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Soil and water Conservation Engineering

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UNIVERSAL SOIL LOSS EQUATION (USLE)

Smith & Wischmeier

Smith and Wischmeier derived an equation to evaluate total amount of soil loss. The equation is

$$A = R .K. L. S. C. P$$

Where,

A = Avg. annual soil loss (t/acre) /(t/ha)

R = rainfall erosivity index

K = Soil erodibility factor

L = Length of slope factor

S = Steepness of slope factor

C = Cropping management factor

P = Conservation practice factor



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R = Rainfall Erosivity Index

R is the sum of individual storm erosivity values (E.I) over a time period (avg. annual or avg. crop stage)

$$R = \sum_{j=1}^n (E \cdot I)_j$$

E = Total energy for a storm

I = Storm's maximum 30 min. intensity

n = No. of storms in the series

Estimates of R made in many locations in the world has been published in **Isoerodent Map** (lines indicating equal values of R on annual basis)

(Hudson, 1985)



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K = Soil Erodibility

- It is the rate of soil loss per unit of R or EI for a particular soil measured on a unit plot.
- Unit plot is defined as continuous cultivated fallow clean tilled plot with an arbitrarily selected slope length L of 22.1m (72.6ft) and slope steepness of 9%. (without influence of crop cover and management)
- K decreases with increase in-
 1. grade and size of clods
 2. coarseness of texture
 3. organic matter content
 4. water intake capacity of soil



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SLOPE LENGTH (L) FACTOR

- The slope length factor is the ratio of soil loss from any length of slope to that from the slope length specified (22.1m) for a given soil erodibility value.



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Slope factor(S)

- The slope factor (S) is the ratio of soil loss from a specific per cent slope to that from a 9% slope for a given soil erodibility value.



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Topographic factor (LS)

LS combinedly is called **topographic factor**.

It is the ratio of soil loss from a field having specific steepness and length of slope (9% and 22.1m to the soil loss from a continuous fallow land.

$$LS = \frac{\sqrt{L}}{100} (0.76 + 0.53S + 0.076 S^2)$$



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Topographic factor (LS)

- Slope length is the distance from the point of origin of overland flow to the point where the slope decreases sufficiently for deposition to occur or to the point where runoff enters a defined channel.

Wischmeier & Smith (1965) --

$$L = \left(\frac{X}{22} \right)^m$$

Where, L = slope length factor

X = slope length, m

m = exponent (depends on steepness of land)



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Topographic factor (LS)

In 1978, they derived the LS equation in MKS system

$$LS = \left(\frac{X}{22}\right)^m (0.065 + 4.56 \sin \theta + 65.41 \sin^2 \theta)$$

Where,

$$\theta = \text{angle of slope} = \tan^{-1} \left(\frac{S}{100}\right)$$

$(0.065 + 4.56 \sin \theta + 65.41 \sin^2 \theta)$ is slope steepness factor S (normalised to give a value as 1.0)



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Cropping management factor(C)

- It is the ratio of soil loss from land cropped under specified conditions to corresponding soil loss from continuous fallow on identical soil, slope and rainfall condition.

Crop and crop practices affect soil erosion from field.

- Kind of crop
- Quality of cover
- Root growth
- Crop water use

These features vary during crop growth period from planting to harvest and rainfall variation within the year.



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CONSERVATION PRACTICE FACTOR (P)

- It is the ratio of soil loss from land for a given practice to that for up and down the slope farming.
 - Ploughing
 - Contouring (effective for 2 – 7% slope)
 - Bunding
 - Terracing
 - Strip cropping



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Application of USLE

- Predict avg. annual soil loss from a field with specific land use conditions.
- Guide the selection of cropping and management system and conservation practices for specific soil and slopes.
- Predict the change in soil loss resulting from a change in cropping or conservation practices on a specific field.
- Estimates soil loss from land use areas other than agricultural lands.
- Provides soil loss estimates for conservationists to use for determining conservation needs.
- As first approximation for estimating sediment yield of watersheds.



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Limitation of USLE

- Empirical
- From field-size small area
- Predicts avg. annual soil loss (gives less value than the measured when rainfall occurs at high rates)
- Does not compute gully erosion (used for sheet and rill erosion) (Gully produces greater eroded soil)
- Does not compute sediment deposition (only soil loss)

(Sediment deposition at bottom of channel is less than the total soil loss taking place from the entire watershed)