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Soil Management To Protect Water Quality

Estimating Soil Erosion Losses And Sediment Delivery Ratios

It is generally assumed that if soil erosion is controlled, then sediment will also be controlled. This is true since erosion must occur to produce sediment. However, it is not practical nor possible to stop all erosion, and there are many alternatives that can be used individually or in combination for cost-effective control of sediment release into the environment. The first step in developing an erosion-control plan is to determine the severity of erosion on your farm: How much soil is eroded or lost from a field? How much sediment is transported or delivered to a nearby stream?

Using The Universal Soil Loss Equation (USLE)

For more than 50 years the U.S. Department of Agriculture and state agricultural experiment stations have researched, developed, and improved the Universal Soil Loss Equation (USLE). The USLE provides a convenient framework for discussing factors affecting soil erosion and its control.

The USLE computes average annual soil loss from sheet and rill erosion. Major erosion factors such as rainfall, soil erodibility, slope length, slope steepness, soil and crop management, and supporting conservation practices are assigned numerical values. The USLE combines these major erosion factors to predict average annual soil losses.

The equation is A = R K L S C P.

In this equation, soil erosion, A, is described as a function of:

R = rainfall and runoff (rain erosivity)

K = soil erodibility

L = slope length

S = slope steepness

C = soil and crop management

P = conservation practices

To estimate average annual erosion potential of any given field, simply multiply the appropriate numerical values developed for each factor. Numerical values for the various USLE factors are available from state and local offices of the Natural Resources Conservation Service. While the USLE has no geographical bounds, you must know the local values of its individual factors to apply it to your location.

A new version of the USLE, called the Revised Universal Soil Loss Equation (RUSLE) is now on the market. It provides more accurate estimates of crop residue cover, incorporation and decomposition, crop growth, soil moisture, annual rainfall erosivity, surface roughness, and effects of support practice factors. Certified software packages may be ordered from the Soil and Water Conservation Society in Ankeny, Iowa.

More About Erosion Factors

The rainfall factor, R, accounts for the potential of falling rain drops and flowing water in a particular area to produce erosion. Cumulative effects of all yearly storms above a certain intensity and duration make up this numerical value. As the energy of a storm increases, the potential for more soil particles to detach increases. Runoff also increases with intensity and duration of storms, thereby increasing erosion potential. At present, little can be done to change the amount, distribution, and intensity of rainfall, but measures can be adopted to limit its effect on erosion. For example, vegetative soil cover can reduce the effect of raindrop impact on the soil and the velocity of runoff.

The soil erodibility factor, K, considers soil properties that influence both detachment and transport of soil materials. These include soil organic matter content, texture, structure, size, shape, and stability of aggregates, and the permeability of the soil to water. Soil erodibility tends to increase with greater silt content and decrease with greater sand and clay contents. Organic matter binds individual particles together thus increasing aggregate strength, hence the resistance to detachment. Soil structure, in terms of its size, shape, and aggregate stability, influences the infiltration rate. Erosion will not occur if the infiltration rate is greater than the rainfall rate. Permeability of the soil to water affects erosion because rainfall must enter and move through the soil if runoff is to be minimal.

Soil erosion by water is affected by slope length, L, and slope steepness, S, which jointly determine the amount and velocity of runoff. Doubling the length of slope increases the erosion hazard one and one-half times. Doubling the steepness of slope increases the hazard two and one-half times.

For a given tract of land, an operator has little direct control over rainfall characteristics, soil properties, topography, or slope. However, the effects these factors have on soil erosion can be limited by management techniques represented by factors C and P.

The soil and crop management factor, C, includes crop sequences, residue management, soil fertility management, time of tillage, intensity of tillage, and row spacing of row crops.

Factor P represents soil conservation practices that essentially slow the runoff water and thus reduce the amount of soil it can carry. The most important of these supporting practices are contour tillage, strip cropping, and terracing.

Using The Sediment Delivery Ratio

While the USLE computes gross sheet and rill erosion, it does not directly predict downstream sediment yield.

The amount of eroded soil that actually reaches a stream is difficult to determine. Many scientists use very complex computer models, which are a collection of mathematical and logic equations, to predict detachment rates, transport rates, and deposition rates of sediment at given points in a watershed.

Many factors affect when and where sediments will be deposited. In a large area, the cropland contribution to sediment in stream flow is influenced by the total amount of sediment produced on the cropland (gross erosion), the density of cropland in the drainage area, and the portion of eroded soil that actually reaches a continuous stream system (sediment delivery ratio).

The sediment delivery ratio (SDR) is used to adjust the gross sediment estimate to compensate for deposition along the path traveled by the runoff water as it moves from fields in the watershed to a continuous stream system. How much sediment is deposited (sediment yield) can be estimated by computing the gross erosion and multiplying by the sediment delivery ratio if a sediment delivery ratio is known or can be approximated from known parameters.

The sediment delivery ratio will be less in situations where erosion sources are located distant from water courses or are separated from water courses by sediment-holding areas such as woodlands, other vegetated areas, or sediment basins. Sediment delivery will also be reduced by larger drainage areas, coarse soil texture, gentle topography, and a predominance of sheet and rill erosion as opposed to gully erosion.

Sediment delivery ratio may range from near 100 percent to less than 1 percent, depending on field slope and what is between the eroded site and stream that can slow down the flow and trap eroded sediment prior to its reaching a flowing stream. The sediment delivery ratios for many agricultural watersheds have been estimated at 25 percent, plus or minus 15 percent, depending more on size of the watershed than any other factor.

Sediment delivery ratios vary widely for any given size drainage area, but limited data have shown that they generally vary inversely with the size of the drainage area. General approximations of delivery ratios are given in Table 1.

Table 1. Variation In Sediment Delivery Ratios With Size Of Drainage Basin.

Drainage Area (Square Miles)	Sediment Delivery Ratio
0.5	0.33
1.0	0.30
5.0	0.22
10.0	0.18
50.0	0.12
100.0	0.10
200.00	0.08

Source: Stewart, et al., 1978.

Because erosion hazards are site specific, soil loss estimates and control guides can be accurately applied only on a field basis.

Erosion rates can even be quite variable within the boundaries of an individual field, which may contain several soil types with variations in slope, texture, and permeability.

Conclusion

Once you have assessed the erosion problem, there are various conservation practices and structures to choose from. All of these are designed to help you manage your soil to minimize erosion and sedimentation. Proper soil and crop management practices will increase infiltration rates, thus increasing groundwater supply, while reducing runoff and improving surface water quality

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