

Soil Erosion Causes and Effects:

Introduction

Soil erosion is one form of soil degradation along with soil compaction, low organic matter, loss of soil structure, poor internal drainage, salinization, and soil acidity problems. These other forms of soil degradation, serious in themselves, usually contribute to accelerated soil erosion. Soil erosion is a naturally occurring process on all land. The agents of soil erosion are water and wind, each contributing a significant amount of soil loss each year in Ontario.

Soil erosion may be a slow process that continues relatively unnoticed, or it may occur at an alarming rate causing serious loss of topsoil. The loss of soil from farmland may be reflected in reduced crop production potential, lower surface water quality and damaged drainage networks.

Erosion by Water

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

Rainfall Intensity and Runoff

Both rainfall and runoff factors must be considered in assessing a water erosion problem. 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 can be easily removed by the raindrop splash and runoff water; greater raindrop energy or runoff amounts might be required to move the larger sand and gravel particles.

Soil movement by rainfall (raindrop splash) is usually greatest and most noticeable during short duration, high-intensity thunderstorms. Although the erosion caused by long-lasting and less intense storms is not as spectacular or noticeable as that produced during thunderstorms, the amount of soil loss can be significant, especially when compounded over time. Runoff can occur whenever there is excess water on a slope that cannot be absorbed into the soil or trapped on the surface. The amount of runoff can be increased if infiltration is reduced due to soil compaction, crusting or freezing. Runoff from the agricultural land may be greatest during spring months when the soils are usually saturated, snow is melting and vegetative cover is minimal.

Soil Erodibility

Soil erodibility is an estimate of the ability of soils to resist erosion, based on the physical characteristics of each soil. 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 which lower soil organic matter levels, cause poor soil structure, and result of compacted contribute to increases in soil erodibility. Decreased infiltration and increased runoff can be a result of compacted subsurface soil layers. A decrease in infiltration can also be caused by a formation of a soil crust, which tends to "seal" the surface. On some sites, a soil crust might decrease the amount of soil loss from sheet or rain splash erosion,

however, a corresponding increase in the amount of runoff water can contribute to greater rill erosion problems.

Past erosion has an effect on a soils' erodibility for a number of reasons. Many exposed subsurface soils on eroded sites tend to be more erodible than the original soils were, because of their poorer structure and lower organic matter. The lower nutrient levels often associated with subsoils contribute to lower crop yields and generally poorer crop cover, which in turn provides less crop protection for the soil.

Slope Gradient and Length

Naturally the steeper the slope of a field, the greater the amount of soil loss from erosion by water. Soil erosion by water also 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).

Vegetation

Soil erosion potential is increased 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 surface runoff and allows excess surface water to infiltrate.

The erosion-reducing effectiveness of plant and/or residue covers depends on the type, extent and quantity of cover. Vegetation and residue combinations that completely cover the soil, and which intercept all falling raindrops at and close to the surface and the most efficient in controlling soil (e.g. forests, permanent grasses). Partially incorporated residues and residual roots are also important as these provide channels that allow surface water to move into the soil.

The effectiveness of any crop, management system or 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. In this respect, crops which provide a food, protective cover for a major portion of the year (for example, alfalfa or winter cover crops) can reduce erosion much more than can crops which leave the soil bare for a longer period of time (e.g. row crops) and particularly during periods of high erosive rainfall (spring and summer). However, 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 by inter-seeding a forage crop (e.g. red clover).

Soil erosion potential is affected by tillage operations, depending on the depth, direction and timing of plowing, the type of tillage equipment and the number of passes. Generally, the less the disturbance of vegetation or residue cover at or near the surface, the more effective the tillage practice is in reducing erosion.

Conservation Measures

Certain conservation measures can reduce soil erosion by both water and wind. 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. For example, contour plowing, strip cropping, or terracing may be considered.

Effects

Sheet and Rill Erosion

Sheet erosion is soil movement from raindrop splash resulting in the breakdown of soil surface structure and surface runoff; it occurs rather uniformly over the slope and may go unnoticed until most of the productive topsoil has been lost. Rill erosion results when surface runoff concentrates forming small yet well-defined channels. These channels are called rills when they are small enough to not interfere with field machinery operations. The same eroded channels are known as gullies when they become a nuisance factor in normal tillage.

Surface runoff, causing gully formation or the enlarging of existing gullies, is usually the result of improper outlet design for local surface and subsurface drainage systems. The soil instability of fully banks, usually associated with seepage of ground water, leads to sloughing and slumping (caving-in) of bank slopes. Such failures usually occur during spring months when the soil water conditions are most conducive to the problem.

Gully formations can be difficult to control if remedial measures are not designed and properly constructed. Control measures have to consider the cause of the increased flow of water across the landscape, and a multitude of conservation measures come into play. Operations with farm machinery adjacent to gullies can be quite hazardous when cropping or attempting to reclaim lost land.

Stream and Ditch Bank Erosion

Poor construction, or inadequate maintenance, of surface drainage systems, uncontrolled livestock access, and cropping too close to both stream banks has led to bank erosion problems.

The direct damages from bank erosion include:

1. The loss of productive farmland.
2. The undermining of structures such as bridges.
3. The washing out of lanes, roads and fence rows.

Poorly constructed tile outlets may also contribute to stream and ditch bank erosion. Some do not function properly because they have no rigid outlet pipe, or have outlet pipes that have been damaged by erosion, machinery, inadequate or no splash pads, and bank cave-ins.

On-Site Effects: The implications of soil erosion extend beyond the removal of valuable topsoil.

Crop emergence, growth and yield are directly affected through the loss of natural nutrients and applied fertilizers with the soil. Seeds and plants can be disturbed or completely removed from the eroded site. 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. 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 condition such a drought.

Off-Site Effects: Off-site impacts of soil erosion are not always as apparent as the on-site effects. Eroded soil, deposited down slope can inhibit or delay the emergence of seeds, bury small seedling and necessitate replanting in the affected areas. Sediment can be deposited on down slope properties and can contribute to road damage.

Sediment which reaches streams or watercourses can accelerate bank erosion, clog drainage ditches and stream channels, silt in reservoirs, cover fish spawning grounds and reduce downstream water quality. Pesticides and fertilizers, frequently transported along with the eroding soil can contaminate or pollute downstream water sources and recreational areas. Because of the potential seriousness of some of the off-site impacts, the control of "non-point" pollution from agricultural land has become of increasing importance in Ontario.

Erosion by Wind

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

Erodibility of Soil

Very fine particles can be suspended by the wind and then transported great distances. Fine and medium size particles can be lifted and deposited, while coarse particles can be blown along the surface (commonly known as the saltation effect). The abrasion that results can reduce soil particle size and further increase the soil erodibility.

Soil Surface Roughness

Soil surfaces that are not rough or ridged offer little resistance to the wind. However, over time, ridges can be filled in and the roughness broken down by abrasion to produce a smoother surface susceptible to the wind. Excess tillage can contribute to soil structure breakdown and increased erosion.

Climate

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

drying of the surface during winter months.

Unsheltered Distance

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

Vegetative Cover

The lack of permanent vegetation cover in certain locations has resulted in extensive erosion by wind. Loose, dry, bare soil is the most susceptible, however, crops that produce low levels of residue also may not provide enough resistance. As well, crops that produce a lot of residue also may not protect the soil in severe cases.

The most effective vegetative cover for protection should include an adequate network of living windbreaks combined with good tillage, residue management, and crop selection.

Resulting Effect

Wind erosion may create adverse operating conditions in the field. Crops can be totally ruined so that costly delay and reseedling is necessary - or the plants may be sandblasted and set back 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. This, in turn, increases the erodibility of the soil and compounds the problem.

The removal of wind-blown soils from fence rows, ditches, roads and from around buildings is a costly process.

Summary

Many farmers have already made significant progress in dealing with soil erosion problems on their farms. However, because of continued advances in soil management and crop production technology that have maintained or increased yields in spite of soil erosion, others have not been aware of the increasing problem on farmland. Awareness usually occurs only when property is damaged and productive areas of soil are lost.

Ontario Ministry of Agriculture – Food and Rural Affairs:

Written by:

OMAFRA Staff; G. Wall - Ontario Institute of Pedology; C.S. Baldwin - Ridgeway
College of Agricultural Technology; I.J. Shelton - Ontario Institute of Pedology

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