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Comments on 'Soil erosion and total denudation due to flash floods in the Egyptian desert'*

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Labib's (1981) estimate of the soil erodibility term in the Universal Soil Loss Equation (USLE) from flash flood data in the Egyptian eastern desert is apparently made incorrectly, although the data presented pose some problems with the assessment. Furthermore, the dimensions assigned to the soil erodibility term are incorrect. References are presented for the correct determination of the soil erodibility value and for correct evaluation of other terms in the USLE.

Introduction

The interesting paper by Labib (1981) extends the knowledge of denudation rates and illustrates again the importance of infrequent but severe storms in contributing to sediment yield. Certainly, with the assumptions involved regarding bedload transport, the specific gravity variability, and solute transport, one can appreciate that estimates of denudation may contain a sizeable error. Such is the case with the section headed *Soil erodability factor*. In fact, this section would be better ignored by the reader, because the estimate of soil erodibility for the Universal Soil Loss Equation is not valid.

Universal soil loss equation

The Universal Soil Loss Equation (USLE) (Wischmeier & Smith, 1978) was developed and intended for use on plot- or field-sized areas where the dominant process is erosion from raindrops striking the soil surface and water moving over the land surface as sheet flow or in shallow rills. Certainly, it does not provide one aggregated estimate for a 98,506 km^2 catchment, as was done by the author. The watershed in question undoubtedly had deposition of eroded material at numerous points where there was a decrease in the landslope and deposition in or along the stream courses, as well as erosion from such additional sources as headcuts, gullies, and channel banks and bed. Thus, the estimate of 4,643,968 tonnes of sediment for the 1975 storm represents the sediment yield plus the solute yield of the watershed. Labib stated that about 75 per cent of the eroded sediments appeared in the Nile main stream. This sediment delivery ratio (SDR) is considerably higher than might be used based on most similar studies in the United States (Roehl, 1962).

All predictive equations like the USLE, have their limitations, and sometimes they are applied to situations in a way that is a misuse. Wischmeier (1976, 1977) identified the limitations of the USLE in a paper that should be required reading for users of this

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technology. Labib's application of the USLE is a classic case of the application of the USLE, quite removed from the original intent.

Wischmeier (1976, 1977) stated:

> The Universal Soil Loss Equation was designed to predict soil loss from sheet and rill erosion. As used here, soil loss must be distinguished from field sediment yield. The soil loss predicted by the equation is that soil moved off the particular slope segment represented by the selected topographic factor. This is the information needed for soil conservation planning. But in most cases, not all of the sediment produced on the slopes leaves the field. A field's sediment yield is the sum of the soil losses on the slope segments minus deposition in depressions within the field, at the toe of slopes, along field boundaries, and in terrace channels. The equation does not account for this deposition.

The USLE is given as:

$$A = RKLSCP$$

where A is the rate of soil loss, R is the factor for annual rainfall erosivity, K is a factor for soil erodibility, L is a factor for slope length, S is a factor for slope steepness, C is a factor for cover-management, and P is a factor for supporting practices. Factors A, R, and K have the dimensions shown in Table 1, and L, S, C, and P are dimensionless. Foster, McCool *et al.* (1981) suggested adopting the units shown in Table 1 for the Metric International System of Units (1980).

Rainfall erosivity (R)

The erosivity R factor in the USLE is the product of a storm's total kinetic energy and its maximum 30 min intensity. It has units, as does K and soil loss (Table 1). Although Labib does not give the units, nor the data used to calculate R, the value of 9·22 is small if the storm is as large as the author contends. Table 3 in the paper indicates about 5·5 mm average precipitation on the basin. As an illustration, I calculated the storm erosivity for 11 thunderstorms with center depths of over 65 mm from the Walnut Gulch and Alamogordo Creek Experimental Watersheds in Arizona and New Mexico, respectively. Even though computed storm erosivities were highly variable, as Table 2 shows, they are much larger than the value used by Labib. This would be reflected in the soil erodibility term calculation (K).

The 5·5 mm average precipitation over the watershed (Labib's Table 3) must indicate extreme spatial variability, because it is highly unlikely that such a low amount would even produce any runoff. In thunderstorm areas, the spatial variability of individual storm events leads to extreme gradients on an isoerodent map (map of equal R values) for both storm and annual totals (Renard & Simanton, 1975*b*). Whereas the precipi-

Table 1. *International System (S.I.) of metric units for* USLE *factors*

Factor	S.I. Units*
Storm erosivity, EI	$\frac{\text{MJ}\cdot\text{mm}}{\text{ha}\cdot\text{h}}$
Annual erosivity, R	$\frac{\text{MJ}\cdot\text{mm}}{\text{ha}\cdot\text{h}\cdot\text{y}}$
Soil erodibility, K	$\frac{\text{t}\cdot\text{ha}\cdot\text{h}}{\text{ha}\cdot\text{MJ}\cdot\text{mm}}$
Soil loss, A	$\frac{\text{t}}{\text{ha}}$

* MJ = megajoule; mm = millimeter; ha = hectare; h = hour; t = tonne; y = year.

Table 2. *Rainfall erosion index for individual storms (from Renard & Simanton, 1975a)*

Location	Date	Storm depth (mm)	Duration (h)	Computed *EI* $\frac{MJ \cdot mm^*}{ha \cdot h}$
Walnut Gulch, Arizona	8/17/57	67	3·53	2298
	7/22/64	65	5·03	1889
	9/10/67	88	1·43	3285
	8/25/68	78	3·98	1326
	7/24/72	81	2·28	2059
Alamogordo Creek, New Mexico	6/05/60	103	3·50	5957
	7/13/61	90	1·80	5072
	6/16/66	101	3·37	4408
	8/21/66	139	13·47	4527
	7/5–6/68	84	25·82	289
	7/20/72	95	17·08	2349
Foster, McCool *et al.*, 1981 Illustration		33	1·50	464

* $\frac{\text{megajoule} \cdot \text{millimeter}}{\text{hectare} \cdot \text{hour}}$, computed from rainfall hyetograph using procedure described by Wischmeier & Smith (1978).

tation during an individual thunderstorm may decrease as much as 10 mm/km, the rainfall erosivity (*R*) may decrease as much as 740 MJ·mm/ha·h for the same event. Thus, if thunderstorms occurred within the storm events being studied (i.e. thunderstorms within a frontal system), a single gage may be, at best, a *very poor* estimate of the storm erosivity unless the measurement is very near the point in question.

Slope length and steepness (*LS*)

The standard plot used to provide the data from which the USLE is developed is 22·1 m long, not 25·3 as quoted by Labib. In any event, the *LS* term cannot be taken as unity. The value for the topographic factor (*LS*) is determined from the equation:

$$LS = \left(\frac{\lambda}{22 \cdot 1}\right)^m (65 \cdot 4 \sin^2 \theta + 4 \cdot 56 \sin \theta + 0 \cdot 065)$$

where λ = slope length in meters;
θ = angle of slope;
m = 0·5 if slope ≥ 5 per cent;
= 0·4 on slopes of 3·5 to 4·5 per cent;
= 0·3 on slopes of 1 to 3 per cent; and
= 0·2 on slopes of less than 1 per cent.

The equation can also be solved graphically using the chart in the USLE Handbook by Wischmeier & Smith (1978). Note that the USLE is intended for use on uniform slopes. This same handbook also describes a technique for dividing complex slopes into segments, but it cautions, 'However, it, (USLE), will not predict the total sediment moved from such interrupted slope, because it does not predict the amount of deposition'.

When the USLE is to be applied to a small watershed, care must be taken in evaluating the *LS* factor. Williams & Berndt (1977) suggested several methods for doing so. They cautioned, 'The *LS* factor is one of the most important factors in the

USLE, because it accounts for more variations in gross erosion than any other factor except, possibly, the cropping-management factor'.

Support practice factor (*P*)

The use of unity for the *P* factor (support practice factor) appears to be satisfactory for the author's estimate. The *P* factor reflects the effects of such practices as contouring, contour listing, contoured residue strips, contour stripcropping, and terracing, practices not widely used in desert areas.

Cover-management factor (*C*)

The use of unity for the *C* factor (cover and management factor) is not acceptable. *C* is the ratio of soil loss from an area with specified cover and management to that from an identical area in tilled continuous fallow. In most cropping systems, the *C* value varies seasonally in relation to the crop growth stage. For most of the Egyptian desert area in question, the land is likely range or idle land with some irrigated cropland along streams. *C* values for the USLE vary from 0·45 for bare, idle land to 0·003 for land with ground cover greater than 95 per cent. Thus, Labib's use of unity for *C* results in a serious error in the estimate of *K*, the soil erodibility factor.

Simanton *et al.* (1980), working in the semi-arid rangelands of southeastern Arizona, U.S.A. have found that the rock or erosion pavement on the land surface acts like a mulch, producing an effect which they include in the *C* factor. The erosion pavement was considered to be any rock larger than 6 mm. In a tall weed or short brush area having 60 per cent erosion pavement, the suggested *C* value would be 0·038, whereas ignoring the erosion pavement would result in a *C* value of 0·36.

Soil erodibility factor (*K*)

In the absence of direct measurements of the soil erodibility factor *K*, a nomograph is presented in Agriculture Handbook 537 which Foster, McCool *et al.* (1981) converted to S.I. Metric Units for estimating *K* from physical measurements of the soils (per cent sand, silt, very fine sand, organic matter, soil structure, and permeability). An estimate of *K* from the nomograph for the Egyptian soils would be of interest.

Table 3. *Possible USLE factors for the Egyptian desert to determine soil erodibility*

USLE factor	Range of values	Remarks
A	2·83 t/ha*	Assumed S.D.R. = 0·10†
R	$500\text{–}5000 \ \frac{\mathrm{MJ \cdot mm}}{\mathrm{ha \cdot h}}$	Based on Arizona storms
C	0·36–0·004	Based on Arizona rangelands
LS	0·7–3·0	Range of values from some small Arizona watersheds
P	1·0	

* The dissolved solids were not added to the sediment load because normal laboratory procedures for sediment concentration do not separate them out. Also, USLE does not reflect dissolved solids.

† $(2{,}790{,}188{\cdot}7) \times \frac{1}{0{\cdot}10} \times \frac{1}{98{,}506} \times \frac{1}{100} = 2{\cdot}83$ t/ha.

Using Labib data to estimate *K*

Although the data presented in Labib's paper are insufficient to determine the values which might be used for determining soil erodibility in the Egyptian eastern desert, the values which might be expected for the USLE are shown in Table 3. Thus, using the values in this table would lead to *K* estimates of between 0·022 and 0·047 t·ha·h/(ha·MJ·mm).

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