Physically Based Regression Equations to Estimate Surface Erosion Capacity

Hui-Ming Shih[1] and Chih Ted Yang[2]
Department of Civil and Environmental Engineering, Colorado State University, Fort Collins.

Abstract. Soil erosion in a watershed caused by water flow is an integrated process of rainfall splash detachment, sheet flow erosion, inter-rill flow erosion and rill flow erosion. Both empirical and physically based approaches were used for the estimation of surface erosion rates. Their applications are mainly limited to small drainage areas or laboratory studies. The maximum allowable sediment concentration or surface erosion capacity is not considered in most of the existing surface erosion models. The lack of erosion capacity limitation may cause over estimations of sediment concentration. In this study, non-linear regression methods are used to estimate soil erosion rate verified by published laboratory and field experiment data.

Bed load sediment transport formulas were recommended by Graf (1971), Foster and Meyer (1972, 1975) and Gilley (1985) for the estimation of surface erosion rate. Factors and mechanics of surface erosion were reviewed by Julien and Simons (1985) and Prosser and Rustomji (2000). A correlation analysis is used to determine the significance of factors that may impact on the surface erosion capacity. This study will use variational mechanics based on energy dissipation rate or unit stream power to estimate erosion rate caused by overland flows. A nonlinear reciprocal model is used to reflect the limit that sediment concentration cannot be over 100% by volume. The coefficients used in the model will be calibrated by published laboratory data. Laboratory data used in the study include those published by Kilinc (1972), Gover (1985), Aziz and Scott (1989), and Guy (1990).

An one-dimensional overland flow diffusion wave model is used in conjunction with the soil erosion equation to simulate field experiment results by Barfield et al. (1983). The study results show that the simulated results using the new surface erosion model agreed with laboratory data and field experiment results very well. It concludes that the non-linear regression method using unit stream power as a dominate factor performs well for the analysis of overland flow erosion processes.

[1] Ph.D. Student, Civil Engineering Department
Colorado State University
Fort Collins, CO 80523-1372
Tel: (970) 310-9860
e-mail: maxshih@engr.colostate.edu
[2] Borland Professor of Water Resources, Civil Engineering Department
Colorado State University
Fort Collins, CO 80523-1372
Tel: (970) 491-8160
e-mail: ctyang@engr.colostate.edu