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Methods to Control Soil Erosion-A Review

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ABSTRACT

Soil erosion is a natural process in which particles of soil are moved by wind and water and displaced to another location. When erosion occurs naturally, soil is re-located at about the same rate it is created, so no harm is done to the environment. Erosion is one of the biggest concerns of earth's land surface. Soil erosion deteriorates soil quality and hence decreases the productivity of land. It has many impacts on agricultural problems and also in all engineering and construction industries. All structures are constructed on the soil; therefore soil should have enough bearing capacity to withstand against the weight of the structure. Different Methods have been adopted over the years to control the soil erosion, but these methods have proven to be insufficient to reduce the soil erosion at permissible level. Therefore, Engineering structures are designed to control run-off and soil erosion in fields where biological control practices alone are insufficient to reduce soil erosion to permissible level. The main aim of this paper is to study or highlight the engineering methods that can be implemented to control the soil erosion. Engineering methods deals with the physical structures that stops or try to prevent the happening of soil erosion. Therefore it is important to construct Engineering structures which can effectively control the velocity of run-off water.

Key words: *Erosion, Run off, Engineering structures, Soil conservation, Agriculture*

INTRODUCTION

Soil is the top layer of the earth's surface that is capable of sustaining life. Soil erosion is the process of the soil degradation or the reduction of the soil's quality under the effect of different factors. Evidently, soil is one of the most valuable resources on the planet, because without its qualities plants will not grow and as a result the quality of life on earth would be quite poor, because there would be no grass eating animals and insects and the consumption chain would be not so varied. Therefore soil is very important to farmers who depend on soil to provide abundant, healthy crops each year. Top soil contains most of the soils nutrients, organic matter & pesticides. Soil erosion causes these substances to move also, what is left behind is soil with poorer structure, lower water holding capacity, different PH values & low nutrient levels.

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Therefore, fertilizers and organic matter must be added in an attempt to restore the soil to its original composition. It is worth mentioning that soil requires hundreds and thousands of years for its creation and development, because microorganisms which produce soil from the organic matter do not fulfill this duty rapidly. So, it is obvious that the humanity has to protect and maintain the quality of soils; otherwise people will simply die from hunger, when there is a collapse of agriculture. The soil's quality can be reduced because of the water and wind erosion and the anthropogenic activity. Soil erosion under effect of wind occurs when the area is not protected by any natural shelters or barriers, like trees of high rocks. When the surface is flat and the wind is strong, the most productive and valuable upper layers of soil are blown away and the area becomes infertile and can suffer from deserting. Water is also dangerous for soils, because it washes away its upper layers as well as the wind does. That is why coastal areas always resemble deserts as there is no fertile soil there. Moreover, when the territory suffers from floods or running streams of water from the hills, it also becomes infertile, because the layers of soil are washed away into low lands. Soil erosion is naturally occurring process that affects all landforms. The causes and effects should be studied in order to control soil erosion. Erosion, whether it is by water, wind or tillage, involves three distinct actions – soil detachment, movement and deposition. Erosion takes place all the time naturally. The erosion potential of any surface is determined by four basic factors: soil characteristics, vegetative cover, topography and climate. Detachment of soil particles is a function of the erosive forces of raindrop impact and flowing water. When soil erosion take place, then much of the eroded soil is deposited either in low areas of the field or it moves or finally enters the streams, rivers & drainage ditches. Soil that enters a watercourse reduces water quality, reduces the efficiency of drainage systems & storage capacity of lakes. Soil that settles in water systems is called sediment. Sediments fill rivers & reservoirs & reduce their capacity to hold flood waters. Sediment is considered to be a major pollutant. Soil erosion is a global problem affecting soils all over the world. The rapid growth in the world's population has resulted in increased cultivation of land which puts more pressure on soil and leads to soil losing its structure & cohesion. Therefore soil can be eroded more easily. Soil is usually protected from erosion by vegetation. When soil is usually covered with shrubs & trees or by a thick mat of grass, then the roots of the plants is able to hold the soil together. Plants slow down water as it flows over the land & it allows much of the rain to soak into the ground. This reduces water erosion.

Types of soil erosion

There are three main types of soil erosion:

Wind erosion

Wind erosion is the removal of soil particles by the force & kinetic energy of the wind. These soil particles are transported & deposited when the wind energy drops. Wind erosion is the detachment & transportation of soil particles by wind when the Airstream passing over a surface generates sufficient lift & drag to overcome the forces of gravity, friction & cohesion. Loss of top soil by the wind relatively reduces soil fertility & crop yield.

Water Erosion

Water erosion is caused by the kinetic energy of the rain falling on the soil surface & by the mechanical force of run-off. Water erosion usually impacts quality of water and degrades the land of its essential nutrients. The greater is the intensity & duration of a rainstorm, higher is the chance of the erosion potential. The impact of raindrops on the soil surface can break down the surface.

Gravity Erosion

Mass movement of soil occurs on steep slopes under the action of gravity. The process involves the transfer of slope- forming materials from higher to lower grounds due to self-weight. Surface creep is the slow downhill movement of soil & rock debris. Slumping occurs at steep hillsides along distinct fracture planes, often within such as clay.

Forms of water erosion

Sheet erosion

Rain drops break apart the soil structure and it is moved down the slope by water that flows overland as a sheet rather than definitive channels. It typically occurs evenly over a uniform slope & goes unnoticed until the most of the productive top soil has been lost.

Rill erosion

Rill erosion is the removal of soil by concentrated water running through little streamlets. This process develops small, short-lived, concentrated flow paths. Areas where precipitation rates exceed soil infiltration rates are more prone to this type of erosion.

Gully erosion

Gully erosion is “the removal of soil or soft rock material by water, resulting in the formation of distinct narrow channels.

Figure – Gully erosion

Causes of Soil Erosion

The predominant causes of soil erosion are either related to naturally-occurring events or influenced by the presence of human activity. Some of the principal causes of soil erosion include:

Rain and rainwater runoff

In a particular heavy rain, soil erosion is common. First of all the water starts to break down the soil, dispersing the materials it is made of. Typically, rain water runoff will impact lighter materials like silt, organic matter, and finer sand particles, but in heavy rainfall, this can also include the larger material components as well.

Slope of the land

The physical characteristics of the land can also contribute to soil erosion. For example, land with a high hill slope will perpetuate the process of rainwater or run off saturation in the area, particularly due to faster movement of the water down a slope.

Lack of vegetation

Plants and crops help maintain the structure of soils, reducing the amount of soil erosion. Areas with less naturally occurring flora may be a hint that the soil is prone to erosion.

Wind

Wind can be a major factor in reducing soil quality and promotion erosion, particularly if the soil’s structure has already been loosened up. However lighter winds will typically not cause too much damage, if any. The most susceptible soil to this type of erosion is sandy or lighter soil that can easily be transported through the air.

Effects of Soil Erosion

A major problem with soil erosion is that there is no telling how quickly or slowly it occurs. If largely impacted ongoing weather or climate events, it may be a slow-developing process that is never noticed. However, a severe weather occurrence or other experience can contribute to rapid moving erosion, which can cause great harm to the area and its inhabitants. Some of the greatest effects of soil erosion include:

Loss of top soil

Obviously, this is the biggest effect of soil erosion. Because topsoil is so fertile, if it is removed, this can cause serious harm to farmer's crops or the ability to effectively work their land.

Soil compaction

When soil under the topsoil becomes compacted and stiff, it reduces the ability for water to infiltrate these deeper levels, keeping runoff at greater levels, which increases the risk of more serious erosion.

Reduced organic and fertile matter

As mentioned, removing topsoil that is heavy with organic matter will reduce the ability for the land to regenerate new flora or crops.

Poor drainage

Sometimes too much compaction with sand can lead to an effective crust that seals in the surface layer, making it even harder for water to pass through to deeper layers.

Long term erosion

Unfortunately, if an area is prone to erosion or has a history of it, it becomes even harder to protect it in the future. The process has already reduced the soil structure and organic matter of the area, meaning that it will be harder to recover in the long run.

Water pollution

A major problem with runoff from soils – particularly those used for agricultural processes- is that there is a greater likelihood that sediment and contamination like the use of fertilizer or pesticide.

Engineering methods to control erosion

Engineering methods deal with the physical structure that stops or try to prevent the happening of soil erosion. Different engineering methods to control soil erosion are:

Check dam

A check dam is a small, sometimes temporary dam constructed across a swale, drainage ditch or waterway to counteract erosion by reducing water flow velocity. A check dam is designed to control the run off velocity of water so that the area below is prevented from eroding. A check dam is placed in the ditch, swale or channel that interrupts the flow of water and flattens the gradient of the channel, thereby reducing the velocity. In turn, this obstruction includes infiltration rather than eroding the channel. They can be used not only to slow flow velocity but also to distribute flows across a swale to avoid preferential paths and guide flows towards vegetation. Although some sedimentation may result behind the dam, check dams do not primarily function as sediment trapping sediment devices. Check dams could be designed to create small reservoirs, without possibility of silting. Check dams have traditionally been implemented in two main environments: across channel bottoms and on hilly slopes. Check dams are used primarily to control water velocity, conserve soil and improve land. They are used when other flow-control practices, such as lining the channel or creating bioswales is impractical. Accordingly, they are commonly used in degrading temporary channels, in which permanent stabilization is impractical and infeasible in terms of resource allocation and funding due to the short life period. Or, they are used when construction delays and weather conditions prevent timely installation of other erosion control practices. This is typically seen during the construction process of large scale permanent dams or erosion control. Many check dams tend to form stream pools. Under low-flow circumstances, water infiltrates into the ground, evaporates or seeps through or under the dam. Under high flow flood conditions, water flows over or through the structure. Coarse and medium grained sediment from run-off tends to be deposited behind check dams, while finer grains flow through. Extra nutrients, phosphorous, nitrogen, heavy metals, and floating garbage are also trapped by check dams, increasing their effectiveness as water control measures. Check dams are a highly effective practice to reduce flow velocities in channels and waterways. Check dams are made of a variety of materials. Because they are typically used as temporary structures, they are often made of cheap and accessible materials such as rocks, gravel, logs, hay bales and sandbags. Of these, logs and rock check dams are usually permanent or semi-permanent and the sandbag check dam is implemented primarily for temporary purposes.

Water ways

Nepal is the second richest country of water resources. Nepal has about 45,000 km of rivers. The rivers flow from the mountains and through steep hills because of which transportation is very difficult. A feasibility study of water transport had also been carried out in koshi, karnali and Mahakali Rivers. The purpose of waterways in a conservation system is to convey runoff at non erosive velocity to a suitable disposal point. Therefore it should be carefully designed. The most satisfactory location of a waterway is in a well vegetated natural drainage lined where the slopes, cross section, soil and vegetation have naturally developed to receive & carry the run off. Artificial waterways are normally protected by grass like paspalum, spp, kikuyu, African star grass and so referred to grassed waterways.

Figure - Waterways covered with grass

Grass waterways are shallow & wide to obtain the maximum spread of water over a wide cross section. These waterways can be used in areas where there is sufficient moisture available to sustain a good grass cover. Before the onset of rains, the grass in the waterway must be cut so that the flow of water can proceed smoothly without causing eddies.

Retaining walls

Retaining walls are structures designed to restrain soil to unnatural slopes. They are used to bound soils between two different elevations often in areas of terrain possessing undesirable slopes or in areas where landscape needs to be shaped severely. Retaining wall is a structure designed & constructed to resist the lateral pressure of soils where there is desired change in ground elevations that exceeds the angle repose of the soil. Retaining walls are commonly used not only for control of erosion, but also to protect shorelines & keep rainwater from seeping into unwanted areas. They also provide soil stability in Areas where there is a risk of significant changes at ground elevation due to earthquakes & floods. The basic material used in construction of retaining wall is concrete, which is meant to serve the function of strength & durability. Retaining walls are relatively rigid walls used for supporting the soil mass laterally so that the soil can be retained at different levels on the two sides. Erosion control is a primary concern for any site with a slope. Soil erosion and run off must be managed both during and after construction of a project to make sites both useable and safe. Retaining walls control erosion by stabilizing slopes that could be washed away with heavy rain. Soil that is washed or blown away from site is likely to make its way to nearby waterways and contributes to sedimentation. A carefully planned retaining wall can be multi-faceted solution to erosion control and storm water management.

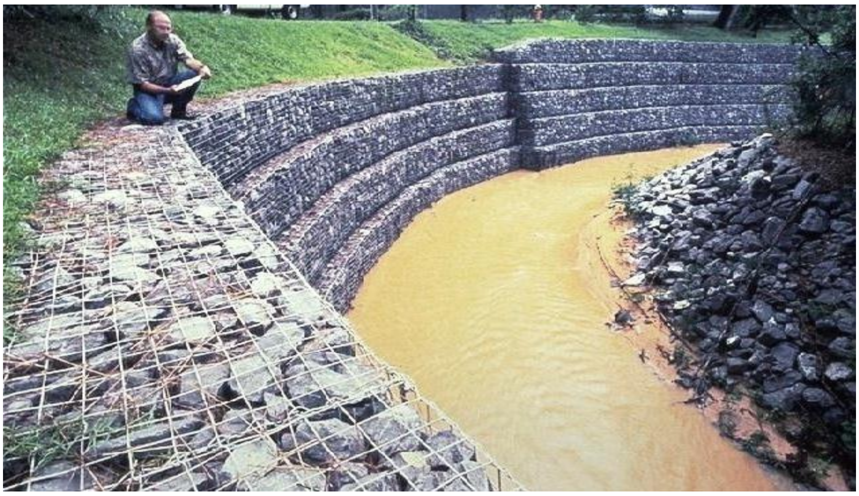

Figure – Retaining wall

Embankments

As land development happens in hilly countryside, more erosion control on steep slopes and embankments is needed. Especially in areas that experience heavy rainfall. An embankment is a raised structure (as of earth or gravel) used especially to hold back water. Embankments are constructed of a material that usually consists of soil, but may also include aggregate, rock or crushed paving material. Steep slopes and embankments that have no vegetation or cover are especially vulnerable to erosion issues. Erosion can cause damage to not only the landscape, but any infrastructure surrounding the project it is important to protect the hill side from erosion during and after the project is complete. On steep slopes and embankments, there is an elevated risk of erosion. Therefore embankment prevents the soil from being washed way and hold back water. Moreovere on steep slopes, grass and shrubs are very effective at stopping soil erosion. Embankments are usually constructed of soil or concrete and they also provide a protection to a surrounding area so that if any construction is taking place in a surrounding area that doesn't get disrupted. So, embankments also provide protection to the surrounding area by holding back the water. Embankments constructed across canals make sure that the soil in the surrounding area doesn't get affected.

Figure -Embankment

Building Terraces

Building terraces is also another way to help prevent soil erosion. Terrace walls help to hold soil in place while providing a convenient surface to plant a variety of plants. Building terraces can be simple as using a couple of wooden blocks to create a terrace wall or it could be more sophisticated and involve the use of engineered stones, concrete retaining wall blocks or green wall solution.

Soil Conservation Methods

In, Kashmir valley, the problem of soil erosion has resulted in the degradation of land at a very large scale. The problem of soil erosion is mainly characterized by degraded steep hill slopes landslips, landslides & general deterioration of the mountainous watersheds, lack of management of forests & agricultural practices.

The methods of soil conservation are:

i. Expansion of vegetative cover and protective afforestation
ii. Controlled grazing
iii. Flood control
iv. Prohibition of shifting cultivation
v. Proper land utilization
vi. Maintenance of soil fertility
vii. Land reforms, reclamation of wasteland
viii. Establishment of soil research institute and training of soil scientists and
ix. Effective agencies for soil management

RESULTS AND DISCUSSIONS

As per the National Bureau of Soil Sciences & Land use planning report, 32 percent of the state of Jammu & Kashmir is affected by the various soil degradation problems out of which 78 percent area is under severe erosion. Average Soil loss in J&K is 20 tonnes/hectre/year, which is higher than the National average loss of 16.37. The problem of soil erosion in the state is due to heavy rains and snowfall. Further, the faulty land use, deforestation, over grazing of pasture lands, over exploitation of natural resources, construction of infrastructure/ development activities has compounded the problems of soil erosion in the state. Also the continuous, unseasonal and heavy rainfalls have also resulted in soil erosion in Kashmir valley. I think the degradation of forests is the main cause of land erosion in the state. So, people should cooperate with the govt. for saving the forests from degradation. At an individual level, we should make an effort to make people understand about importance of the forests and how can they help us in preventing soil erosion.

CONCLUSION

Soil Erosion is the loss of top soil by the agents of wind, water & gravity etc. As the erosion takes place, soil loses all its nutrients, Clogs River with dirt & turns the whole Area into desert. Human activities are also responsible for soil erosion. Soil erosion turns health land into difficult terrain by causing landslides & mudslides. Soil erosion can be easily controlled on site if the right methods, means & tools are used. The engineering ways of controlling erosion are the most effective methods in which physical structures are constructed which holds back the water & control the velocity of run-off. Therefore this prevents the soil from being washed away. Different structures constructed to control the velocity of runoff water are check dams, retaining walls, embankments etc.

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