Estimation of hillslope interrill soil erosion using empirical modeling approach

° Mohamed A. M. Abd Elbasit[1,2], H. Anyoji[2], H. Yasuda[2], T. Saito[2]

1. Introduction:

Upland interrill areas represent an important source of sediments and contaminants related to the sediment delivered to the rivers and water bodies. In general, models fall into three main categories; Empirical, Conceptual, and Physical-based that is depending on the physical processes simulated by the model. The interrill erosion determined base on the following equation

$$D_i = K_i \, I^p \, S_f \qquad [1]$$

where D_i is the interrill erosion rate (mass per unit area per unit time), Ki is the interrill erodibility, I is the intensity of rainfall (volume per unit area per unit time), p is regression coefficient, and S_f is slope factor. This study, therefore attempt to simulate the interrill sediment generation using different empirical modeling approaches base on eq. [1].

2. Material and Methods:

A rainfall simulator experiments were conducted at the Arid Land Research Center, Tottori University. Two rainfall intensities (I), 38 and 55 mm hr^{-1}, and three slopes (S), 10, 15, and 20 degrees were used. The treatments were replicated three times. The rainfall depth was 38mm and the rainfall duration was adjusted for the different rainfall intensities. Runoff volume (RO), sediment yield (SY) and drainage volume (DR) (infiltration) were observed at 5 minutes time step.

3. Results and discussion:

Table 1 shows the correlation coefficients between different hydrological components. A significant positive correlation existed between I and RO (r=0.87, P<0.001), SY (r=0.75, P<0.001), and sediment concentration (SC) (r=0.67, P=0.002). On the other hand, the total drainage was negatively correlated to I (r=-0.58, P=0.01). The correlation between RO and SY was significant (r=0.78, P<0.001), which indicated the great role of surface runoff on sediment delivery in hillslopes.

Table 1 Correlation coefficient for the hydrological components

	(I)	(S)	(RO)	(DR)	(SY)	(SC)
(I)	1.0	0	$0.87^{(<0.001)}$	$-0.58^{(0.013)}$	$0.75^{(<0.001)}$	$0.67^{(0.002)}$
(S)		1.0	$0.08^{(ns)}$	$-0.27^{(ns)}$	$0.44^{(ns)}$	$0.57^{(0.01)}$
(RO)			1.0	$-0.85^{(<0.001)}$	$0.78^{(<0.001)}$	$0.0.72^{(<0.001)}$
(DR)				1.0	$-0.60^{(0.008)}$	$0.62^{(0.006)}$
(SY)					1.0	$0.98^{(<0.001)}$
(SC)						1.0

ns: not significant ,

I. Model development

Eq. [1] was fitted under two conditions: 1) linear rainfall factor (I); and 2) squared rainfall factor (I^2). **Table 2** shows the models with fitted parameters, R^2, and the significance level. The model (4) and (5) contain runoff factor (q). The I^2 factor results

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1 The United Graduate School of Agricultural Sciences, Tottori University.
2 Arid Land Research Center, 1390 Hamasaka, Tottori
* Key words: empirical modeling; interrill soil erosion; rainfall simulator

the best R^2 (0.77) for SY prediction when total *I* was used. The exponents of I and S in model (3) were determined using non-linear regression **(Table 2)**.

Table 2 Fitted empirical models for soil loss estimation

	Model	Fitted Parameters	R^2	P-value	Remarks
(1)	$Di = k_i I^a S^b$	b=1.19	0.53	<0.001	I-Linear
(2)	$Di = k_i I^a S^b$	b=1.22	0.77	<0.001	I^2
(3)	$Di = k_i I^a S^b$	a= 3.45 b=1.26	0.85	<0.001	Fit I exponent
(4)	$Di = k_i I S^b q^c$	b=1.22 c= 2.21	0.96	<0.001	Linear I
(5)	$Di = k_i I^2 S^b q^c$	b= 1.23 c= 1.67	0.94	<0.001	I^2

ii. Models validation:

The model (2), (3) and (4) were validated by comparing the scaling factor of these models with equivalent laboratory experimental model developed by Jayawardena and Rezaur (1998). **Fig 1** shows the validation of model (2), (3) and (4), R^2 were 0.80, 0.89 and 0.96 respectively. The model using the linear rainfall factor (*I*) estimated the sediment generation better than I^2 factor when we the runoff factor was considered in the model, which agrees with Kinnel (1993) and Jayawardena and Rezaur(1998).

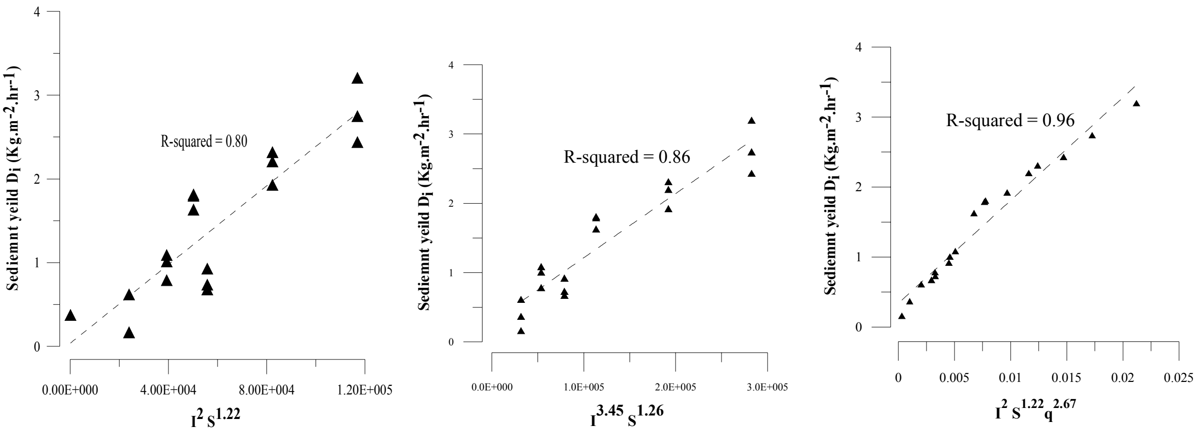

Fig. 1 Validation of models (2), (3), and (4) scalars using Jayawardena and Rezaur (1998) model data; respectively.

4. Conclusion:

Empirical models were assessed to evaluate the capability of those to estimate the sediment yield. The model using the linear rainfall intensity (*I*) and runoff (*q*) estimated sediment yield satisfactorily (R^2 = 0.96).

References

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