Comment on “Raindrop-Induced Soil Detachment and Sediment Transport from Interrill Areas”

In their paper, Sharma et al. (1995) commented that the current consensus on the WEPP algorithm is toward using

$$D_i = k_i Q I S_i$$  \[1\]

where $D_i$ is the interrill delivery rate (mass per unit area per unit time), $k_i$ is an estimate of interrill erodibility (mass per unit area per unit time), $Q$ is runoff rate (depth per unit time), $I$ is rainfall intensity (depth per unit time), and $S_i$ is a factor dependent on slope gradient, which results from Kinnell (1993). They later remarked that exclusion of raindrop energy from the basic detachment and transport model propagates error while extrapolating soil erodibility data collected from artificial rainfall into natural rainstorms and among seasonally and physiographically variable rainstorms. I cannot help but agree with this comment. However, in my paper (Kinnell, 1993), there was discussion about the fact that, for a rain with a given characteristic ($r$) impacting flow over soil with characteristics ($s$), the sediment discharge rate ($q_s$, mass per unit width of flow per unit time) was given by

$$q_s(s,r) = k_s I u f(h,r)$$  \[2\]

where $k_s$ is a soil-related factor, $u$ is flow velocity (length per unit time), and $h$ is flow depth (length), and that the influence of variations in the rain characteristic was not considered in Eq. [1] because the omission of rainfall kinetic energy as a term in Eq. [1] and the then current WEPP algorithm was not critical to the analysis being performed at that time. I went on further to say that, in cases where raindrop characteristics vary, both Eq. [1] and the current WEPP model needed to be modified in order to account for variations in rain energy level on erosion. Work such as that reported by Meyer and Harmon (1992) support this need. It would seem that the warning has been heeded. The current WEPP model (Foster et al., 1995) includes an adjustment factor ($F_{model}$) to account for sprinkler irrigation nozzle impact energy variation.

In addition to their comment about the failure to consider rainfall energy in Eq. [1], Sharma et al. suggested

$$D_i = k_i Q (E - E_0) S_i$$  \[3\]

where $k_i$ is a parameter dependent of the transportability of the soil material, $E$ is the unit kinetic energy of the rainfall (energy per unit depth of rain), and $E_0$ is the critical unit kinetic energy that must be exceeded before detachment occurs, as a generic interrill sediment delivery equation due to raindrop impact. Currently, the effects of variations in resistance to detachment and transport are not separated in the WEPP model. However, Sharma et al. later commented that Eq. [3] does not consider the effect of flow on detachment and transport of sediments from interrill areas. Perhaps this failure could be overcome by combining the concept of effective energy proposed by Sharma et al. with the expanded version of Eq. [1] to give

$$D_i = k_i Q I (E - E_0) f(S) f(L)$$  \[4\]

where $L$ is slope length. This equation is consistent with the concept that sediment concentrations are dependent on an effective level of rainfall kinetic energy ($E - E_0$) that is dependent on the drop size and velocity characteristics of the rainfall and the resistance of the particles to detachment, and another soil factor ($k_i$) that is largely dependent on the transportability of the detached particles. Nonspecific functions of slope gradient and length are included in Eq. [4] because (i) some uncertainty exists about the general applicability of any particular slope steepness model (Kinnell, 1993), and (ii) flow characteristics are dependent not only on slope gradient but also slope length. Obviously, what practical advantage such an approach may yield is a matter for further study.

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References


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We appreciate the interest and thoughtful comments by Dr. Kinnell on our article (Sharma et al., 1995). We conducted an analysis similar to one suggested by Dr. Kinnell on the interrill erosion data from the Water Erosion Prediction Project (WEPP) interrill experiments. The interpretations were excluded from the final draft of our manuscript in response to comments of the reviewers.

In the context of the WEPP algorithm and experimental data set (Liebenow et al., 1990), the interrill sediment delivery rate ($D_i$) is represented by the following equations:

$$D_i = k_i I^2 S_i$$  \[1\]  
(Meyer, 1981; Sharma et al., 1995, Eq. [1])

$$D_i = k_2 Q I S_i$$  \[2\]  
(Kinnell, 1993; Sharma et al., 1995, Eq. [23])

$$D_i = k_3 I (E - E_0) S_i$$  \[3\]  
(Sharma et al., 1995, Eq. [22])

where $I$ is rainfall rate, $Q$ is runoff rate, $E$ is unit impact energy, $E_0$ is soil-strength-dependent threshold kinetic energy, and $S_i$ is a slope factor. While Eq. [1] represents the original WEPP interrill model, Eq. [2] is a modified version. Equation