fills: Clean fills dispose of unwanted fill material which may contain other material.

d. Roading: The linear nature of roading poses challenges for erosion and sediment control measures. They need to be planned to ensure controls are successful.

1.9 Minimise Disturbance:

The most effective form of erosion control is to minimise the area of disturbance, retaining as much existing vegetation as possible. This is especially important on steep slopes or in the vicinity of water bodies, where no single measure will adequately control erosion and where receiving environments may be highly sensitive. Match land development to land sensitivity. Watch out for and avoid areas that are wet (streams, wetlands, springs), have steep or fragile soils. Analyze all the “limits of disturbance”.

a. Stage Construction: Temporary stockpiles, access and utility service installation all need to be considered.

b. Protect Steep Slopes: Steep slopes should be avoided where practicable.

c. Protect Water bodies: All water bodies and proposed drainage patterns. Map all water bodies and show limits of disturbance and protection measures.

d. Stabilize Exposed Areas Rapidly: Conventional sowing to mulching. Mulching is an effective instant protection.

e. Install Perimeter Controls: Perimeter controls above the site keep clean water runoff out of the worked area. Common controls are diversion drains, silt fences and earth bunds.

f. Employ Detention Devices: Earthworks will still discharge sediment-laden runoff during storms.

g. Runoff Diversion Channel/Bund: This is a non-erodible channel or bund constructed for the conveyance of runoff constructed to a site-specific cross section and grade design. It is done to either protect work areas from upslope runoff, or to divert sediment laden water to an appropriate sediment retention structure.

h. Contour Drain: It is a temporary ridge or excavated channel, or combination of ridge and channel, constructed to convey water across sloping land on a minimal gradient. To periodically break overland flow across disturbed areas in order to limit slope length and thus the erosive power of runoff and to divert sediment laden water to appropriate controls or stable outlets.

i Rock Check Dam: Small temporary dam constructed across a channel (excluding perennial water bodies), usually in series, to reduce flow velocity. It may also retain coarse sediment. Check dams are constructed in order to reduce the velocity of concentrated flows, thereby reducing erosion of the channel. Rock check dams will trap some sediment, but they are not designed as a sediment retention measure.

j. Level Spreader: A non-erosive outlet to disperse concentrated runoff uniformly across a slope. The level spreader provides a relatively low-cost option, which can convert concentrated flow to sheet flow and release it uniformly over a stabilized area.

k. Pipe Drop Structure / Flume: A temporary pipe structure or constructed flume placed from the top of a slope to the bottom of a slope. A pipe drop structure or a flume structure is installed to convey surface runoff down the face of unestablished slopes in order to minimise erosion on the slope face.

l. Benched Slope: Modification of a slope by reverse sloping to divert runoff to an appropriate conveyance system. To limit the velocity and volume and hence the erosive power of water flowing down a slope and therefore, minimizing erosion of the slope face.

m. Surface Roughening: Roughening a bare earth surface with horizontal grooves running across a slope or tracking with construction equipment.

To aid in the establishment of vegetative cover from seed, to reduce runoff velocity, to increase infiltration, to reduce erosion and assist in sediment trapping.

n. Stabilized Construction Entrance: A stabilized pad of aggregate on a filter cloth base located at any point where traffic will be entering or leaving a construction site. To prevent site access points from becoming sediment sources and to assist in minimizing dust generation and disturbance of areas adjacent to the road frontage by giving a defined entry/exit point.

o. Geosynthetic Erosion Control Systems (GECS): The protection of channels and erodible slopes utilizing artificial erosion control material such as Geosynthetic matting, geotextiles or erosion matting. To immediately reduce the erosion potential of establish protective vegetation. There are both Temporary and Permanent Non-Degradable GECS.

1.10 Revegetation Techniques:

a. Top Soiling: The placement of topsoil over a prepared subsoil prior to the establishment of vegetation. To provide a suitable soil medium for vegetative growth while providing some limited short term erosion control capability.

b. Temporary and Permanent Seeding: The planting and establishment of quick growing and/or perennial vegetation to provide temporary and/or permanent stabilization on exposed areas. Temporary seeding is designed to stabilize the soil and to protect disturbed areas until permanent vegetation or other erosion control measures can be established.

c. Hydroseeding: Hydroseeding is a planting process that uses a slurry of seed and mulch. It is often used as an erosion control technique. The application of seed, fertilizer and a paper or wood pulp with water in the form of a slurry which is sprayed over the area to be revegetated. To establish vegetation quickly while providing a degree of instant protection from rain drop impact.

d. Mulching: Mulches are loose coverings or sheets of material placed on the surface of cultivated soil. Organic mulches also improve the condition of the soil. As these mulches slowly decompose, they provide organic matter which helps keep the soil loose. This improves root growth, increases the infiltration of water, and also improves the water-holding capacity of the soil. The application of a protective layer of straw or other suitable material to the soil surface. To protect the soil surface from the erosive forces of raindrop impact and overland flow. Mulching assists in soil moisture conservation, reduces runoff and erosion, controls weeds, prevents soil crusting and promotes the establishment of desirable vegetation.

e. Turfing: A surface layer of earth containing a dense growth of grass and its matted roots; sod. Turfing is an artificial substitute for such a grassy layer, as on a playing field. The establishment and permanent stabilization of disturbed areas by laying a continuous cover of grass turf.

To provide immediate vegetative cover to stabilize soil on disturbed areas.

1.11 Sediment Control Measures:

a. Sediment retention pond: A temporary pond formed by excavation into natural ground or by construction of an embankment and incorporating a device to dewater the pond at a rate that will allow suspended sediment to settle out. To treat sediment-laden runoff and reduce the volume of sediment leaving a site, thus protecting downstream environments from excessive sedimentation and water quality degradation.

b. Chemical flocculation systems: A treatment system designed to add a flocculating chemical to sediment retention ponds. Used to increase the sediment capture performance of sediment retention ponds by causing suspended. Sediment to “clump” resulting in faster settling rates.

c. Silt fence: The purpose of a silt fence is to retain the soil on disturbed land. The three principal aspects of silt fence design are: proper placement of fencing, adequate amount of fencing, and appropriate materials.

A silt fence is a temporary sediment barrier made of porous fabric. It’s held up by wooden or metal posts driven into the ground, so it’s inexpensive and relatively easy to remove. The fabric ponds sediment-laden stormwater runoff, causing sediment to be retained by the settling processes. A temporary barrier of woven geotextile fabric is also used to intercept sediment laden Runoff from small areas of soil disturbance.

d. Super Silt Fence: A temporary barrier of woven geotextile fabric over chain link fence used to intercept sediment laden runoff from soil disturbance in small catchment areas. A super silt fence provides more robust sediment control compared with a standard silt fence and allows up to four times the catchment area to be treated by an equivalent length of standard silt fence.

e. Stormwater inlet protection: A barrier across or around a cesspit (stormwater inlet). To intercept and filter sediment-laden runoff before it enters a reticulated stormwater system via a cesspit, thereby preventing sediment-laden flows from entering receiving environments.

f. Decanting Earth Bund: A temporary berm or ridge of compacted earth constructed to create impoundment areas where ponding of runoff can occur and suspended material can settle before runoff is discharged. Used to intercept sediment-laden runoff and reduce the amount of sediment leaving the site by detaining sediment-laden runoff.

g. Decanting Topsoil Bund: A temporary berm or ridge of track rolled topsoil, constructed to create impoundment areas where ponding of runoff can occur and suspended material can settle before runoff is discharged. Used to intercept sediment-laden runoff from small areas (less than 0.3 ha) and reduce the amount of sediment leaving the site by detaining sediment-laden runoff.

h. Sump / Sediment Pit: A temporary pit which is constructed to trap and filter water before it is pumped to a suitable discharge area. To treat sediment-laden water that has been removed from areas of excavation or areas where ponded sediment-laden water cannot drain by other means.

i. Riprap: Rock pieces are piled up to create a structure called as rip-rap. These are rubble composed of a variety of rock types including limestone and granite, which are used to armor embankments, shorelines, bridge abutments, streambeds and other seaside constructions to prevent soil erosion due to concentrated runoff or other water-related causes. A limitation of riprap arises when the slopes of the considered area are greater than 2:1; the rubble becomes unstable and is itself prone to erosion. In these circumstances, gabions are used.

j. Gabions: Gabion is an Italian word gabbia meaning "cage". The gabions are riprap encased in galvanized, steel-wire mesh cages or cylinders. These are used to stabilize slopes, stream banks, or shorelines against erosion. They are usually placed on slopes at an angle—either battered or stepped back, rather than stacked vertically. The life expectancy of gabions rely entirely on their wire frames, and premium ones have a guaranteed structural consistency of fifty years.

k. Buffer Strip: These are narrow areas of land maintained in permanent vegetation to trap sediment, slow down runoff, and even control air, soil, and water quality. The root systems of the vegetation anchor soil particles together which help stop the soil from being eroded by winds. They also reduce the risk of by this landslides and other slower forms of erosion by stabilizing stream banks.

l. Soil Binders: Soil binders bind soil particles together in order to make the soil matrix more water and pressure resistant. Soil binder has two functions: erosion control and soil stabilization. The success of common soil binder applications varies significantly depending on the local conditions and use of stabilized soil. Soil binders have multiple purposes: soil stabilization, dust control and erosion control. Some soil binder products can combat all these issues at the same time. Cement is commercial soil binder although it has numerous drawbacks. Lime soil binder products are quicklime, hydrated lime and lime slurry. Fly ash is typically used to stabilize subbase or subgrade, and is not among soil binder products suitable for surfacing due to low resistance to abrasive action of traffic. Fly ash application has adverse effect on environment.

1.12 Soil Conservation Methods:

The preeminent methods of soil conservation are:

a. Expansion of vegetative cover and protective afforestation,
b. Controlled grazing,
c. Flood control,
d. Prohibition of shifting cultivation,
e. Proper land utilization,
f. Maintenance of soil fertility,

g. Land reforms, reclamation of wasteland,
h. Establishment of soil research institute and training of soil scientists, and
i. Effective agencies for soil management

1.13 Conclusion:

Erosion is the loss of soil. As soil erodes, it loses nutrients, clogs rivers with dirt, and eventually turns the area into a desert. Although erosion happens naturally, human activities can make it much worse. Erosion can turn once healthy, vibrant land into arid, lifeless terrain and further cause landslides and mudslides. Erosion can be controlled easily on a construction site when the right means, tools, and methods are used at the right time. The most natural and effective way to prevent erosion control is by planting vegetation. Roots from plants, especially trees, grip soil and will effectively prevent the excess movement of soil throughout the ground. Another popular erosion control method is the use of a silt fence. A silt fence is a long fabric barrier that is installed along a hill, and collects any stormwater that would carry loose soil. Another effective technique used for soil erosion control is erosion control matting. Erosion control matting is laid on top of loose soil and is secured into place. Fertility of soil is the future of civilization. So, we should conserve it for us and also for our generation.

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