THE INTENSITY OF WATER EROSION ON CHERNOZEMS SOUTH MORAVIA

Hrabovská B.

Department of Agrochemistry, Soil Science, Microbiology and Plant Nutrition, Faculty of Agronomy, Mendel University in Brno, Zemedelska 1, 613 00 Brno, Czech Republic

E-mail: beata.hrabovska@mendelu.cz

ABSTRACT

Erosion processes went on for ages and will go on forever. The soil has a relatively high ability to withstand adverse environmental influences. Often due to water erosion the natural soil fertility can be reduced. Soil erosion strongly influences the Chernozems in loessic hilly land in the South Moravia.

The erosion control evaluates the erosion processes as intensity of erosion, meaning how much soil is lost from the unit area per unit of time, what is expressed as 1t.ha $^{-1}$year. The rain erosivity R-factor is one of the main parameters in the Universal Soil Loss Equation (USLE). For the Czech Republic it is recommended to use the average value R = 40 MJ.ha^{-1}.cm.h^{-1}.

The paper aims to assess admissible soil loss by comparing the values of old R-factor (R-factor = 25 MJ.ha^{-1}.cm.h^{-1}) with a newly proposed (value corresponding to the central European average R-factor = 40 MJ.ha^{-1}.cm.h^{-1}), to which in the future the R-factor value should be modified to as part of the Wishmeier-Smith equation.

Collection of samples was conducted in late summer and early autumn of 2013. On each slope, three sampling site were selected. Samples were taken from the topsoil and subsoil. Subsequently gradients and slope lengths were measured.

Admissible soil loss value for factor R = 25 for deep soil, which includes the Chernozems should be maximally 10 t ha^{-1}.yr. This condition fulfill only two locations - Dambořice 2 and Klobouky u Brna 2.

For the new proposed value of R = 40 are the values of G multiple times higher. Because of the calculated values it would be appropriate and useful to do anti-erosion measures. As an examples for lowering the value of G an anti-erosion measure called diking can be used. For the new factor R = 40 diking is not a sufficient measure of anti-erosion.

Key words: water erosion, USLE, soil, rainfall; rainfall erosivity factor, Chernozem

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INTRODUCTION

The basic means of production in the primary agricultural is land. It is a natural resource which cannot be recovered and has a huge importance for the mankind. Soil quality is expressed as fertility and reflects the physical, chemical and biological processes, soil components and their mutual inner interactions.

In the past century large plots of arable land came to creation, which in some areas had caused undesirable rapid development of water erosion. Original Chernozem on loess as a result of the degradation activity across the land often changed to Regosol on loess. On large surfaces were humic horizons of Chernozem washed off. The eroded material is accumulated in the depression positions where they generated up to 2 m thick colluvial soil in some places. (Novák P., Batysta M., Havelková L. 2013)

Almost everywhere, where land consolidation programmes have been carried out, rates of soil erosion have increased. (Morgan R. P. C. 2005)

Due attention should therefore be given to research in soil erosion. A characteristic of erosion is that it starts on cultivated farmland without any visible manifestations. When this happens, the danger is underestimated and erosion control measures are taken only in exceptional cases, or in those cases in which eroded soil has already lost its fertility. (Zachar D. 1982)

Soil erosion is a complex phenomenon involving the detachment and transport of soil particles, storage and runoff of rainwater, and infiltration. The relative magnitude and importance of these processes depends on a host of factors, including climate, soil, topography, cropping and land management practices, control practices, the antecedent conditions, and the size of the area under consideration. (Romkens M.J.M. *et al.* 2001)

By intercepting rainfall and reducing the velocity of runoff, plant cover can protect the soil from erosion. Different plant cover affords different degrees of protection, so that human influence, by determining land use, can control the rate of erosion to a considerable degree. (Morgan R. P. C. 2005)

Soil erosion is a complex and multifaceted process which involves a host of factors and conditions with combinations, variations, and interactions that substantially affect the observed soil loss. (Romkens M.J.M. *et al.* 2001)

MATERIAL AND METHODS

During the terrain survey, which was conducted in the spring of 2013 five sloping lands were selected with arable land on which according to the BPEJ code were modal carbonate Chernozems on loess. In fact, the Chernozems were preserved on top of the hill, in the middle of the slope they were changed to Regosol and at the bottom of the slope to colluvium. Erosion was either directly visible or there was a high probability of its occurrence.

Collection of samples was conducted in late summer and early autumn of 2013. Four lands were after wheat harvest and one was sown with winter crops. On each slope, three sampling site were selected. The first place was at the top of the slope (a likely place to maintain the original profile), second place in the middle of the slope (a likely place of maximum erosion of the material) and third place was at the bottom of the slope (a likely place for maximum accumulation of material). Soil pits were excavated so that their forehead was directed against the slope and the depth was about 60 to 150 cm. Samples were taken from the topsoil and subsoil. In each depth were collected corrupted and intact soil samples for physical and chemical analysis. Subsequently gradients and slope lengths were measured.

This paper will address the determination of the Universal soil loss equation. The dissertation will determined physical and chemical properties.

$$G = R.K.L.S.C.P \ (t.ha^{-1}.year^{-1})$$

where:

G – mean annual soil loss ($t.ha^{-1}.year^{-1}$)

R – rainfall erosivity and runoff factor

K – soil erodibility factor

L – slope length factor

S – slope steepness factor

C – crop management factor

P – erosion control practice factor (Wischmeier W.H. and Smith D.D. (1958) IN Janeček M. *et al.* 2002)

RESULT AND DISCUSSION

Rainfall erosivity and runoff factor (R-factor)

For the formation and intensity of erosion processes are in most cases decisive rainfall. Erosive effect of torrential rainfall is caused by surface drainage of large intensity and is more effective because of kinetic energy of raindrops on the soil surface.

Runoff from rainfall is a direct factor that causes water erosion. It depends on soil infiltration capacity, which is influenced by many factors, including soil characteristics, slope surface area and its vegetation cover. (Holý M. 1970)

Rainfall erosion effect is strongest in the beginning of the erosion process when raindrops fall on the soil surface. (Janeček M. *et al.* 2002) on which the aggregates are broken and prepares the surface water run-off material to erosion. (Holý M. 1970)

Janeček M. *et al.* 2002 writes that during the period from June to August 90% of rainfall occurs and therefore at this time the soil conservation is most important. Torrential rainfall are characterized by considerable intensity, short duration and limited areal extent.

R-factor defined by Wischmeier W.H. and Smith D.D. (1958) IN Janeček M. *et al.* 2002, considering the rains yield to 12.5 mm, separated from the preceding and subsequent six-hour rainfall and longer breaks and rains, the maximum intensity shall not exceed 24 mm . h^{-1}.

To obtain data on the maximum annual values of the R factor it is needed to process the data for a minimum period of 50 years for the best results. If there are no specific values of the R factor available, it is possible for Brno to use an average value of R = 25 $MJ.ha^{-1}.cm.h^{-1}$. To calculate this value results were used from precipitation observations from three stations of the Czech Hydrometeorological Institute - Prague - Klementinum, Tábor a Bilá Třemšná (Janeček M. *et al.* 2012) for a period of 50 years, where were only rains evaluated, which exceeded the total intensity of 12.5 mm and 24 $mm.h^{-1}$. (Janeček M. *et al.* 2002)

Based on an ongoing study it is currently considered as the average value of R = 40 $MJ.ha^{-1}.cm.h^{-1}$(Janeček M. *et al.* 2012), which is more closer to reality than the previous average R-factor = 25 $MJ.ha^{-1}.cm.h^{-1}$. (Podhrázská J., Dufková J. 2005)

In this work the value of R = 25 $MJ.ha^{-1}.cm.h^{-1}$ is used, as for the average value for Brno the value of R = 40 $MJ.ha^{-1}.cm.h^{-1}$, is used as the new proposed value, which is closer to the current situation.

Soil erodibility factor (K – factor)

Janeček et al. 2002 K-factor as the soil erodibility factor, respectively the susceptibility of soil to erosion, is in the Universal equation defined as porterage of land in t ha^{-1} per unit of rain factor R from the standard plot length of 22.13 m (on a gradient of 9%), which is maintained as plowed black outfield, cultivated in the direction of the slope.

Loss Equation (USLE), the soil erodibility (K) is estimated using the texture, organic matter content, permeability and structure of a soil. The USLE was originally developed for non-calcareous soils in the USA. However, in calcareous soils, calcium is an important factor affecting soil structure and hence may influence soil erodibility. This factor reflects the fact that different soils erode at different rates when the other factors that affect erosion are the same. (Vaezi A.R. *et al.*2008)

Least resilient are clay soils, having moderate permeability and considerable incoherence, caused by a large proportion of dust particles. The least favorable properties have nonhumic loess and clay loess with a lack of binding colloidal particles. (Holý M. 1970)

It is true that greater the cohesion of soil particles, greater the need for more energy to be released. On the other hand, the greater the infiltration capacity of the soil, lower the drain and the ability to grind and transport. (Fulajtár E. Janský L. 2001)

K factor values are subtracted from the second and third points of the BPEJ code and were established on K = 0.45. (Podhrázská J., Dufková J. 2005)

According to the taxonomic classification of soils of the Czech Republic the value of K-factor for Chernozem modal was set at 40 $MJ.ha^{-1}.cm.h^{-1}$. (Janeček M. *et al.* 2012)

Slope length factor and slope steepness factor (L – factor and S – factor)

The influence of relief is determined by two basic parameters - slope (S - factor) and slope length (L - factor). Both parameters influence the rate of runoff. The greater the rate of runoff, the less remains for infiltration. Also, steeper and longer the slope, the more speed the flowing water gains. (Fulajtár E. Janský L. 2001)

S-factor expresses the ratio of soil loss from areas with a certain tendency to loss of soil from the surface with a standard 9% slope. (Fulajtár E. Janský L. 2001)

Value of the S-factor was determined according to the relationship:

$$S = \frac{0{,}43 + 0{,}30s + 0{,}043\, s^2}{6{,}613}$$

where s - slope (%).

Next to the slope the intensity of erosion processes is dependent on its length. With the growth of the slope length there is a growth in the amount of runoff water, its speed and tanging forces and consequently a significant increase in the intensity of erosion processes. (Holý M. 1970)

In the middle position, the slope of the land ranges from 10 to 15%. Length of the relevant plots range from 200 to 550 m.

Slope length factor (L - factor) expresses the ratio of soil loss from a certain area of the loss of soil from the surface with a standard length of 22.13 m. (Fulajtár E. Janský L. 2001)

L-factor was calculated according to the formula:

$$L = \frac{l_d}{22{,}13}^{p}$$

where l_d - unbroken slope length (m)

p - exponent involving the impact of slope

where in the 1st and 3rd place the slope of the plot was between 3-5%. In the remaining places it was over 5%.

Table 1 Slope (Podhrázská J., Dufková J. 2005)

Slope in %	p
5	0,5
3 - 5	0,4

It was found that on a direct slope the water erosion with the highest intensity takes place in the middle and lower third of the slope and on the concave slope in the upper and middle third. On some of concave slopes operates mutual combination of decreasing slope and increasing its length by increasing the erosion process, which reaches its maximum in the middle third of the slope and decreases only at very low values of inclination. (Holý M. 1970)

Crop management factor (C-factor)

Vegetation cover is an important parameter used in assessing the relationship between vegetation and soil erosion. (Zhongming W. *et al.* 2010)
Plant cover, after the relief is another extremely important factor affecting erosion. His influence is felt directly protecting the soil from destructive action of the impacting raindrops, slowing down the rate of surface runoff, and indirectly also affects the soil properties (porosity, permeability). (Janeček M. *et al.* 2012)
(C-factor) is defined as the ratio of soil erosion from land covered with some kind of vegetation to soil erosion of puffy black outfield. (Fulajtár E. Janský L. 2001)
The lowest level of protection is provided by field culture, which is characterized by a relatively small leaf area per unit area, a smaller increase in aboveground organs in most of the growing season and a smaller extent of the root system. (Holý M. 1970)
The C-factor accordingly to Malíšek 1992 IN Fulajtár E. Janský L. 2001was set at 0,180. This value corresponds to winter crops, which were growing on the land in the last few years.
Vegetation cover is one of the most common parameters used in assessing the relationship between vegetation and soil erosion. In general, soil erosion decreases with an increase in vegetation cover. This relationship has caused vegetation cover to be widely used in studies such as soil erosion classification, soil erosion risk assessment and soil loss evaluation. (Zhongming W. *et al.* 2010)

Effectiveness of anti-erosion measures (P-factor)

A value of the factor of effectiveness of anti-erosion measures (P-factor) was set for example by Wischmeier W.H. and Smith D.D. (1978). If the conditions have not been complied with the conditions of maximum lengths and the number of strips, count with a value of P = 1.

Since it is not possible to assume that the conditions have been complied with maximum lengths and the number of bands, this value was set at P = 1.

This paper would like to propose as measure of anti-erosion diking of the soil surface. Diking of the soil surface for slope 7 – 12% is 0.3 and for slope 12 – 18% is 0.4.

Table 2 Soil loss

G (t.ha^{-1}rok)	P = 1		P = 0,3 – 0,4	
	R25	R40	R25	R40
Domanín	12.30	19.68	3.69	5.90
Dambořice	14.40	23.05	5.76	9.22
Dambořice 2	9.67	15.47	2.90	4.64
Klobouky u Brna	18.91	30.26	7.56	12.10
Klobouky u Brna 2	9.74	15.59	2.43	4.85

Admissible soil loss value for factor R = 25 for deep soil, which includes the Chernozems (Němeček J. *et al.* 2011) should be maximally 10 t ha^{-1}.yr. This condition fulfill only two locations - Dambořice 2 and Klobouky u Brna 2. Physically, these 5 sites do not fulfill condition for deep soils (> 60 cm) in the upper and middle part of the slope. It would therefore be advisable to move these properties into category of soils moderately deep. Even the middle of the location (eroded) should be moved into shallow soils.

Table 3 Acceptable soil loss by water erosion

	5th No of BPEJ code	t.ha$^{-1.}$ year^{-1}
shallow soils (to 30cm)	5, 6, 8*, 9*	1
moderately deep soils (30 – 60cm)	4, 7*	4
deep soil (over 60 cm)	0, 1, 2, 3	10

* Refine data on the depth of soil from a complex survey of agricultural soils

For the new proposed value of R = 40 are the values of G multiple times higher. Because of the calculated values it would be appropriate and useful to do anti-erosion measures. As an examples for lowering the value of G an anti-erosion measure called diking can be used. For the new factor R = 40 diking is not a sufficient measure of anti-erosion. (Table 2, P 0.3 – 0.4)

CONCLUSIONS

Soil erosion is now being studied from different angles by many specialists in differen't fields; many publications are devoted to a particular type or form of erosion which is of special regional significance, but relatively few works take a comprehensive view of erosion.

The prevention of soil erosion, which means reducing the rate of soil loss to approximately that which would occur under natural conditions, relies on selecting appropriate strategies for soil conservation, and this, in turn, requires a thorough understanding of the processes of erosion. (Morgan R. P. C. 2005)

In deep soils, which include Chernozems soil is by Janeček M. *et al.* 2012 recommended to use the value of allowable soil loss rate of 4 t. ha^{-1}.year^{-1} originally recommended 10 t ha^{-1}.year^{-1} as it is the most fertile agricultural land. Ideally it should be the goals for which the intensity does not exceed the rate of erosion of soils.

Dufková J., Podhrázská J. 2005 the land which is damaged for example by erosion it is recommended to lower the values of acceptable soil loss by one level. Examine the land for damage from water erosion, and it would be advisable to make anti-erosion measures on such land.

We conclude that the phenomena of erosion, are as complex as the natural conditions under which they occur, as well as the different types of land involved. Therefore no theoretical work can provide practical solutions to problems of soil erosion under specific conditions, but such a work may help to throw light on the basic features of the phenomenon and indicate the general direction of a practical solution.

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