Int. Agrophysics, 1994, 8, 31-35

EVALUATION OF EROSIONAL FACTORS ACCORDING TO RUSLE IN LOESSIAL BELT OF LUBLIN UPLAND (SE POLAND)*

R.Dębicki[1], *J. Rejman*[1], *R. Turski*[2]

[1]Institute of Agrophysics, Polish Academy of Sciences, Doświadczalna 4, 20-236 Lublin, Poland
[2] Institute of Soil Science, University of Agriculture, Leszczyńskiego 7, 20-069 Lublin, Poland

A b s t r a c t. Field and laboratory model experiments were carried out to evaluate the K factor of brown soils (Orthic luvisols) developed from loess in Lublin Upland (SE Poland) according to RUSLE. The soils represented different erosion classes. The K-values calculated from the nomograph appeared to be very high (0.055-0.066), which suggest high susceptibility of the soils studied to erosion. Contrary to this, initial results from field studies carried on according to USLE standard show that the K-values for all soils are more than 10-fold overestimated. Especially high discrepancy between the values of soil losses estimated according to RUSLE and those obtained in the field occur in the spring/summer period, characterized by high EI values. Nevertheless, the K-values reflect in a proper way the differences in erodibility among the studied soils. That was confirmed by soil losses recorded in the field and laboratory experiments with the use of rainfall simulator.

K e y w o r d s: soil water erosion, RUSLE, K-value

INTRODUCTION

In many regions all over the world attempts are still undertaken to adopt the USLE model for estimation of soil losses due to water erosion under specific conditions of a given site [2,4,9]. The results published so far are very discussible and they cannot be transferred to slopes or catchment areas outside the areas under investigation [1,3,8,12]. USLE, being a field-scale simple non-parameter, 0 dimensional model can be used easily basing on little topographic, soil and field management data. It gives, as an output, an annual soil loss for one field and one horizon.

The Revised Universal Soil Loss Equation (RUSLE), a further development of the USLE, retained all the six factors to calculate average annual soil losses [7,14]. One of the major change introduced to the RUSLE concerns the soil erodibility factor - K, which reflects its variability within a year based on rainfall erosivity index (EI_{30}) distribution.

The objective of this paper was to estimate the soil losses from fields being under different stage of erosion and in the laboratory experiments with the use of K-factor according to RUSLE for brown soil developed from loess in Lublin Upland (SE Poland).

METHODS

Field experiments were started in spring 1992 at the Agriculture Experimental Station in Czesławice (Lublin region). They consist of

* This work was partly financed by the State Committee for Scientific Research, Poland under the grant No. 1119 5 91.

four-sets of 'Wischmeier plots' on slightly, moderately, and completely eroded as well as deluvial soils. Each plot was 20 m long and 3 m wide, located on a 9 % slope and was maintained in continuously clean-fallow. Soil loss data were monitored from September, 1992.

The soils studied in the experiments are characterized in Table 1. Other characteristics are given in earlier papers [6,11]. The 10-year mean precipitation in the studied area is 498.2 mm, and the 10-year EI value is 798.27 MJ mm/ha h (Fig. 1).

For laboratory experiments, with the use of rainfall simulator, soil samples were taken from the plough layer, representing all distinguished soil erosion classes. The simulation tests were performed on initially dry soils of a density 1.2 Mg m^{-3}, placed on a 10^o slope. The duration time of each test was 1 h, the intensity of the rain 40 mm h^{-1} (kinetic energy of the rain was 19.5 J m^{-2} mm^{-1}.

The data recorded and the calculations carried out allow us to present the following results (Tables 2 and 3, Fig. 2).

RESULTS

The K-values calculated in SI units [5] from the USLE nomograph of Wischmeier et al. [13,14], for the soils being under various degree of erosion ranged from 0.055 to 0.066 (Table 1). So high K-values suggest that the soils studied are very susceptible to water erosion. Splitting the measurement periods of EI_{30} index in the RUSLE into two-week periods and including mean temperatures

Table 1. Some properties of loess soil of different erosion classes at the experimental site

Soil erosion class	Symbol	Grain size distribution (%)			C organic (%)	K-value acc. to USLE nomograph (in SI units)
		Sand	Silt	Clay		
Non-eroded	A	0.7	90.3	9	1.16	0.062
Slightly eroded	B*	1.0	87.0	12	0.99	0.061
Moderately eroded	C*	0.5	84.5	15	0.98	0.055
Severely eroded	D	1.1	86.9	12	1.06	0.061
Completely eroded	E*	3.0	86.0	11	0.92	0.064
Deluvial	F*	0.9	89.1	10	0.89	0.066

* Soils tested in the field experiment.

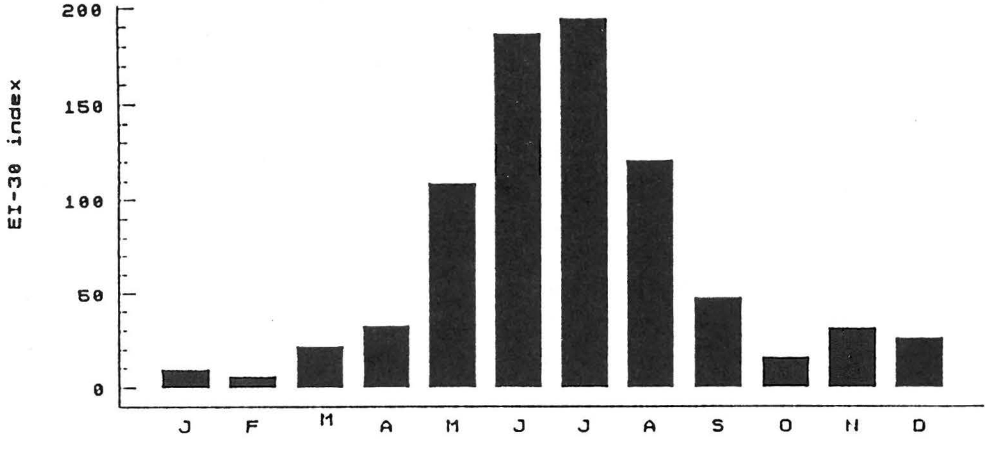

Fig. 1. Monthly distribution of EI-30 index in Czesławice for the period 1982-1991. Mean annual value - 798.3.

results in increase of the K-values for the soils studied in relation to those calculated according to USLE (see Tables 1 and 3). Contrary to this, the initial data of soil losses recorded in the field experiments, carried on according to USLE standard, show that the K-values are more than 10-fold overestimated. Table 2 presents the comparison of soil losses observed on plots located on deluvial soil with the estimated soil losses. Especially high discrepancy between the soil loss values estimated with the use of RUSLE model and those recorded in the field occur in the spring/summer period, characterized by high EI_{30} values (see Fig. 1).

Data presented in Table 3 and Fig. 2 show, however, that the K-values calculated from RUSLE reflect in a proper way the differences in erodibility of the soils studied. This has been confirmed both by the field experimental data (Table 3) and the data obtained in a model laboratory tests with the use of rainfall simulator (Fig. 2). The highest soil losses were recorded from completely eroded and deluvial soils and the lowest from moderately eroded. This is in agreement with the data obtained by other authors [6,11]. It means that in some cases the RUSLE model can be used for comparative estimation of soil erosion in loessial soils in Lublin Upland. However, this estimation should also be performed with the use of other, more sophisticated models like, e.g., an OPUS model (former CREAMS-2), a deterministic, numerical simulation model, which predicts not only the effects of agricultural management practices on total annual soil losses but also on runoff, soil erosion and deposition as well as nutrient and pesticide losses for agriculturally used fields [1,10].

Table 2. Comparision of soil losses (T/ha) recorded in the field during the study period and estimated according to RUSLE on the example of deluvial soil in Czesławice

Measurement period	Soil losses (T/ha)	
	Field experiment	Estimated value
21.09.92 - 14.10.92	1.714	0.670
14.10.92 - 28.10.92	0.118	0.205
28.10.92 - 26.11.92	0.040	0.812
26.11.92 - 22.03.93	0.097	2.407
22.03.93 - 14.04.93	0.049	1.919
14.04.93 - 25.05.93	0.133	12.784
25.05.93 - 18.06.93	0.567	12.579
18.06.93 - 22.07.93	0.177	16.266
22.07.93 - 05.08.93	0.033	4.405

Table 3. Comparison of K-values and soil loss from the field experiment and estimated using RUSLE model

Soil erosion class	Experimental		Calculated acc. to RUSLE	
	K-value	Soil loss*	K-value	Soil loss**
	$\left(\frac{\text{T ha h}}{\text{ha MJ mm}}\right)$	(T/ha)	$\left(\frac{\text{T ha h}}{\text{ha MJ mm}}\right)$	(T/ha)
Slightly eroded	0.0013	1.44	0.0736	50.93
Moderately eroded	0.0013	1.40	0.0712	49.27
Completely eroded	0.0031	3.31	0.0744	51.48
Deluvial	0.0029	3.08	0.0754	58.17

*Calculated according to formula $A = K\,EI$; **Calculated according to formula $A = \sum_{i=1}^{n} K_i\,EI_i$.

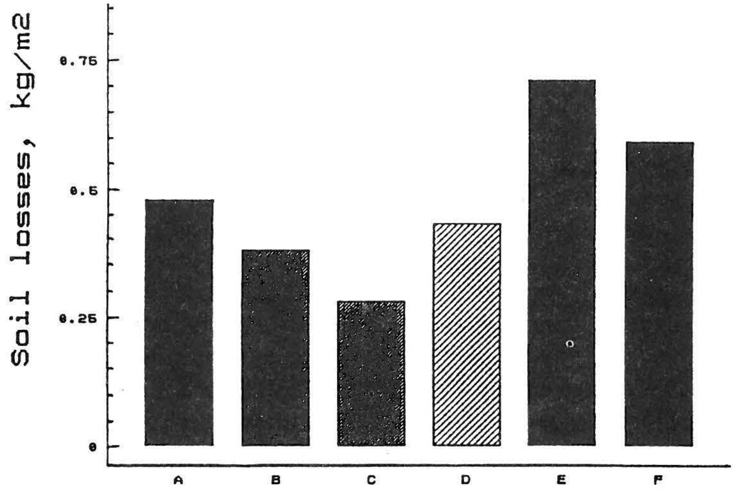

Fig. 2. Erodibility of loess soil based on laboratory studies with the rainfall simulator. A - non-eroded, B - slightly eroded, C - moderately eroded, D - severely eroded, E - completely eroded, F - deluvial soil.

CONCLUSIONS

The initial results from the field experiments (summer 1992-autumn 1993), carried on according to USLE standard, show that K-values calculated according to RUSLE for all soils are more than 10-fold overestimated in comparison to those derived from the field observations, especially in the spring-summer period, that is characterized by high EI_{30} values.

The K-values reflect, however, in a right way the differences in erodibility among the studied soils, which is confirmed both by the soil losses observed in the field and in the laboratory studies with the use of a rainfall simulator.

Because of the above mentioned overestimation of erosion losses with the use of RUSLE, further studies should concentrate on estimation of soil erosion and deposition using models which do not ignore the effects of single storms and changes in surface conditions between erosive storms, i.e. a second generation of erosion models, e.g. OPUS (former CREAMS-2), a deterministic, numerical simulation model developed by USDA-ARS.

REFERENCES

1. **Bork H.R., Hensel H.:** Estimation of soil erosion and deposition using the OPUS simulation model. Geol. Jb., A 122, 483-492, 1992.
2. **De Boodt M., Gabriels D.** (Eds): Assessment of Erosion. J.Wiley and Sons, New York, 1980.
3. **Dębicki R., Rejman J.:** Estimation of soil erosion losses (in Polish). Probl. Agrofizyki, 59, 1990.
4. **El-Swaify S.A., Moldenhauer W.C., Lo A.** (Eds): Soil Erosion and Conservation. SCSA Publ., Ankeny, 1985.
5. **Foster G.R., McCool D.K., Renard K.G., Moldenhauer W.C.:** Conversion of the USLE to SI metric units. J. Soil Water Conserv., 36, 6, 355-359, 1981.
6. **Rejman J.:** A rainfall simulation experiment on a brown soil developed from loess of the Lublin Upland. Part I. Erodibility of soil with various levels of erosion. Polish J. Soil Sci., 25(1), 17-23, 1992.
7. **Renard K.G., Foster G.R., Weesies G.A., McCool D.K.:** Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE). USDA-ARS Publ., 1991.
8. **Rohdenburg H.:** Methods for the analysis of agroecosystems in Central Europe, with emphasis on geological aspects. Catena, 16, 1-57, 1989.
9. **Schwertmann U., Vogl W., Kainz M.:** Bodenerosion durch Wasser: Vorhersage des Abtrags und Bewertung von Gegenmassnahmen. Ulmer Verlag, Stuttgart, 1987.
10. **Smith R.E.:** OPUS - An Advanced Simulation Model for Non-Point Source Pollution Transport at the Field Scale. USDA-ARS, Ft. Collins, CO, 1988.
11. **Turski R., Paluszek J., Słowińska-Jurkiewicz A.:**

The effect of erosion on the spatial differentiation of the physical properties of Orthic Luvisols. Int. Agrophysics, 6, 3-4, 123-136, 1992.

12. **Varallyay G.** (Ed.): Soil Erosion Prevention and Remediation. Proc. US-Central and Eastern European Workshop, Budapest, I/II, 1992.

13. **Wischmeier W.H., Johnson C.B., Cross B.V.:** A soil erodibility nomograph for farmland and construction sites. J. Soil Water Conserv., 26, 189-193, 1971.

14. **Wischmeier W.H., Smith D.D.:** Prediction Rainfall Erosion Losses: A Guide to Conservation Planning. USDA Handbook, 537, 1978.