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A Study of Factors Causing Soil Erosion, its Effects and Recent Developments in its Control Measures

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Abstract: Soil is earth's life supporting cover. The healthy soils are crucial for the existence of natural biodiversity and ecosystems, for the production of food and fiber, for continuous cycling of matter between living and nonliving fragments of the environment etc. Hence soils are a highly valuable natural resource which is essential for the survival of life and for the economic progress of people of any country. The most evident effect of soil degradation is soil erosion which directly affect the soil fertility and thus is a critical problem being faced by the farmers and the public who depend upon fertile agriculture land for their livelihoods. The present study deals with some key factors, their effects and some practical remedial measures for soil erosion.

INTRODUCTION

The increase in human population has resulted in an enhanced demand of agricultural produce and so the production has perceived a huge increase in the last 3 decades. So to increase agriculture land forests and grasslands are converted into agriculture lands. Due to this conversion of forests and grasslands into agriculture lands, which poorly hold the soil has great impact on the environment. When natural vegetation is cleared and when farmland is ploughed, the exposed topsoil is often blown away by wind or washed away by rain. Result is soil erosion is the absolute soil losses in terms of topsoil and nutrients along with the applied manure and agrochemicals. As soil erosion involves wearing away of a field's topsoil, which is fertile, high in organic matter and soil life, it extensively reduces the cropland productivity that is why soil erosion can have the highest impact on farmers and agricultural land. Soil erosion, or the steady decrease of topsoil in a geographic area, can be affected by both natural and unnatural processes, but it can also have large influence on inhabitants of an affected area. Soil erosion not only affects future productivity of soil, but also the terminal value [1].

Soil erosion can be a slow process that may continue comparatively unnoticed or may take place at an alarming rate, producing a grave loss of topsoil. Both natural factors and human activities contribute considerably to soil erosion. In hilly areas, it is a natural process, but due to poor management practices it is frequently turned worse. The susceptibility of soil to get eroded called as soil erodibility is based on the physical and chemical characteristics of each soil. Erosion affects soil structure, stability, quality and texture. The loss of fertile soil leads to land less productive for agriculture, poor crop cover, which in turn affords less crop protection for the soil, produces new deserts, pollutes waterways and can change how water flows through the landscape, potentially resulting in more common flooding. With the development of science and technology, environmental concerns are also rising and 21st century is considered as environment saving century as enormous efforts are being done by environmental scientists and experts to raise these issues and discovering remedies for them.

FACTORS AFFECTING SOIL EROSION

Climatic factors and geography

The climatic factors inducing the soil erosion mainly include amount, intensity and frequency of rainfall and wind velocity, the potential ability of rainfall, runoff and wind to course erosion.

Rain and rainwater runoff: The most common cause for soil erosion is specifically a heavy rain. Initially, the water starts to

breakdown the soil, scattering the constituents it is composed of. Then rainwater runoff particularly impacts lighter substances like silt, organic matter and finer sand particles but in heavy rainfall the even larger material components can also get washed away as well. Rainfall is the most vital factor causing erosion through splash and excessive run off. Run off that results in erosion is determined by intensity, amount, duration and frequency of rainfall. Higher the intensity and duration of a rainstorm, greater will be its potential to cause erosion. is usually during The short-duration and high-intensity rainstorms result in greatest and most noticeable soil erosion. Although the erosion caused by long-lasting and less-intense storms are not usually as striking or noticeable, but the toal amount of soil loss can be substantial when considered over time. When rain falls gently, it gets time to enter the soil where it strikes and some of it will gently run off, but in case it falls in torrents, there is not sufficient time for the water to infuse through the soil and it runs off quickly producing soil erosion. During spring months, the impact of runoff is greatest as the soils are usually saturated due to very less vegetative cover. A rough estimate of soil erosion and sedimentation for India reveals that about 5300 million tons of top soil are eroded annually and 24% of this quantity is carried by rivers as sediments and deposited in the sea, and nearly 10% is deposited in reservoirs.

Slope of the land: Land with a high hill slope will preserve the process of runoff saturation in the area, mainly due to the faster movement of the water down the slope. Steeper fields with 10-15 percent slopes are much more vulnerable to erosion as compared to flat fields. Slope speeds up erosion as it escalates the velocity of flowing water if there is excess water on a slope which cannot be seeped into the soil or due to the greater accumulation of runoff. As the slope length increases soil erosion by water further increases. Even small differences in slopes make vast difference in damage due to erosion. According to the laws of hydraulics, the velocity of flowing water doubles a four times increase in slope, and hence increases the erosive power of runoff four times[2].

Wind: Wind can be a major factor in promoting soil erosion and thus reducing soil quality predominantly when the soil's structure has already been loosened up due to some other factors. Fine-to-medium size soil particles are lifted to short distances by the air and drop back to the soil surface, damaging crops. Loose, dry soils are highly erodible by wind relative to the smooth surfaces which offer very less resistance to the wind. However, ridges left due to tillage dry out more rapidly in a windy climate and can be available to blow. Sandy or lighter soil, dry and devoid of humus soil that can easily be easily carried away by the air are the most vulnerable soil to this type of erosion. Thus in case of extremely drained soils or during long periods of drought or freeze-drying of soil surface during winter months lead to very low moisture levels at the surface of soil and result in increased erodibility of soil by winds. However, lighter winds do not cause much damage.

Physical and chemical properties of soil

Physical and chemical properties of the soils such as soil texture, structure, organic matter, quantity and types of salts present significantly affect the permeation rate of soil, which in turn influences the runoff and hence soil erodibility. Because of these characteristic differences some soils are much more susceptible to get eroded than other under similar conditions.

Soil Permeability: Sandy soil has less susceptibility to get eroded by rain because water is absorbed readily due to its high absorbency. Water holding capacity of the soil increases with increase in organic manure in the soil as it improves its granular structure. Thus due to reduction in organic matter, soil erodibility increases. Fine textured and alkaline soils are more prone to erosion. Soil rich in clay particles is less erodible as clay particles are more difficult to be separated than sand, but once detached they are easily transported on a level land and much more rapidly on slopes.

Soil Texture: Sand, sandy loam and loam-textured soils has low tendency to get eroded than silt, very fine sand and certain clay-textured soils. Generally, very fine sand, clay, silt and organic matter are readily removed by the fast blowing winds, raindrop splash and runoff water, but to move larger sand and gravel particles greater wind energy or runoff amounts are required. Fine-to-medium size soil particles are raised to short distances by the air and drop back to the soil surface, destroying crops. Soil detachment increases with increase in particle size, whereas

soil transportability increases with the reduction in particle size. Loose, dry soils are highly erodible by wind relative to the smooth surfaces which offer very less resistance to the wind. However, ridges left due to tillage dry out more rapidly in a windy climate and can be available to blow. Thus in case of extremely drained soils or during long periods of drought or freeze-drying of soil surface during winter months lead to very low moisture levels at the surface of soil and result in increased erodibility of soil by winds.. Also due to the poor structure of the exposed subsurface soils on eroded sites tend to be more erodible than the original soils. With cultivation erodibility of clay decreases whereas the erodibility of sandy soils increases.

Overgrazing and Deforestation

Plants and crops help in maintaining the structure of soils and thus reducing the amount of soil erosion. Regions with less naturally-occurring flora give a clue that the soil is susceptible to erosion. Both overgrazing and deforestation decrease vegetation cover on the land, reducing humus content and hence resulting in soils poor in organic matter. The plant and its residue cover the soil and protect the soil from raindrop impact and splash hence tend to slow down the movement of runoff water and allows the excess surface water to permeate. De-vegetation reduces permeation capacity of soil, reduces absorption of water and ability for plants to grow. As more water is lost with surface runoff, thus it promotes erosion and compaction of the land by wind and rain. Forests and grasses are more effective in preventing erosion than the cultivated crops as their roots almost keep a tight hold of the soil. After their removal, soils become loose and hence susceptible to erosion.

Another influence of soil erosion is on botanical composition of the overgrazed and de-forested land. In the process many species of herbs and grasses having high nutritional value are lost and their ability of regeneration is also reduced. The overgrazed plants do not get sufficient time to grow to the correct height and their leaf area is also condensed, which decreases capture of sunlight required for photosynthesis that further reduces plant growth. Hence plants become week due to poor growth and increased root length [3]. The overgrazed pastures due to continuous grazing are dominated by short-grass species and weeds which because of their poor holding capacity lead to increasing soil erodibility. In addition, these lands are less able to soak up water, making flooding more common. Excessive overgrazing resulting in de-vegetation in arid or semi-arid areas may even cause irreversible degradation of soil to such a level that it can not be recovered for its original use causing desertification [4].

According to a data published by National Bureau of Soil Survey and Land Use Planning, out of total 187.8 million ha land degraded annually, 167.0 million ha land is degraded due to soil erosion, and causing an estimated total annual loss in productivity of major crops as a result of soil erosion as 7.2 million tones [5, 6]. Approximately, 5300 million tonnes of top soil get eroded in India annually and 24% of this amount is carried by rivers as sediments and deposited in the sea, and nearly 10% is deposited in reservoirs [7].

Cropping and Vegetation Tillage Practices

Plant and residue cover protects the soil from raindrop influence and splash, slow down the movement of runoff water and let excess surface water to penetrate. Crops in the field also protect the soil from the influence of rain and winds. But different crops provide different levels of protection. The erosion-reducing efficiency of crops depends on the type, extent and amount of the surface cover. Vegetation that totally covers the soil, captures all raindrops falling at and close to the surface are the most effective in preventing soil erosion [8]. The effectiveness of surface cover is also be determined by the fact that how much protection is available at various periods during the year. For example alfalfa or winter cover crops can reduce erosion much more than crops like row crops, that leave the soil bare for a longer period of time mainly during periods of highly erosive rainfall such as spring and summer. Wheat is sowed in the fall of the year and it covers the soils in the fall, winter and spring before it is harvested. Soybeans on the other hand are ingrained in the spring and harvested in the late summer. Therefore the field has very less protection in the fall of winter and early spring. The most of the erosion on annual row-crop land can be reduced by leaving a residue cover greater than 30% after harvest and over the winter months, or inter-seed a cover crop.

Tillage Practices

Soil erosion by water is also increased by tillage operations, depending on the depth, direction and timing of cultivation, type of tillage equipments. Tillage and cropping practices that reduce soil organic matter levels, infiltration rate, or result in soil compaction, cause poor soil structure, salinity and soil acidity, increase the soil erodibility and speed up the soil erosion process. Tillage and other cultivation practices executed up and down field slopes create paths for surface water runoff and can speed up the soil erosion process. Soil eroded from the land, carry along with pesticides and fertilizers applied to the fields, washes into streams and waterways thus causing water pollution. This sedimentation and pollution can damage freshwater and marine habitats; can harm fish and other aquatic life and the local communities that depend on them.

Mining Activities

Mining activities lead to large scale deforestation, causing destruction of landscapes because trees, plants and topsoil are cleared from the mining area, as a result its water resources gets damaged, soils get contaminated, part or total of flora and fauna gets vanished, air and water get polluted [9]. By losing its green cover the land or by getting disturbed otherwise due to mining activities gets exposed to erosion. Rain water washes away this loosened top soil resulting in sedimentation of rivers, lakes and coastal areas which can obstruct stream and drainage channels, fill in reservoirs and degrade downstream water quality. It may also speed up bank erosion which may further cause river and dam siltation, siltation of harbours and channels, loss of reservoir storage, damage to roadways and sewers, disruption of stream ecology and damage to public health. In addition, it can increase the frequency of flooding by raising stream beds and burying streamside wetlands, sediment

Control measures

More Vegetation: Presence of vegetation ground cover retards erosion, as it intercepts the erosive beating action of falling raindrops retards the amount and velocity of surface fun off, permits more water flow into the soil and creates more storage capacity in the soil. Trees and grasses are more effective in this context than the cultivated crops.

Crop rotation: Plenty of crop rotation is important for keeping land healthy. This leads to organic matter build up and creating future plantings more productive.Crop management practices favoring contour farming and strip-cropping techniques can further reduce the amount of erosion.

Management of steeper fields: In case of steeper fields, the simplest crop management practice considered is cross-slope planting, in which farmers plant the crops in rows perpendicular to the slope of the land. This slows down the runoff water and reduces the energy contained in this runoff water. Slower water is not able to transport as much soil as rapidly flowing water. Cross-slope cultivation and contour farming techniques discourage the concentration of surface water runoff and limit soil movement.

Reduction in length of runoff: Reduction in length of runoff or wind blow through construction of terrace, bunds etc. in case of water erosion and wind breaks or shelter belts in case of wind erosion can be highly fruitful.

Construction of check dams: Other management practices that farmers can take on to reduce soil erosion include construction of check dams along the gullies, bench terracing, contour binding, land leveling and planting of grasses along contours. Use of gentler slopes, higher density drainage, smaller drainage basins, avoiding terraces and contour banks should be proffered. Management practices including water development, placement of salt and supplements, fertilizer application, fencing and the planting of special forages which can be used to enhance grazing by livestock in underutilized areas can be used to improve grazing distribution to avoid soil erosion.

Careful tilling: Perform less tilling with fewer passes in order to preserve more of the crucial topsoil as tilling activity breaks up the structure of soil and thus accelerate soil erosion.

Re-vegetation: Soils affected by mining should be returned to a safe and productive condition through proper reclamation/restoration planning. Re-vegetation selecting suitable plant species in the mine area after mining should be the mandatory protocol for mining industry. Development of permanent vegetation, specially the forests, by stabilizing soil, soil organic matter

and soil nutrients should be a major component of reclamation activity after mining to avoid soil erosion. For that mining industry, government and the local people must work together.

Public Awareness: The best way to prevent soil erosion is educating more and more people who work with the land on the factors which accelerate soil erosion and how they can help to reduce it. That is train farmers in susceptible areas for methods that they can use to protect their crops from severe weather, or techniques that they can use to make their soil remain compact without hampering their plant growing activities.

CONCLUSION

Soil erosion is a critical environmental issue affecting soil quality and causing water pollution. It has direct influence on food resources, biodiversity and socio-economic effect. There are several factors such as rainfall, runoff, winds, plant cover, slope, soil properties, overgrazing, mining activities, presence or absence of conservation measures etc. responsible for soil erosion.

There is necessity to cultivate sustainable land management methods to fight this issue to conserve and restore soil functions and ecosystem services. Lack of knowledge regarding soil erosion from various human activities further adds to this grim problem. There is sincere necessity of programs aiming at prevention, control and restoration of land management measures to check soil threats and degradation due to erosion, along with their costs and benefits and adverse effects. There should be correct implementation and regular assessment of these measures in order to acclimatize them to local perspectives. Above all, our economic development must have respect for the environmental integrity.

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