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CONTENT

Poster section

DIFFERENT METHODS FOR DETERMINING THE INTENSITY OF WATER EROSION IN SLOVAKIA AND THE CZECH REPUBLIC

Jakub PAGÁČ[1], Alexandra MOKRÁ[1]

[1]Slovak Agriculture University in Nitra

Abstract

Report to the topic of differences in water erosion determination procedures in Slovakia and the Czech Republic points to differences in the application of methodical procedures for the determination of water erosion intensity using the universal soil loss equation (Wischmeier - Smith, 1978). To compare the methodological practices of both countries, we chose the model land (Kuzelov), located in the southern part of the Czech Republic. On the case of the types of land, 63% of agricultural land and 31% of the total area of the cadastral land is forest land. Through the use of the Universal Soil Loss Equation (USLE), we analyzed six factors loss of soil (R - rainfall factor, K - soil erodibility factor, LS - topographical factor, C - cover management factor, P - support practice factor) as is methodic used in the Czech Republic and Slovakia. The result is a comparison loss of soil factors, their calculation and determination. Also graphically and computationally displayed loss of soil in t.ha-1year-1 in model area by Slovak and Czech methodical procedures. The values of the areal erosion were classified into 6 classes (0 - 4, 4 - 8, 8 - 12, 12 - 16, 16 - 20, 20 and more t.ha - 1year - 1) in the model area. From the results it can be stated that the biggest difference in methodical procedures is the difference in LS factor calculation, where the USLE2D software is used in Czech practice. Other significant differences are in the R factor. No other factor were noted for expressively differences.

Key words: Water erosion, intensity of water erosion, Czech Republic, methodology loss of soil calculation

Introduction

Soil is one of the most valuable natural resources of every country and a non-renewable natural resource. It represents an important component of the environment with a wide range of functions and is a basic means of production in agriculture and forestry. Soil the land does not only fulfill the production function, it also has non-productive functions: accumulating, filtration, sanitation, transport, transformation, etc. Soil formation is a consequence of the so- Soil-forming processes that run from hundreds to thousands of years during which the soil passes through different stages of development. The soil cover has a large breadth and variety resulting from the diversity of application of factors and conditions of soil-forming processes (Vopravil, 2009).

Soil erosion, a severe concern worldwide, is commonly considered as one of the major causes of land degradation (Muchová et al., 2016). Damaging effects of soil erosion on agricultural products, surface and ground water quality, human health, and environments have been considered as a drastic problem for human stability. Performance of land management strategies depends on assessing and understanding the soil loss rate in agricultural and pasture lands (Prasuhn et al., 2013). The usual method for measuring soil erosion is hard, costly and time-consuming. Indeed, several empirical models have been developed to quantify soil erosion from watersheds. The Universal Soil Loss Equation (USLE; Wischmeier and Smith, 1978) and later the Revised Universal Soil Loss Equation (RUSLE; Renard et al., 1994).

Under Slovak (SR) conditions, the most vulnerable soil is the degradation by water erosion. The range of erosion (soil loss) is divided into four categories (none to weak, medium, high, and extreme erodibility). Up to 44% of agricultural land (1 066 088 ha) is classified as medium to extreme loss of land. Potential water erosion of agricultural soils in Slovakia (according to the VUPOP) is in the category of medium 9.5 %, high 14.6 % and 19.8 % extreme erodibility.

Soils in the SR are erosively threatened and destroyed annually by erosion of 50% of arable land, which is about 1 500 000 ha. In total, 40% of the Czech Republic's agricultural land is currently damaged annually. (VÚMOP Praha 2013). There are plowing and shallow soils that can already be completely washed or where one step depth can be measured (from 60 cm to 30 cm or less).

The results which obtained in this comparative study provide us with basic information on the procedures and the determination of the intensity of water erosion in Slovak and Czech conditions. Provided valuable evidence to experts considering reconsideration of the values of some parameters of the universal soil loss equation in water erosion research.

Material and methods

Kuželov is a village in the district of Hodonín in the South Moravian Region, 3 km southwest of Velké nad Veličkou in the mountainous region of Moravian Slovácko on the northern slope of the main ridge of the White Carpathian Mountains at an altitude of 294 m. m. on the cadastral area of 1019 ha. It is adjacent to the villages Hrubá Vrbka and Malá Vrbka. The cadastral area of the village passes through the border of the Protected Landscape Area of the White Carpathian

Mountains, proclaimed in 1980. It is a border village, whose borders are immediately adjacent to the border of Slovakia. The village has 405 inhabitants (1 January 2014).

The village has climatic conditions between the oceanic and continental climates. The warmest is July with an average temperature of 19 °C, the coldest is January with an average temperature of -2.5 °C. The yearly average is 8.5 °C. The long-term annual precipitation diameter is 650 mm and the vegetation period is 300 mm. Snow cover of 15 to 30 cm is 2-3 months. The village extends into the slightly warm climatic region.

The watercourses form a diverging river network, falling into the Morava sub-basin. The main stream is the Kuželov river. Its tributaries are Zábařinčový and Malanský river.

The basic for determination of the intensity of water erosion in the area is:

- Ombrographic records,
- base map in scale 1 : 10 000,
- georeferenced ortofotomap,
- ZABAGED,
- updated map BPEJ,
- LPIS.

The most using equations for estimating soil erosion are the USLE (1) (Wischmeier and Smith, 1978) and the revised universal equation (RUSLE) (2) (Muchová et al., 2015). It is caused in particular to a simple and robust form of equations as well as their success in predicting average, long-term erosion on uniform slopes or terrain units. Many researchers also apply them in river catchment or in larger areas to estimate soil erosion (Kinnell, 2000, 2010).

$$SP = R \cdot K \cdot L \cdot S \cdot C \cdot P \qquad (1)$$

$$SP = R \cdot K \cdot LS \cdot C \cdot P \qquad (2)$$

Sp – loss of soil caused by water erosion [$t.ha^{-1}$. $year^{-1}$]
R – rainfall-runoff erosivity factor [$MJ.ha^{-1}.cm.h^{-1}$]
K – soil erodibility factor [$t.MJ^{-1}$]
L – slope length factor [-]
S – slope steepness factor [-]
C – cover management factor [-]
P – support practice factor [-]
LS – topographic factor [-]

Rainfall-runoff erosivity factor (R)

Factor R is calculated as the sum of the total kinetic energy of the rain and its biggest 30 min. of intensity. The necessary data should be obtained from omrographic rain records for at least 50 years (Mališek, 1990) (3).

$$R = E \,.\, I_{30} \qquad (3)$$

R – rainfall – runoff erosivity factor [$MJ.ha^{-1}.cm.h^{-1}$]

E – total value kinetic energy of rain [$J.m^{-2}$]

I_{30} – 30 minute intensity of rain [$cm.h^{-1}$]

SR: To determine the R factor in Slovakia, values with ombrographic records (Mališek, 1990) from 86 ombrographic stations, which are mentioned in the publication by Ilavská, Jambor, Lazúr (2005). Given that the village of Kuželov is situated on the border with Slovakia, we used the same procedure of determining the R factor as in the Slovak Republic.

CZ: For determination of R factor, the values with ombrographic records (CHMI) from 31 ombrographic stations are used, which are mentioned in the publication by Janeček et al. (2012). The value of the R factor is determined from long-term rainfall records and represents the sum of the erosion effects of the individual storm rainfall, which occurring in that year, with no deductions of less than 12.5 mm being considered.

Soil erodibility factor (K)

The susceptibility of the soil to erosion is expressed in the USLE equation as a dependence between the soil substrate and the erosion of the soiltransport. It is defined as a loss of soil of 1 ha in tons per unit of rainfall factor R, from a standard land of continuous fallow with a slope of 9% and a slope length of 22.13 m (Wischmeier, Smith, 1978).

SR: Determination of K factor in Slovak conditions is possible in several ways. Indicative determination of K-factor values by type of soil is most often used. The K factor values were determined by comparing the main soil unit with the Slovak Bonitative System. We have determined the types of soil to which we assigned the appropriate factor value.

CZ: The soil erodibility factor can be determined by the relation derived from factor K, with a nomogram constructed on the basis of that relation or approximately according to the main soil units of the soil bonitation system (Janaček et al., 2012). The most common method is the approximate determination of factor K. For determination it is necessary to know the main soil units. If there is no factor K for the main soil units, the equation (4) or nomogram must be used to determine it. Factor K values where this value is not present in the SR are limited (extreme hydromorphic soils, rock estates, rocks, etc.).

$$100\,K = 2{,}1M^{1.14} \cdot 10^{-4} \cdot (12 - a) + 3{,}25\,(b-2) + 2{,}5\,(c - 3) \qquad (4)$$

Topographic factor (LS)

Topographic LS factor shows the influence of length and incline of slope on soil erosion (Brady, Weil, 2002). Negative influence on the development of erosion has a above all relief. In respect of to the relief of the area, the erosion-washed threat areas with a slope of 5 ° (8%) and regular erosion sufferers an area with a slope above 10 ° (16%) (Cablík, Jůva, 1963).

SR: The value of the LS factor was calculated for the direct slopes from the relation (Wischmeier, Smith, 1978) (5).

$$LS = ld_{0,5}(0{,}0138 + 0{,}0097s + 0{,}00138s^2) \qquad (5)$$

LS – topographic factor [-]
ld – uninterrupted slope length [m]
s – slope [%]

CZ: On the present, software for automatic calculation of LS-factor from digital GIS data using ArcGIS and 2D is used in Czech Rebuplic. Programme USLE 2D works only with Idris data. Therefore, you have to convert data to Idris format (* .rst). There is a conversion program for data transfer from ArcGIS to Idris and back. For 2D applications, we need to specify the slope length per unit of the source area. The source area unit can be defined as the source area per unit of width (Desmet, Govers, 1996) (6):

$$L_{(x,y)} = \frac{(A_{(x,y),in} + D^2)^{m+1} - A_{(x,y),in}^{m+1}}{D^{m+2} * x_{(x,y)}^{m} * 22.13^{m}} \qquad (6)$$

$L_{(x,y)}$ – factor L for a given cell in the coordinates X, Y;
$A_{(x,y),\,in}$ – total contributing area on entry to cell(m^2);
D – distinction the rastra cell (m);
m – exponent for calculating Factor L for slope inclination;
$x_{(x,y)}$ – correction factor (= $\sin \alpha_{x,y} + \cos \alpha_{x,y}$);

Cover management factor (C)
Cover management factor is defined as the ratio between the intensity of erosion in the soil with the vegetation cover and the intensity of the erosion on the continuous fallow at the same effect of other factors (Wischmeier, Smith, 1978). In the model catchment we have specified 3 types of soil.

SR: Factor C values for individual features of the current landscape utilization were taken from the author of the Alena (1986).

CZ: If it is not possible to determine the structure cultivated of crops and their repeating, is the area for which C calculating extensively, the frame C factor can be determined by the average crop representation in the site using the C factor values specified by the author (Janeček et al., 2012).

Support practice factor (P)
Support practice factor of expressive the impact of anti-erosion measures, the ratio loss of soil from the land under investigation and the loss of soil from the unit land, cultivated in the slope direction of the slope (Holý, 1978).

For missing data on land management, we determined the value P factor = 1 for both Slovak and Czech procedures.

Results and discussion

The biggest representation in the analyzed area according to the topographical map and the register of agricultural production areas LPIS has arable land with a 32% share, forest land (31%) grassland (29%). (Figure 1).

Rainfall-runoff erosivity factor (R) - For problems with the methodical and background material set by the R factor, it is not yet expedient to regionalize the territory of the Czech Republic. The resultant R factor according to Czech procedures was used for USLE average annual value of 40 $MJ.ha^{-1}.cm.h^{1}$. The greatest difference in the comparison and analysis of the universal equation factors USLE has been recorded in the erosive efficiency of the rain. To determine the R factor by the Slovak procedures we used the values from the 4 closest ombrographic stations (Mališek, 1990), which entered the calculation. It was Senica (15,32), Trencin (14,21), Piešťany (15,40) and Skalica (17,22), which are publication in Ilavská, Jambor, Lazúr (2005). The value of the R factor according to the Slovak procedures is 16 $MJ.ha^{-1}.cm.h^{1}$, which is 24 $MJ.ha^{-1}.cm.h^{1}$ less than according to the Czech methodology (40 $MJ.ha^{-1}.cm.h^{1}$).

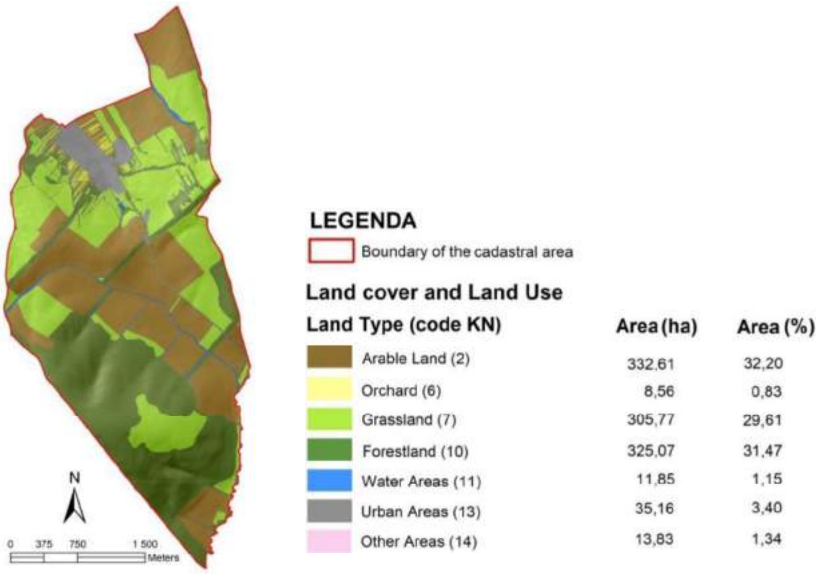

Figure 1 Land cover and land use map

Soil erodibility factor (K) – The soil composition in the model area is represented by heavy soils (clay) 37% and moderate soils (clay) 29%. The procedure for determining the Czech and Slovak factor K is very similar. The K factor value was determined based on the estimated main soil unit according to the Slovak bonitated soil ecological unit. The range of the factor K factor (Ilavska et al., 2005) was 0.23 - 0.51 for each HPJ in the area under consideration. The resulting factor K factor according to Czech procedures was determined (Janeček et al., 2012): 0.23 - 0.48 (Table 1).

Topographic factor (LS) – The biggest difference in determining the factors of the universal loss of soil equation is the topographic factor. To determine the LS factor we have used the equation (5) in the ArcGIS 10.5 software. For the calculation of the LS factor, we also took into account the barriers, existing water management and anti-erosion measures supporting the transformation of surface runoff into subsurface. The value of the topographic factor ranged from 0 to 32. USLE2D software was used to calculate the Czech method. The program automatically calculated the LS factor value based on the digital model relief and erosively contributing areas (agricultural land). This method of calculation also includes barriers but only on the basis of interruption of the contributing area. The value of the range of the LS factor is calculated in the Czech way (0 - 56) is almost double with the comparison of Slovak values.

Table 1 Table of main soil unit comparison and K factor determination

HPJ - SR	K factor - SR		HPJ - CZ	K factor - CZ
39	0.51		1	0.41
42	0.4		6	0.32
38	0.4		20	0.28
78	0.4		24	0.38
61	0.31		30	0.23
77	0.4		38	0.31
82	0.4		41	0.33
84	0.4		48	0.41
71	0.35		49	0.35
13	0.26		59	0.35
22	0.23		60	0.31
20	0.25		61	0.32
26	0.28		63	0.31
94	0.3		71	0.47
94	0.3		72	0.48

Cover management factor (C) – Based on land use elements, we determined C factor values. In Slovakia, we used values (Alena): grassland - 0.005, arable land - 0.29 and for orchards - 0.45. Czech Factor C values: grassland - 0.005, arable land - 0.254 and orchards - 0.4.

Mean annual soil loss (Sp)

According to the USLE equation (2), we determined the calculated water erosion intensity in the cadastral territory of Kuželov on agricultural land according to Slovak and Czech procedures (Figure 2). The average amount of eroded soil in the area was calculated according to Slovak procedures and was 1.82 $t.ha^{-1}.rok^{-1}$ and Czech procedures 5.30 $t.ha^{-1}.rok^{-1}$.

The total annual loss of soil from the model area calculated according to Slovak procedures (41. 61 t.rok-1) is almost 3 times smaller than the values obtained using the Polish formula (117.81 t.rok-1). It results from a different way of calculating the LS factor and the different R factor values.

On the basis of calculated loss of soil, we divided the area from 1 no or very small to 6 catastrophic risk of erosion into zones with risk of water erosion according to criteria (Janeček et al., 2012) (Table 2).

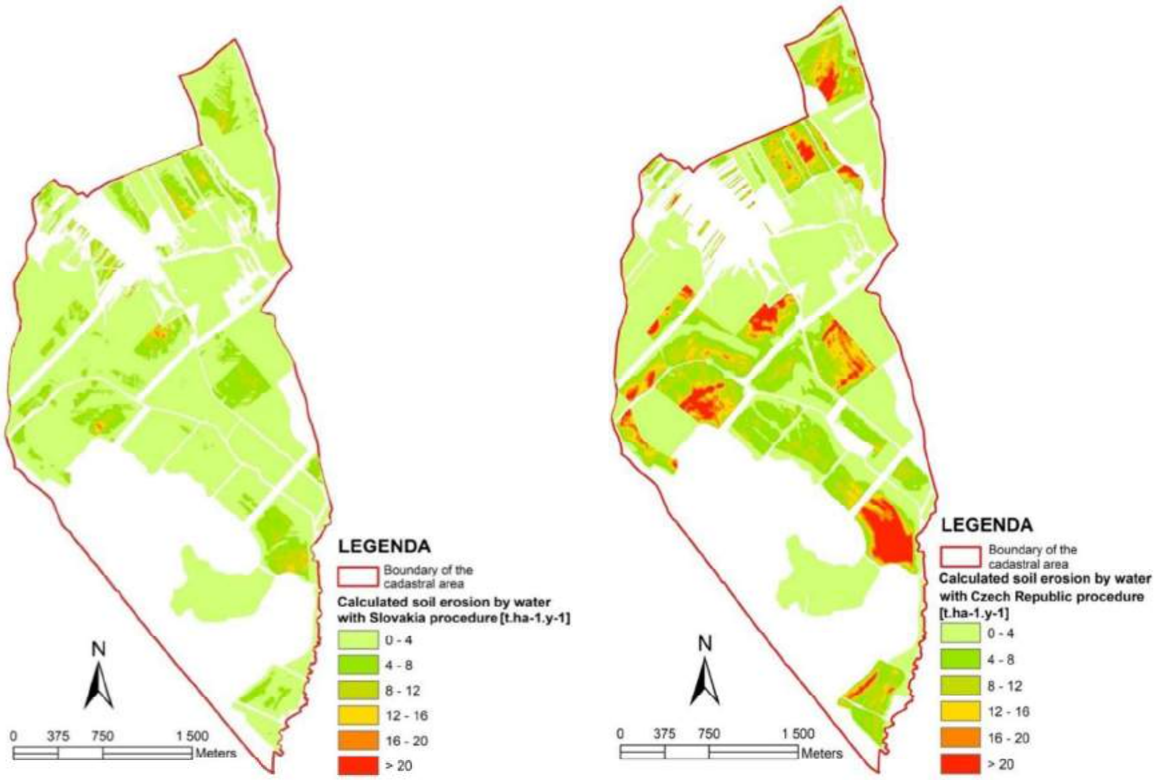

Figure 2 Predicted soil loss on model area

Table 2 Classification of erosion risk criteria according to (Janečka et al., 2012)

Threat class	Loss of soil [$t.ha^{-1}.year^{-1}$]	Comparison intensity water erosion [%]	
		SR procedures	CZ procedures
1	< 4	84.28	57.72
2	4 - 8	11.78	17.16
3	8 - 12	3.29	11.21
4	12 - 16	0.54	5.59
5	16 - 20	0.11	3.44
6	> 20	0.01	4.87

Permissible values of soiltransport for water erosion are given according to Slovak procedures in STN 75 4501. In Czech procedures, we determine the permissible value loss of soil according to

Janeček et al. (2012). For both procedures, we determine the permissible loss of soil value according to each soil depth category as shown in Table 3.

Table 3 Permissible values of soiltransport for water erosion on Slovakia and Czech Republic

Deep soil	STN 75 4501	Janeček et al. 2012
	$S_{p,\ príp}$ [t.ha^{-1}.year^{-1}]	G_p [t.ha^{-1}.year^{-1}]
Thick soil (< 30 cm)	1	1
Medium deep soil (30 - 60 cm)	4	4
Deep soil (> 60 cm)	10	4

The reciprocal share between the calculated and permissible erosion shows us the threat erosion of the soil and we call it the degree erosion risk of soil with (SEOP). We include in SEOP into 4 classes (Table 4, Figure 3).

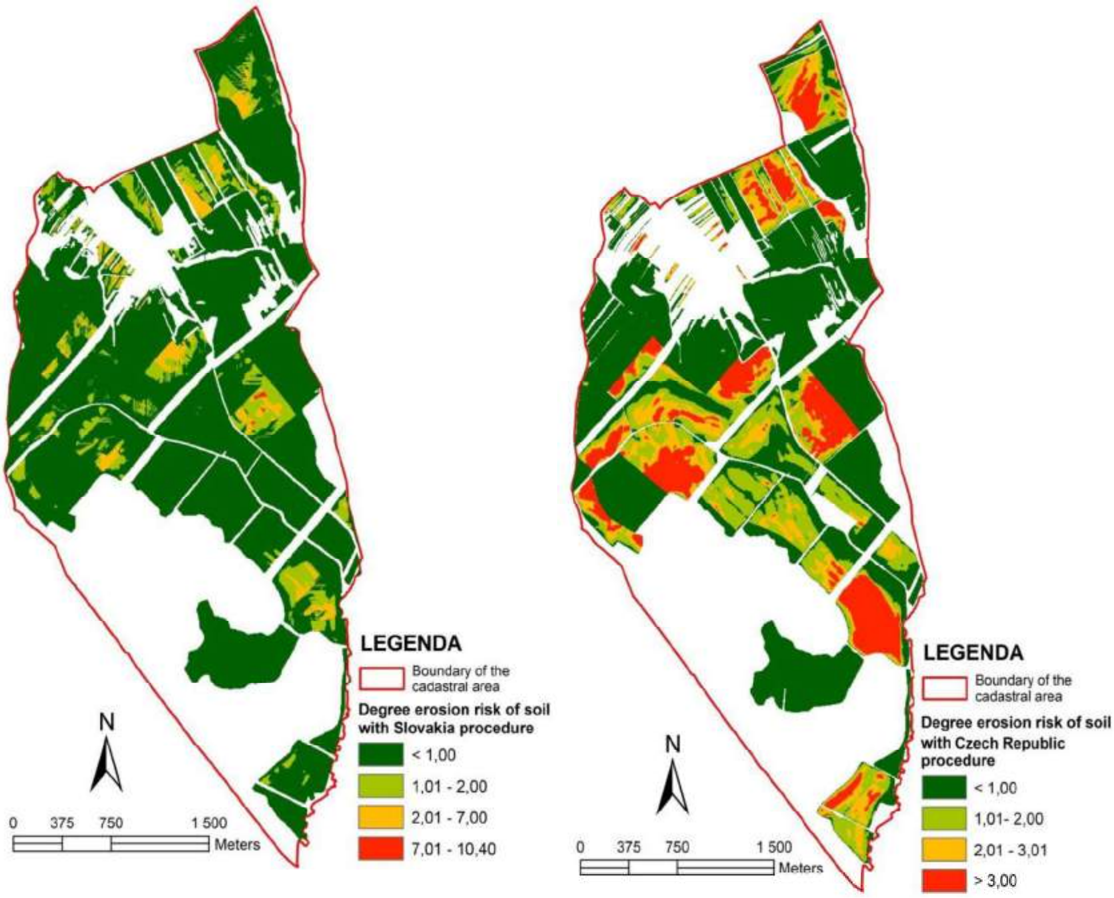

Figure 3 Comparison of the degree erosion risk of soil

Table 4 Comparison of the degree erosion risk of soil (SEOP)

Class SEOP	Degree erosion risk of soil			
	SR procedures		CZ procedures	
	Index SEOP	Comparison [%]	Index SEOP	Comparison [%]
1	< 1,00	86,91	< 1,00	57,70
2	1,01 - 2,00	9,61	1,01 - 2,00	17,11
3	2,01 - 7,00	3,40	2,01 - 3,00	11,11
4	7,01 - 28,00	0,07	> 3,00	14,08

Conclusion

The USLE model is present used in commonly research in the world's way of assessing the loss of soil by water erosion. Its versatility of use makes it possible to compare the obtained modeling results with other world results that have taken place in different parts of the country or in the world (Muchová et al., 2015). On the basis of the modeling carried out, the following conclusions can be presented:

- Significantly lower factor R in Slovak conditions.
- Another method of calculation (determination of value) of LS factor by Czech methodical method.
- Small to negligible differences in factor C and factor K.
- The results of erosion determination using the USLE method adjusted for SR conditions are 25% lower than the values determined for the conditions of the Czech Republic.
- The average amount of soil leaching per year is estimated at 1.82 (SR) and 5.30 $t.ha^{-1}$ (CR) depending on the calculation method used.
- Difference in the classification degree classes and allowable value loss of soil.

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References

ALENA, F. 1986. Stanovenie straty pôdy eróznym splachom pre navrhovanie protieróznych opatrení, Bratislava.

CABLÍK, J. - JŮVA, K. 1963. Protierozní ochrana půdy. Praha : Státní zemědělské nakladatelství, 324 s.

DESMET, P. J. - GOVERS, G. 1996. A GIS procedure for automatically calculating the USLE LS factor on topographically complex landscape units, Journal of Soil and Water Conservation, vol. 51.

HOLÝ, M. 1978. Protierozní ochrana, SNTL, Praha : 288 s.

ILAVSKÁ, B. - JAMBOR, P. - LAZÚR, R. 2005. Identifikácia ohrozenia kvality pôdy vodnou a veternou eróziou a návrhy opatrení. Bratislava : VÚPOP. 60 s.

JANEČEK, M. a kol. 2012. Ochrana zemědělské půdy před erozí 2012. Praha: Výzkumný ústav meliorací a ochrany půdy, v. v. i.. 76 s.

KINNELL, P. 2000. AGNPS-UM: applying the USLE-M within the agricultural non point source pollution model Environmental Modelling and Software, Vol. 15 (2000), pp. 331-341, ISSN:1364-8152.

MALIŠEK. A. 1990. Zhodnotenie faktora eróznej účinnosti prívalovej zrážky. In: Geografický časopis, 42, č. 4. Bratislava, SAV. s. 410–422.

MUCHOVÁ, Z. - LEITMANOVÁ, M. – PETROVIČ, F. 2015. A more detailed approach to the assessment of the water erosion threat for a territory. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, Bulgaria, SGEM, 2015, 1st ed. 738, pp. 3-10.

MUCHOVÁ, Z. - LEITMANOVÁ, M. - PETROVIČ, F. 2016. Possibilities of optimal land use as a consequence of lessons learned from land consolidation projects (Slovakia), Ecological engineering. vol. 90, pp. 294-306.

PRASUHN, V. et al. 2013 A high-resolution soil erosion risk map of Switzerland as strategic policy support system Land Use Policy, 32 (2013), pp. 281-291, ISSN:0264-8377.

RENARD, K. G. - FREIMUND J. R. 1994. Using monthly precipitation data to estimate R-factor in the revised USLE, Journal of Hydrology, vol. 157, pp. 287-306.

STN 75 4501 Hydromeliorácie. Protierózna ochrana poľnohospodárskej pôdy. Základné ustanovenia.

VOPRAVIL, J. et al. Půda a její hodnocení v ČR 1.díl. Praha: Výzkumný ústav meliorací a ochrany půd, v.v.i., 2009. ISBN 978-80-87361-02-3.

WISCHMEIER, W. H. - SMITH, D. D. 1978. Predicting fall erosion losses – a guide to conversation planning. USDA. Washington, D.C. Agric. Handb., 537 p.

Contact address: Ing. Jakub Pagáč, Slovak University of Agriculture in Nitra, Horticulture and Landscape Engineering Faculty, Department of Landscape Planning and Land Consolidation, Hospodárska 7, 949 76 Nitra, Slovakia, 0949 765 856, pagac.jakub@gmail.com

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