RUNOFF COMPUTATION AND UNIVERSAL SOIL LOSS EQUATION

Prediction of runoff is difficult as it depends upon several factors. The following method is generally used in soil and water conservation for estimating the rate or the maximum rate of runoff that could occur from a particular catchment.

Rational Method: In this method, the peak rate of runoff is given by the equation.

$$Q = \frac{CIA}{36}$$

where,

Q = Peak rate of runoff ($m^3\ s^{-1}$)

I = Intensity of rainfall (cm h^{-1}) for a duration equal to the time of concentration and for the given frequency

C = Runoff coefficient, and

A = Area of the catchment (ha)

Runoff coefficient C is defined as the ratio of the peak runoff rate to the rainfall intensity. Values of C for different slopes and land use conditions, determined from field observations are given in table below.

VALUES OF 'C' FOR USE IN RATIONAL FORMULA

Soil Types	Land use		
	Cultivation	Pasture	Forest
With above average infiltration rate usually sandy or gravelly	0.29	0.15	0.10
With average infiltration rates, no clay pans, loams and similar soils	0.40	0.35	0.30
With below average infiltration rates, heavy clay soils or soils with a clay pan near the surface, shallow soils above impervious rock	0.50	0.45	0.40

Example: Estimate the peak rate of runoff for a 10 year frequency from a watershed of 25 hectares, having 15 hectares under cultivation (C = 0.5), 5 hectares under forests (C = 0.4) and 5 hectares under grass cover (C = 0.45). There is fall of 5 metres in a distance of 700 metres. The distance from the remotest point in the watershed to the outlet is 700 metres.

Solution:

$$\text{Weighted value of C for the entire watershed} = \frac{15*0.5+5*0.4+5*0.45}{25} = 0.47$$

For L = 700 m, S = 5/ 700

Time of concentration, $T_c = 0.02L^{0.77}S^{-0.385}$

where,

T_c = Time of concentration (min); L = Length of channel reach (m)

S = Average slope of channel reach (m/ m)

$$T_c = 0.02*700^{0.77}*\left(\frac{5}{700}\right)^{-0.385} = 21 \text{ min}$$

1 hour rainfall intensity for 10 years frequency = 100 mm h^{-1}

Intensity for 21 minutes rainfall = 17.5 mm h^{-1}

$$\text{Peak runoff rate, } Q = \frac{0.47*17.5*25}{360} = 5.7 \text{ cumecs.}$$

Universal Soil Loss Equation

Wischmeier in 1959 presented the universal soil loss equation, which has adaptability to wide range of conditions. The factors involved in the equation and its applicability to some situations in India.

The equation is given by:

A = RKLSCP

where,

A = Average soil loss for the given period

R = Rainfall erosivity index

K = Soil erodibility factor

C = Cropping management factor

L = Length of slope factor

S = Steepness of slope factor, and

P = Conservation practice factor

The different factors in the above equation are to be selected to suit the units under considerations.

Average Soil Loss, A: This is normally expressed in tones per hectares. It may be computed for any period and also on probability basis (*e.g.* once in two years, once in five years etc.) using the rainfall erosivity index 'R' for the corresponding period.

Rainfall Erosivity Index, R*:* This is the product of the kinetic energy and the maximum 30 minutes intensity of the rain storm. Values may be expressed for any length of period (like daily, monthly or annual) or for any desired probability level.

Soil Erodibility Factor, K: This factor is expressed as tones of soil loss per hectare per unit of rainfall erosion index for a slope of specified dimensions (9 per cent and 22.0 metres long) under continuous cultivated, fallow without the influence of crop cover.

The estimated k will be given by,

$$K = \frac{\text{Total adjusted soil loss (A)}}{\text{Total EI}}$$

K values varied from 0.03 to 0.69 under gravel and silt loam conditions respectively in USA conditions. For a silt loam soil at Dehradun an average values of 0.30 tonnes ha^{-1} per EI was obtained.

Slope Length, L and Slope Factor, S: The slope length factor is the ratio of soil loss from any length of slope to that from the slope length specified (22 m generally) for a given soil erodibility value.

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

where,

L_p = Slope length; S = per cent slope

Conservation Practice Factor, P: This is the ratio of soil loss for a given practice to that for up and down the slope farming.

CONSERVATION PRACTICES FACTOR VALUES

Slope (%)	Contouring	Contouring and Strip Cropping
1.1 – 2.0	0.60	0.30
2.1 – 7.0	0.50	0.25
7.1 – 12.0	0.60	0.30
12.1 – 18.0	0.80	0.40
18.1 – 24.0	0.90	0.45

CONSERVATION PRACTICE FACTORS FOR 4% SLOPE AS COMPARED TO 1% FOR UP AND DOWN SLOPE FARMING

Contour Cultivation : 4.74

Strip Cropping 3: 1 (Maize: Cowpea): 0.51

Strip Cropping 4: 1 (Maize: Cowpea): 0.62

By evaluating the factors of the soil loss equation, the soil loss from a field under a given set of conditions can be determined. If the soil loss is higher than the soil loss permissible for maintaining productivity, suitable changes in the crop management and conservation practices should be made to reduce the expected soil loss.

Example:

In an area subjected to soil erosion, the following information is available.

Rainfall erosivity index = 1200 metre tonned ha^{-1}; Soil erodibility index = 0.20

Crop factor = 0.60; Conservation practice factor = 1.0

Slope length factor = 0.1

What will be estimated annual loss? Explain how this soil loss will decrease by adopting conservation practices.

Solution:

Using the Universal soil loss equation, the soil loss is obtained as,

$A = 1200*0.20*0.60*1.0*0.1 = 14.4$ tonnes ha^{-1} $year^{-1}$

To reduce the soil loss, if conservation practices are introduced, let us say the factor P is now 0.6.

$A = 14.4*0.6 =$ **10.44 tonnes ha^{-1} $year^{-1}$**