TOPIC: -

SOIL EROSION

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INTRODUCTION: -

Soil erosion is an important social and economic problem and an essential factor in assessing ecosystem health and function. Soil erosion is a natural process which has increasingly been exacerbated by human activities such as agriculture and deforestation. Thus, soil erosion is a continuous process and may occur either at a relatively unnoticed rate or an alarming rate contributing to copious loss of the topsoil. While erosion is a natural process, human activities have increased by 10–40 times the rate at which erosion is occurring globally. Excessive (or accelerated) erosion causes both "on-site" and "offsite" 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. Soil erosion reduces cropland productivity. Soil erosion contributes to the pollution of adjacent watercourses, wetlands and lakes.

Soil erosion can be defined as a process of detachment and transport of soil particles from one place to another (Singer and Munns, 1999; and Cutler, 2006).

The total land area subjected to human-induced soil degradation is estimated at about 2 billion ha.

Of this, the land area affected by soil degradation due to erosion is estimated at 1100 mha by water erosion and 550 mha by wind erosion.

In India, nearly 80 mha area is exposed to the threat of soil erosion, and 43 mHa area is actually affected.

In states like Madhya Pradesh, Rajasthan, Maharashtra and Punjab, upto 15 per cent of the total land suffers from soil erosion.

It is reported that the annual loss of fertility by erosion is 20 times faster than what is lost by growing crops. Each year, 10,000 hectares' area is exposed to erosion. Nearly 145 mha area in India is in need of conservation measures.

With respect to land conservation and practice, soil erosion in tropical and semi-arid regions considered as a hazard traditionally associated with agriculture (Morgan, 1995). This occurs mainly due to rainfall intensity, poor soil conditions and improper landuse management. In simple terms, soil erosion refers to the wearing a way of a field's topsoil by the natural physical

forces of water and wind. It can be a slow process. It is relatively unnoticed or can occur at an alarming rate, causing serious loss of topsoil. Soil compaction, low organic matter, loss of soil structure, poor internal drainage, salinization and soil acidity problems are other serious soil degradation conditions that can accelerate the soil erosion process.

Erosion is a major problem affecting soils all over the world. The rapid growth of the world's population has resulted in increased cultivation of land. This puts more pressure on land and leads to soil losing its structure and cohesion, which means that it can be eroded more easily. Heavy farming machinery can also 'compact' soil, which causes water to run straight off the surface after rain, taking soil particles with it, instead of infiltrating into the soil.

SOIL EXHAUSTION: -

Soil exhaustion basically means the loss of nutrients in soil from farming the same crop over and over again. It mostly happens in rainforests. Some crops such as corn exhaust soil quickly while others such as beans actually take nitrogen from the atmosphere and replenish the soil. Soil exhaustion occurs when poorly managed soils are no longer able to support crops or other plant life. Soil exhaustion has consequences beyond limited production; it also increases the risk of soil erosion. Soil exhaustion can be prevented in a number of ways. Commercial farms often reapply commercial fertilizers every year, but this can be expensive and damaging to the environment. Natural compost from animal waste can be added which is a more natural way to prevent soil exhaustion, but they too can damage the environment from water runoff. A better way to prevent soil exhaustion is to rotate crops. Cover crops can also help prevent soil exhaustion by protecting soil from erosion. So there is not any particular crop which causes soil exhaustion. The phenomenon mostly occurs by the repeated cultivation of same crop.

FACTORS AFFECTING SOIL EROSION: -

The factors affecting erosion can be divided into two categories; natural and human induced (Dingman, 1994; and Wu et al., 2004). Precipitation and slope steepness comprise natural factors for the most part, while human factors consist of development or activities related to agriculture, mining and constructions. Such activities generally remove the protective vegetation cover, resulting in accelerated erosion by both water and wind. Natural factors commonly affect the upper soil layer as compared to human induced factors. Both contribute a significant amount of soil loss due to water and wind erosion. The main causes of soil erosion are overgrazing (35 percent), deforestation (30 percent) and agricultural activities (28 percent).

Overgrazing causes degradation when the soil loses it fertility and sparse vegetation cover. The major factors affecting soil erosion are:

1. **CLIMATIC FACTORS: -** The amount and intensity of precipitation is the main climatic factor governing soil erosion by water. The relationship is particularly strong if heavy rainfall occurs at times when, or in locations where, the soil's surface is not well protected by vegetation. Wind erosion requires strong winds, particularly during times of drought when vegetation is sparse and soil is dry. Other climatic factors such as average temperature and temperature range may also affect erosion, via their effects on vegetation and soil properties. In general, given similar vegetation and ecosystems, areas with more precipitation, more wind, or more storms are expected to have more erosion.
2. **TOPOGRAPHY**: - The topography of the land determines the velocity at which surface runoff will flow, which in turn determines the erosivity of the runoff. Longer, steeper slopes (especially those without adequate vegetative cover) are more susceptible to very high rates of erosion during heavy rains than shorter, less steep slopes. Steeper terrain is also more prone to mudslides, landslides, and other forms of gravitational erosion processes.
3. **SOIL ERODIBILITY: -** 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.
4. **DEFORESTATION**: - It causes increased erosion rates due to exposure of mineral soil by removing the humus and litter layers from the soil surface, removing the vegetative cover that binds soil together, and causing heavy soil compaction from logging equipment. Once trees have been removed by fire or logging, infiltration rates become high and erosion low to the degree the forest floor remains intact. Severe fires can lead to significant further erosion if followed by heavy rainfall. Globally one of the largest contributors to erosive soil loss in the year 2006 is the slash and burn treatment of tropical forests.
5. **AGRICULTURE: -** It also causes the worst type of soil erosion on farmland in the form of wash-off or sheet erosion. The following agricultural practices can lead to accelerated soil erosion:

a. **TILLING OR PLOUGHING: -** increases the chances of erosion because it disturbs the natural soil surface and protective vegetation.

b. **CONTINUOUS CROPPING: -** Continuous cropping of the same land and extending of cultivation of marginal and sub-marginal lands encourages soil erosion.

c. **CULTIVATION ON MOUNTAIN SLOPES: -** Cultivation on mountain slopes without appropriate land treatment measures such as bounding, terracing and trenching cause soil erosion and loss of soil nutrients.

d. **MONOCULTURE: -** Monoculture practices can lead to soil erosion in three ways.

(i) A monoculture crop is harvested all at one time, which leaves the entire fields bare exposing it to both water and wind.,

(ii) Without vegetation natural rainfall is not retained by the soil and flows rapidly over the surface rather than into the ground. It also carries away the top soil which results in soil erosion and degradation and

(iii) In the event any disease or pest invades the field, the entire crop is usually wiped out leaving the bare soil susceptible to water and wind.

6. **ECONOMIC ACTIVITIES: -** Soil erosion also occurs due to economic activities. The extraction of useful natural resources such as metals, minerals and fossil fuels etc., from the land causes serious disturbance to the land leading to soil erosion and drastic changes in the landscape.

7. **OVERGRAZING: -** It means too many animals are allowed to feed on a piece of grassland. Trampling and grazing by cattle destroys the vegetation of the area. In the absence of adequate vegetative cover the land becomes highly susceptible to both wind and water erosion.

8. **DEVELOPMENTAL ACTIVITIES: -** Soil erosion may also occur because of various developmental activities such as housing, transport, communication, recreation, etc. Building construction also promotes soil erosion because accelerated soil erosion takes place during construction of houses, roads, rail tracks etc. The construction of such facilities causes massive disturbance to land, resulting in soil erosion and disruption of natural drainage system.

9. **CLIMATE CHANGE: -** Soil erosion rates are expected to change in response to changes in climate for a variety of reasons. The most direct is the change in the erosive power of rainfall.

TYPES OF SOIL EROSION: -

A. Soil erosion in nature may be (a) a slow process (or geological erosion) or (b) a fast process promoted by deforestation, floods, tornadoes or other human activities. These two processes are explained below:

a. GEOLOGICAL EROSION: - Geological erosion is a slow process that continues relatively unnoticed and has been occurring for millions of years. The first phase of this soil forming process is called weathering which is a physico- chemical process that leads to the breakdown of rocks by wind and water into small fragments and formation of soil particles.

b. ACCELERATED (SPEEDED UP) EROSION: - Accelerated soil erosion occurs when the protective vegetation cover is destroyed. This may occur due to natural causes like flooding or due to human activities. One of the main human activity responsible for accelerated soil erosion is cultivation of land. Land under cultivation is more vulnerable to natural agencies like wind and water. Human activities accelerate removal of surface soil by wind and /or water at a faster rate. The rate and extent of accelerated soil erosion is much higher as compared to natural geological soil erosion.

B. Soil erosion is also classified on the basis of the physical agent responsible for erosion. The various types of soil erosion are consequently referred to as: (I) Water erosion (II) Wind erosion and (III) Mass Wasting

(1) WATER EROSION: - Running water is one of the main agents, which carries away soil particles. Soil erosion by water occurs by means of raindrops, waves or ice. Soil erosion by water is termed differently according to the intensity and nature of erosion.

a. **SPLASH EROSION: -** It 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 two feet vertically and 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.

b. SHEET EROSION: - The detachment and transportation of soil particles by flowing rainwater is called sheet or wash off erosion. This is very slow process and often remains not noticed.

c. **RILL EROSION: -** In rill erosion finger like rills appear on the cultivated land after it has undergone sheet erosion. These rills are usually smoothened out every year while forming. Each year the rills slowly increase in number become wider and deeper. When rills increase in size they are called gullies. Ravines are deep gullies.

d. **BANK EROSION: -** It 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. Stream bank erosion damages the adjoining agricultural lands, highways and bridges.

e. **COASTAL EROSION: -** Coastal erosion of soil occurs along sea shores. It is caused by the wave action of the sea and the inward movement of the sea into the land.

(2) WIND EROSION: - Wind erosion is a major geomorphologic force, especially in arid and semi-arid regions. 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: (a) surface creep, where larger, heavier particles slide or roll along the ground; (b) saltation, where particles are lifted a short height into the air, and bounce and saltate across the surface of the soil; and (c) 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.

(3) MASS WASTING: - Mass wasting 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 wasting processes are always occurring continuously on all slopes; some mass wasting 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.

GLOBAL OUTLOOK OF SOIL EROSION: - Soil is eroding faster than it is forming on more than one-third of the world's cropland. The total land area subjected to human-induced soil degradation is estimated at about 2 billion ha. Of this, the land area affected by soil degradation due to erosion is estimated at 1100 mha by water erosion and 550 mha by wind erosion. n India, nearly 80 mha area is exposed to the threat of soil erosion, and 43 mHa area is actually affected. In states like Madhya Pradesh, Rajasthan, Maharashtra and Punjab, upto 15 per cent of the total land suffers from soil erosion. It is reported that the annual loss of fertility by erosion is 20 times faster than what is lost by growing crops. Each year, 10,000 hectares' area is exposed to erosion. Nearly 145 mha area in India is in need of conservation measures.

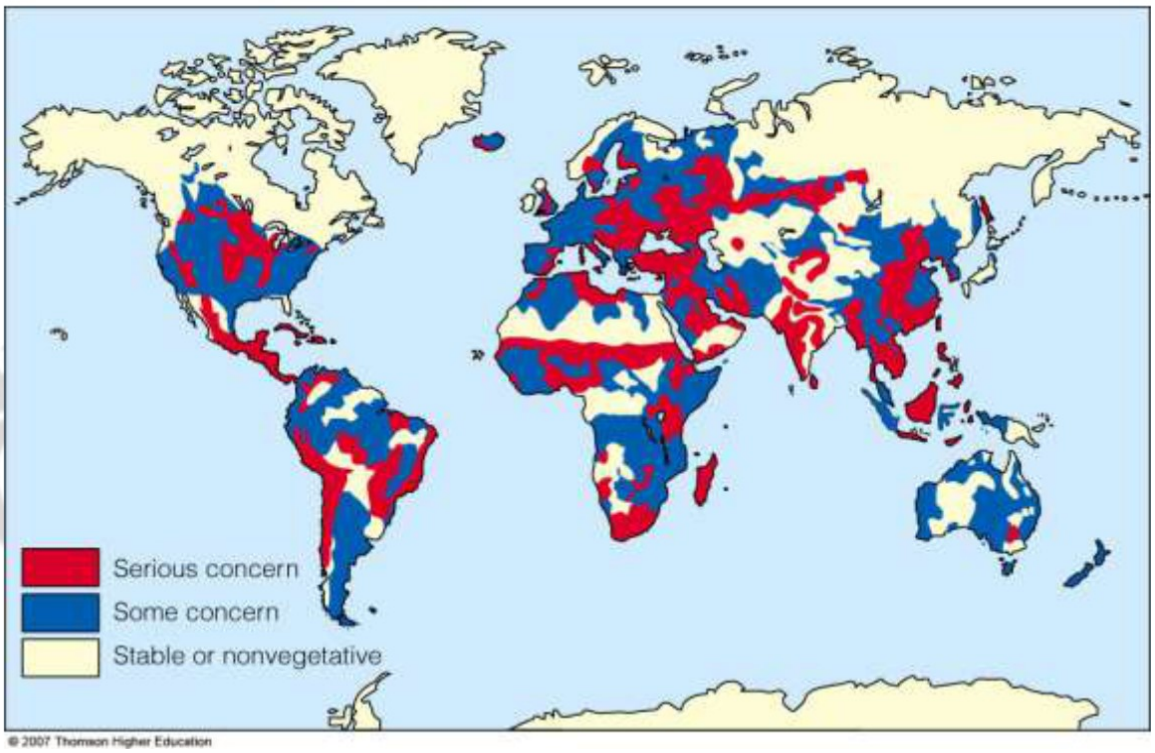

Fig.1: Global Outlook of Soil Erosion

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:

(i) **LAND DEGRADATION: -** Water and wind erosion are now the two primary causes of land degradation. They are responsible for 84% of degraded acreage. Each year, about 75 billion tons of soil is eroded from the land—a rate that is about 13–40 times as fast as the natural rate of erosion. Approximately 40% of the world's agricultural land is seriously degraded.

(ii) **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.

(iii) **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.

(iv) **AIRBORNE DUST POLLUTION: -** Soil particles picked up during wind erosion of soil are a major source of air pollution, in the form of airborne particulates—"dust". These airborne soil particles are often contaminated with toxic chemicals such as pesticides or petroleum fuels, posing ecological and public health hazards when they later land, or are inhaled/ingested.

(v) **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.

(vi) **DESERTIFICATION: -** Soil erosion is a major driver of desertification. It gradually transforms a habitable land into deserts. The transformations are worsened by the destructive use of the land and deforestation that leaves the soil naked and open to erosion.

DECLINE IN SOIL CAPACITY: - When the soil is removed bodily from field, both potential and available plant food along with mineral material is carried away. As erosion progresses, the compact soil of low infiltration capacity is approached.

The ability of the land to supply moisture for plant growth is reduced and the beneficial activity of micro-organisms lessened. Due to these bad effects, the yields are lowered.

(viii) **SOIL ACIDITY LEVELS: -** When the structure of the soil becomes compromised, and organic matter is greatly reduced, there is a higher chance of increased soil acidity, which will significantly impact the ability for plants and crops to grow.

(ix) **FLOODING OF STREAMS: -** Soil erosion in catchment areas of streams due to deforestation and other destructive activities leads to silting of streams and reservoirs. This reduces the capacity of these water bodies to carry large volumes of water, as they occur during the rainy season. This way the streams are more prone to flooding. One such example is River Brahmaputra that has been exposed to siltation because of large-scale deforestation in the hills, and the floods in Brahmaputra valley have become an annual phenomenon now.

(x) **ISSUES WITH PLANT REPRODUCTION: -** When soil is eroded in an active cropland, wind in particular makes lighter soil properties such as new seeds and seedlings to be buried or destroyed. This, in turn, impacts future crop production.

REMEDIAL STRATEGIES FOR PREVENTION OF SOIL EROSION: -

When it comes to finding solutions for soil erosion, the most useful techniques found tend to be those that emphasize reinforcing the structure of the soil, and reducing processes that affect it.

(A) **BIOLOGICALMEASURES: -** The following are biological methods to control soil erosion:

(i) IMPROVING THE EXISTING SURFACE COVER: - This can be done by resorting to cover cropping by growing groundnut or berseem (a fodder crop) or through grasslands development by growing grasses like dub, kudzu, pans.

(ii) STRIP CROPPING: - This practice consists of growing erosion-permitting crops (jowar, bajra, maize) in alternate strips with erosion checking close- growing crops (grasses, pulses). The erosion checking strips check and hold the flowing water and soil.

(iii) CROP ROTATION: - Plenty of crop rotation is crucial for keeping land happy and healthy. This allows organic matter to build up, making future plantings more fertile.

(iv) **STUBBLE MULCHING**: - Access of wind to the soil should be controlled by leaving the stubble or mulch on the soil.

(v) USING ORGANIC MANURES: - Organic manures like cow dung, green manure, farmyard manure etc., improve the soil structure. Granular and crumby structures increase infiltration and permeability in the soil and conserve soil moisture.

(vi) Other measures include checking overgrazing, reducing surplus cattle, stopping shifting cultivation and taking preventive measures against forest fires.

(B) MECHANICAL MEASURES: -

The mechanical measures that can be used to control erosion are as follows.

(i) CONTOUR TILLAGE: - On sloping lands, all tillage operations should be done at right angles to the slope of the land. This way, each furrow intercepts the flowing water and allows it to soak into the soil.

(ii) CONTOUR BUNDING: - The idea is to break the slope of the land into smaller, more level compartments by constructing mechanical structures of suitable size along contours. Each bund, thus, holds the rainwater within each compartment.

(iii) TERRACING: - Terracing is an extremely effective means of erosion control, which has been practiced for thousands of years by people all over the world.

(iii) **WATER HARVESTING: -** This refers to trapping or channelling of water into low-lying areas. This helps in checking the run-off and also acts as a flood control measure

(iv) **SCIENTIFIC SLOPE MANAGEMENT**: - The cropping activity on slopes should be taken up as per the nature of slope. If the slope is between 1:4 and 1:7, proper farming can be done; if more, pastures should be developed; if still more, forestry operations can be undertaken; if it is still greater, then terracing is required before any cropping activity can be done.

(v) **WATER CONTROL: -** For those areas where soil erosion is predominantly caused by water

– whether natural or man-made – specialized chutes and runoff pipes can help to direct these water sources away from the susceptible areas, helping stave off excess erosion.

(vi) **INCREASED KNOWLEDGE: -** A major factor for preventing soil erosion is educating more and more people who work with the land on why it is a concern, and what they can do to help reduce it. This means outreaches to farmers in susceptible areas for ways that they can help protect crops from inclement weather, or ways that they can help make sure their soil remains compact without restricting their plant growing activities.

CONCLUSION: -

Today soil erosion is considered as one of the most serious natural resource depletions in the world. Over the past several thousand years, deforestation, fuel wood, overgrazing, agriculture and industrialization activities have contributed to the greatest soil erosion problem.

The adoption of various soil conservation measures reduces soil erosion by water, wind and tillage. Tillage and cropping practices, as well as land management practices, directly affect the overall soil erosion problem and solutions on a farm. When crop rotations or changing tillage practices are not enough to control erosion on a field, a combination of approaches or more extreme measures might be necessary.