Landform Analysis, Vol. 9: 45–48 (2008)

Contribution of water and tillage erosion to bright patches formation on the base of erosion modelling (Case study Trnavská pahorkatina Hill Land, Slovakia) Preliminary results

Anna Smetanová*

Comenius University in Bratislava, Department of Physical Geography and Geoecology, Mlynská dolina, Bratislava 84 215, Slovak Republic

Introduction

The relief of agricultural land is influenced by various geomorphic processes variable in space, time and intensity. Water and wind erosion are considered to be dominant, but the recognition of the influence of tillage erosion on soil redistribution (Bac 1928, Lobotka 1958, Lazúr 2001, 2005, cf. Van Oost et al. 2006) and landform evolution (e.g. Janicki et al. 2002, Van Oost et al. 2005, Stankoviansky 2008) is growing. The processes results in the variation in soil properties, uncovering of maternity rock and consequently to relief lowering. The areas with loess substratum visible on the surface have a great extent in the loessic areas in Slovakia. So-called bright patches are easily distinguishable due to contrast between bright loess and surrounding darker soils. So far mainly their occurrence, distribution and soil properties has been studied (e.g. Sobocká, 2002, Ilavská, Jambor 2005). Several suggestion on their origin have been proposed. Possible relationships with archaeological sites occurrence (Kohan 1993), relict (Linkeš et al. 1992) or recent water erosion (Fulajtár, Janský 2001) as well as polygenetic origin with contribution of eolian processes (Stankoviansky 1993) were presumed. However possible contribution of tillage erosion has been suggested recently (Smetanová 2008) more detailed research on bright patches genesis and relief development of loessic hill land is needed. The objective of the paper is to contribute to this discussion by study of bright patches occurrence and modelling of erosion processes.

Methods

Two study areas (64 and 82 hectares) are situated in SW of Trnavská pahorkatina Hill Land in Danube Lowland. They represent typical relief of this part of hill land, which is divided by neoteconic fault activity into softly modelled depression and elevated plateaus connected with steeper slopes. There in the steepest parts (with average slope 2° and maximum slope 8.6°) the first study area is situated. In the west it borders with the riverbed of brook Ronava and in its northern part shallow dell occurs. The second area represent moderate relief of the plateau with average slope 0.65° (max. 2.6°). Chernozems on loess strongly affected by erosion are predominant and bright patches occur.

Bright patches were identified using visual interpretation of orthophotomaps and ortorectified aerial images. Detailed DEMs were created on the basis of topographic maps (1:10,000, 0.5–1m distance between contour lines) and GPS terrain measurements. The WATEM model (Van Oost et al. 2000) was used to asses water and tillage erosion rates and their spatial distribution. Values of rainfall erosivity and soil erodibility factor for water erosion modelling were previously published (Ilavská 2005, Ilavská,

* e-mail: smetanovaa@fns.uniba.sk

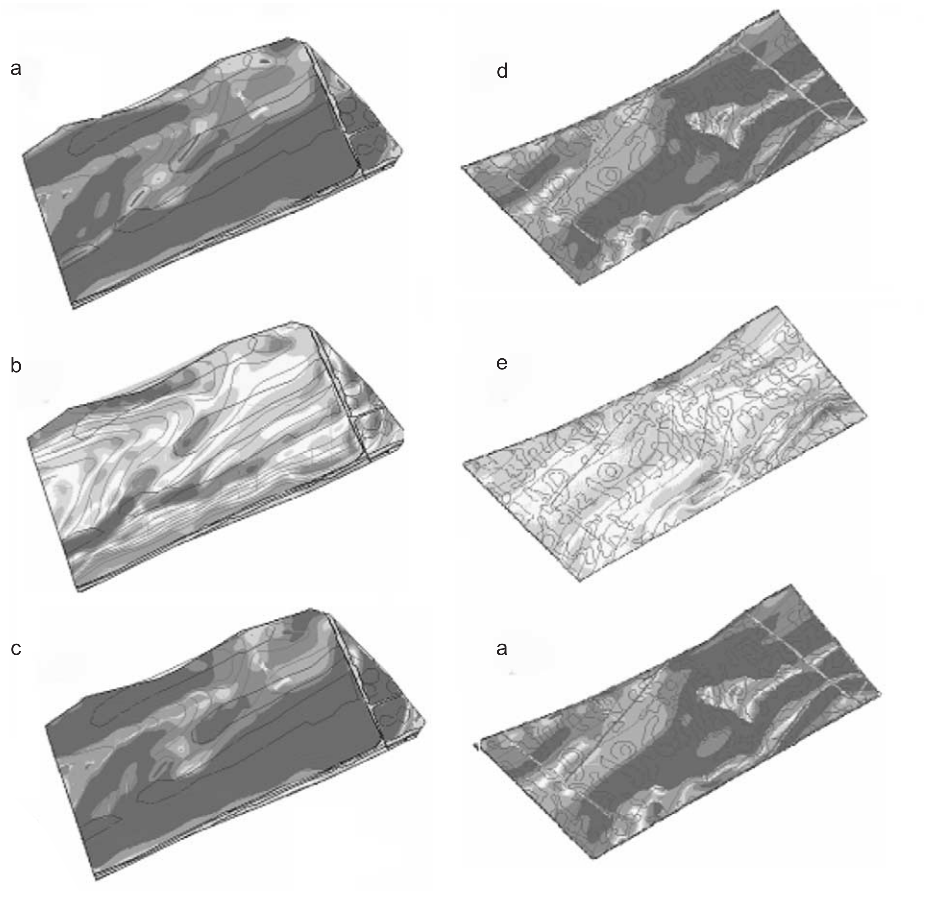
Jambor 2005, Styk, Pálka 2005). Crop erosivity factor was calculated as weighted three year average of the erosivity of particular crops and the area covered by them on the basis of available crop rotation data.

Tillage erosion is a diffusion-type process controlled by the change in slope gradient and intensity dependent on the value of tillage transport coefficient (Van Oost et al. 2000). Previously published values (Van Muysen at al. 2000) refering to applied mouldboard, tillage depth and average speed were used. The results of water erosion, tillage erosion modelling and their cumulative effect were compared with bright patches distribution.

Results and conclusion

The bright patches cover significant part of the studied areas (21.3% and 42.9% respectively). Long and narrow patches are predominant on the steeper slopes. Smaller in slope direction elongated patches prevail in the second study area. The highest water erosion rates (with maximum 6.12 $t{\cdot}ha^{-1}{\cdot}a^{-1}$) occur in the steepest lower parts of slopes in the first study area (Fig. 1a). Accumulation increases up to 6, 87 $t{\cdot}ha^{-1}{\cdot}a^{-1}$ there (32.8 $t{\cdot}ha^{-1}{\cdot}a^{-1}$ in the area close to riverbed of creek Ronava). The greatest rates of tillage erosion (5.51 $t{\cdot}ha^{-1}{\cdot}a^{-1}$) are connected with ridges and terrain edges (Fig. 1b), less intensive process can be observed close to field boundaries. Accumulation (maximum 3.32 $t{\cdot}ha^{-1}{\cdot}a^{-1}$) occurs in concave parts. Comparing the areas of erosion and bright patches occurrence their connection to the areas with highest tillage erosion rates is noticeable. They extent partly in the areas with tillage accumulation, where water erosion is more intensive and therefore antagonistic effect of both processes is responsible for the formation of bright patches. (Fig. 1c).

In the second study area both processes are less intensive (Fig. 1d, e) with the maximum water (tillage) erosion 2.4 (0.63) $t{\cdot}ha^{-1}{\cdot}a^{-1}$ and accumulation 35.7 (0.95) $t{\cdot}ha^{-1}{\cdot}a^{-1}$ rates. Bright patches are distributed within the whole slope without significant linkage to tillage erosion. They occur more often in areas



a,b,c – study area nr. 1, d,e,f – study area nr. 2
a,d – water erosion and accumulation
b,e – tillage erosion and accumulation
c,f, – cumulative effect of water and tillage erosion and accumulation

Fig. 1. Water and tillage erosion and their cumulative effect

with higher water erosion or with acumulation. The cumulative effect of both processes is more dependent on water erosion (Fig. 1f).

Modelled cumulative rates (with maximum 6.68 and 2.3 $t \cdot ha^{-1} \cdot a^{-1}$) are lower than values estimated by Linkeš et al. (1992) by ^{137}Cs measurements in soil catena (study site near Voderady). The difference between modelled and measured values of erosion indicated the need for further evaluation of current erosion pattern. The evaluation of historical erosion and its variability is crucial for the study of bright patches formation. Further research is also needed to distinguish the role of particular processes, including tillage erosion which probably more influences the formation of long and narrow patches linked to terrain edges, ridges and tops.

Acknowledgements

Financial support provided for the scientific project *The evaluation of geomorphological effect and environmental impact of runoff and tillage processes* (VEGA, nr. 1/3051/06) by the Slovak Scientific Grant Agency of the Ministry of Education of the Slovak Republic and Slovak Academy of Scienece and for the scientific project (UK no. 295/2008) *The effect of accumulation on the spreading of bright patches and the morphogenesis of agricultural areas (on the examle of Trnavská hill land, Slovakia)* provided by the Comenius University in Bratislava is acknowledged. The author is also grateful to Ing. P Lipták from cooperative farm PD Voderady – Slovenská Nová Ves for provided information and to Doc. RNDr. Miloš Stankoviansky, Bc. Katarzyna Dąbrowska for their help and advice.

References

Bac S. 1928. The contribution to research of relief elevation changes in loessic areable areas. (Original in Polish: Przyczynek do badań nad zmianą położenia powierzchni ornych gruntów loessowych). Roczniki nauk rolniczych i leśnych, 19: 461–490.

Fulajtár E., Janský L. 2001. Water erosion and soil protection. (Original in Slovak: Vodná erózia pôdy a protierózna ochrana). Výskumný ústav pôdoznalectva a ochrany pôdy, Bratislava, 310 s.

Ilavská B. 2005. Comparison of erosion distribution modelling calculating by USLE equation and bonity pedo – ecological units. Proceedings of Soil Science and Conservation Research Institute, 25: 31–37.

Ilavská B., Jambor P. 2005. Soil erodibility in the conitions of Slovakia. Proceedings of Soil Science and Conservation Research Institute, 27: 35–42.

Janicki G., Rodzik J., Zgłobicki W. 2002. Geomorphic effects of land use changes (a case of Gutanów loess catchment, Poland). Geografický časopis (Geographical Journal), 54: 39–57.

Kohan L'. 1993. Bright patches – the results od intensive erosion – denudation proecesses in th loess hill lands in Slovakia (Original in Slovak: "Svetlé plochy" výsledok intenzívnych erózno-denudačných procesov v sprašových pahorkatinách Slovenska). [In:] Proceedings of workshop Geografia – aktivity človeka v krajine, Pedagogická fakulta univerzity Pavla Jozefa Šafárika, Prešov, s. 25–28.

Lazúr R. 2001. Soil erosion caused by tillage. [In:] Jambor, P. (ed.) Proceedings of the Trilateral Co – operation Meeting on Physical Soil Degradation, VÚPOP, Bratislava, 2001, 49–57.

Lazúr R. 2005. Tillage Effects on soil erosion. [In:] Proceeding 25: Vedecké práce VÚPOP, 2005, s. 61–67.

Linkeš V., Lehotský M., Stankoviansky M. 1992. Contribution to the knowledge of the soils water erosion on the hill lands of Danube Lowland with use of Caesium-137. (Original in Slovak: Príspevok k poznaniu vývoja vodnej erózie pôd na pahorkatine Podunajskej nížiny s využitím ^{137}Cs). Proceedings of Soil Science and Conservation Research Institute, 14: 113–119.

Lobotka V. 1958. Contribution to the problematic of tillage erosion. (Original in Slovak: Príspevok k problému erózie z orania). Pol'nohospodárstvo, 5: 1172–1191.

Smetanová A. 2008. Contribution to the discussion on the origin of bright patches in loessic areas with Chernozems (Case study: selected part Trnavská pahorkatina Hill Land, Slovakia). [In:] 15th Internat. Congress of ISCO: Proceedings Volume (Budapest 18.–23.5.2008). Budapest: Geographical Research Institute HAS, 2008, 4 p.

Sobocká J. 2002. Soil erosion processes influence on Luvisols characteristic in Trnavian loess hill land. (Original in Slovak: Vplyv eróznych procesov na charakter hnedozemí Trnavskej sprašovej pahorkatiny). Phytopedon Supplement, 2002/1: 221–226.

Stankoviansky M. 1993. The relief development of the southerm part of the Trnavská tabula Table. (Original in Slovak: Vývoj reliéfu južnej časti Trnavskej tabule). Geografický časopis (Geographical Journal), 45: 93–107.

Stankoviansky M. 2008. Influence of long-term tillage on landform evolution in the Slovak Carpathians. (Original in Slovak: Vplyv dlhodobého obrábania pôdy na vývoj reliéfu slovenských Karpát.) AGUC, Vol. 50, 2008.

Styk J., Pálka B. 2005. Potential vulnerability of agricultural soils of Slovak Republic by water erosion using the empiric USLE model. (Original in Slovak: Potenciálna ohrozenosœ pol'nohospodárskych pôd

SR vodnou eróziou vyhodnotená využitím empirického modelu USLE). [In:] Sobocká, J. (ed.), Zborník prednášok VII. Zjazdu SSPPLPV pri SAV, D. Pedologická sekcia. SSPPLPV Bratislava – VÚPOP Bratislava, pp. 73–77.

Van Oost K., Govers G., Desmet P. 2000. Evaluating the effects of changes in landscape structure on soil erosion by water and tillage. Landscape ecology, 15: 577–589.

Van Oost K., Van Muysen W., Govers G., Deckers J., Quine T.A. 2005. From water to tillage erosion dominated landform evolution. Geomorphology, 72: 193–203.

Van Oost K., Govers G., de Alba S., Quine T.A. 2006. Tillage erosion: a review of controlling factors and implications for soil quality. Progress in Physical Geography 30, 4, 2006: 443–466.