Invalid modifications and applications of existing soil erosion models

Mathematical models of erosion have to obey mathematical rules with respect to both the units and the values of the parameters involved Some modifications of the Universal Soil Loss ignore these rules.

The USLE operates on the basis that the primary physical model is represented by the "unit" plot, a bare fallow area 22 m long on a 9 % slope with cultivation up and down the plot.

The soil loss from the unit plot is determined by the product of R and K and both of these parameters have units. The units for R are MJ mm ha^{-1} h^{-1} y^{-1} and for K, t h MJ^{-1} mm^{-1} so that their product is soil loss with units t ha^{-1}. The remaining 4 factors have no units and are used to modify the value of the soil loss from the unit plot (A_1) to predict soil loss from areas that are different for the unit plot. The model operates in two steps

$$A_1 = R\ K \qquad (1)$$
$$A = A_1\ L\ S\ C\ P \qquad (2)$$

The units for R are derived from the fact that in the USLE, and subsequent valid revisions and improvements, the event erosivity factor (R_e) is given by the product of storm kinetic energy (E) and the maximum 30-minute intensity. K is in effect the regression coefficient in the relationship between R_e and the soil loss from runoff producing events on the unit plot. **If the event erosivity factor is changed from EI_{30} then K cannot be used.**

Invalid modifications of the USLE event erosion equation
(A_e = soil loss for an event)

$A_e = EI_{30}\ K_e\ L\ S\ C_e\ P_e$ **VALID** (3)

The MUSLE

$SY_e = 11.8\ (q_e\ q_{pe})^{0.56}\ K\ L\ S\ C_e\ P_e$ **INVALID** (4)

SWAT uses the **MUSLE**

APEX

$SY_e = X_e\ K\ L\ S\ C_e\ P_e$ (ROKF) (5)

$X_e = EI_{30}$ **VALID** (6a)

$X_e = 1.586((q_e\ q_{pe})^{0.56}\ DA^{0.12}$ **INVALID** (6b)

$X_e = 0.65EI30 + 0.45\ (q_e\ q_{pe})^{0.33}$ **INVALID** (6c)

$X_e = 2.5\ (q_e\ q_{pe})^{0.5}$ **INVALID** (6d)

$X_e = 0.79(q_e\ q_{pe})^{0.65}\ DA^{0.009}$ **INVALID** (6e)

$X_e = b_1\ q_e^{b2}\ q_{pe}^{b3}\ DA^{b4}$ **INVALID** (6f)

Estimates of R produced by another means must produce the same numerical values as if based on EI_{30} values

$$F_M = \sum_{i=1}^{12} \frac{P_i^2}{P}$$

P_i = month i rain, P = annual rain

$R = 0.739\ F_M^{1.847}$, USA (Renard and Freimund, 1994) (7)

$R = 3.82\ F_M^{1.41}$, Australia (Yu, 1996) (8)

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