PROTECTING STEEP SLOPES AGAINST SOIL EROSION: GEOTEXTILES AND ITS EFFECTIVENESS UNDER HEAVY RAINFALL

CTU CZECH TECHNICAL UNIVERSITY IN PRAGUE
DEPARTMENT OF LANDSCAPE WATER CONSERVATION
GEOSYNTETIKA, s.r.o.
STRIX CHOMUTOV

Tomas Laburda (1), Petr Kavka (1), Martin Neumann (1), David Zumr (1), Adam Tejkl (1), Dušan Dufka (2), Martin Vaníček (3)

(1) Czech Technical University in Prague, Faculty of Civil Engineering, Departement of Landscape Water Conservation, (2) STRIX Chomutov,a.s., Chomutov, CZ, (3) Geosyntetika, s.r.o., Praha, CZ

A. INTRODUCTION

Soil erosion is a natural phenomenon that creates significant geomorphological changes on the Earth's surface. The most prone places for soil erosion are **steep slopes** with **unprotected bare soil**, which can be found on civil and transportation construction sites. Moreover, these slopes are even more vulnerable as they often arise during periods of **heavy rainfall**.

Figure 1 Field rainfall simulator and experimental plots for testing rolled erosion control products (RECPs)

Experimental testing of selected types of **rolled erosion control products (RECPs)** generally known as geotextiles was carried out at two sites. Both synthetic and natural fiber materials used in construction were tested. The aim was to find out how different types of geotextiles are able to mitigate surface runoff and prevent soil erosion, i.e., to determine their effectiveness.

B. METHODOLOGY

Testing selected types of soil erosion control materials was performed at two sites, both equipped with rainfall simulators and experimental plots. The following products were selected to represent both category: **erosion control blankets (ECB)** made from degradable natural or polymer fibers and **turf reinforcement mats (TRM)** made from non-degradable synthetic fibers.

Product name	Description	Type	Producer	Picture
Biomac-C	Jute-coir fibres reinforced with polypropylen scrim netting	ECB	Maccafferi	
K700 (K400)	100% coir fibres	ECB	Geomat	
Enkamat 7220	3D polyamid geomat with open structure and one side flat back	TRM	Geofabrics	
Enkamat 7010	3D polyamid geomat with open structure	TRM	Geofabrics	
Macmat 8.1	3D polyamid geomat	TRM	Maccafferi	
Macmat 18.1	3D polyamid geomat	TRM	Maccafferi	

Methodology is based on the comparison of the sediment fluxes from plots with bare soil and plots with rolled erosion control products. During all experiments are measured following parameters:

- Surface runoff and soil loss (and its texture) in fixed time intervals
- Soil moisture in different soil depths
- Surface changes with photogrammetry method "Structure from Motion"

Each material is tested in two replicates consisted of dry and wet 30-minutes long simulations with another dry-wet experiment with rills and cracks already formed.

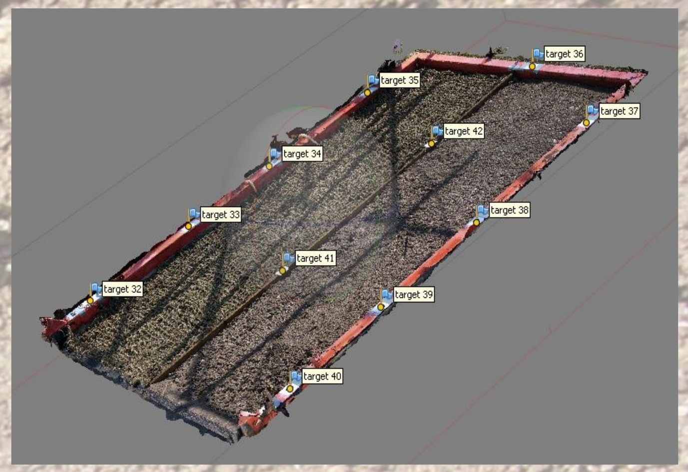

Figure 2 Experimental plot diveded on 2 halves – left one covered with tested geotextile and right one with bare soil without any protection.

FIELD RAINFALL SIMULATOR

- Jet type outdoor simulator with stable metal construction
- Tarpaulin cover to avoid influence of wind
- 4 spraying nozzles (WSQ 40) 2,6 m above surface
- Water pressure: 0,75 bar
- Christiansen uniformity index: 71,3%
- 5 experimental plots— each with area of 2 x 4 m
- 3 plots with simulated rainfall (different slopes 1:1,5, 1:1,75, 1:2,5)
- 2 plots for longterm observation under natural rainfall

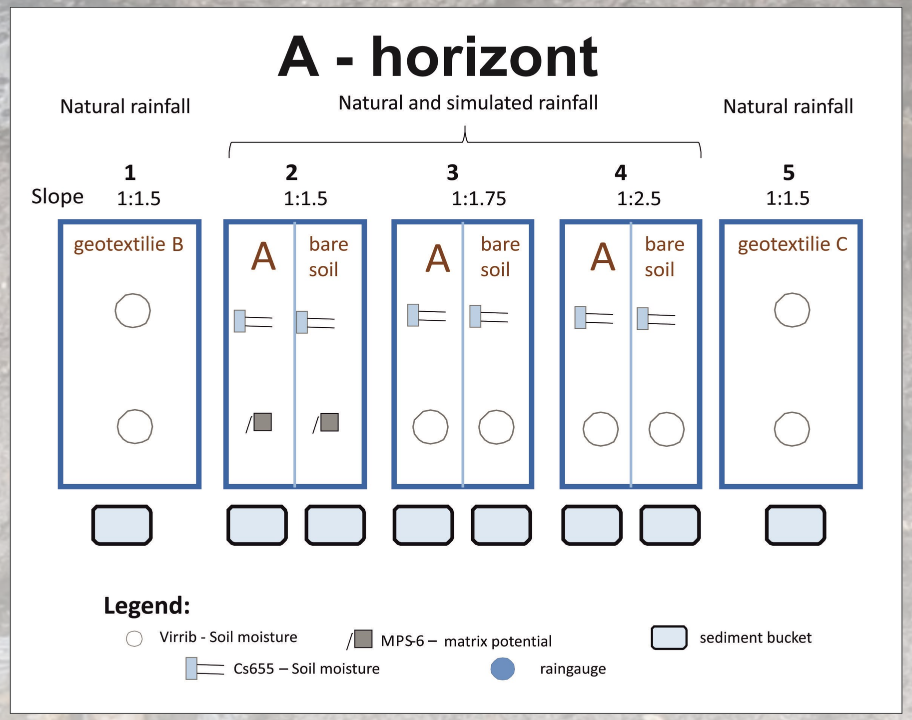

Figure 3 Experimental plots at the field rainfall simulator.

LABORATORY RAINFALL SIMULATOR

- Two spraying systems
  - swing plane nozzles (V jet type)
  - intermittent spraying system (WSQ jet type)
- Soil sample (plot) up to 1 x 5 m
- Variable height of nozzles with the maximum of 2,6 m
- Precipitation intesity from 10 to 200 mm/h
- Variable slope from 0 to 40°
- Adjustable soil temperature from -15 °C to +60 °
- Constructed in 2018

Figure 4 Laboratory rainfall simulator.

C. RESULTS

Figures 5 and 6 show how increasing slope (from 22° - 1:2,5 to 34° - 1:1,5) increases the effect of protection material in term of surface runoff and soil loss compare to bare soil. During the simulation erosion rills are formed, but their growth is hindered. First simulations show grater variability because of the rill formation. In the case of sediment production, slope is not a primary factor.

Figures 7 and 8 show variability of effectiveness against soil loss and surface runoff. While there is no obvious difference in reduction of runoff, in soil loss the differences are more noticeable. Higher effectiveness in reduction of soil loss at the natural material based materials (ECB). Main difference is in the rigidity of the material. Erosion control blankets are softer and their contact with surface is tighter, thus they hold more soil mass. These materials also absorb water and thereby adhere even better to the surface. Geotextiles based on artificial materials (TRM), layed on the surface and anchored on several spots, do not contact with soil very well, thus forming of rills under the geotextile and movement of the soil particles is possible.

Figure 9 shows example of results from photogrammetry analysis of surface changes. Left plots with protection on geotextiles shows on DoD (digital elevation model of difference) very low detected difference before and after simulated rainfall. Right plots without any protection are eroded by large rills. These rills account for about 30 % of the soil loss, while the remainder is the soil loss from sheer erosion.

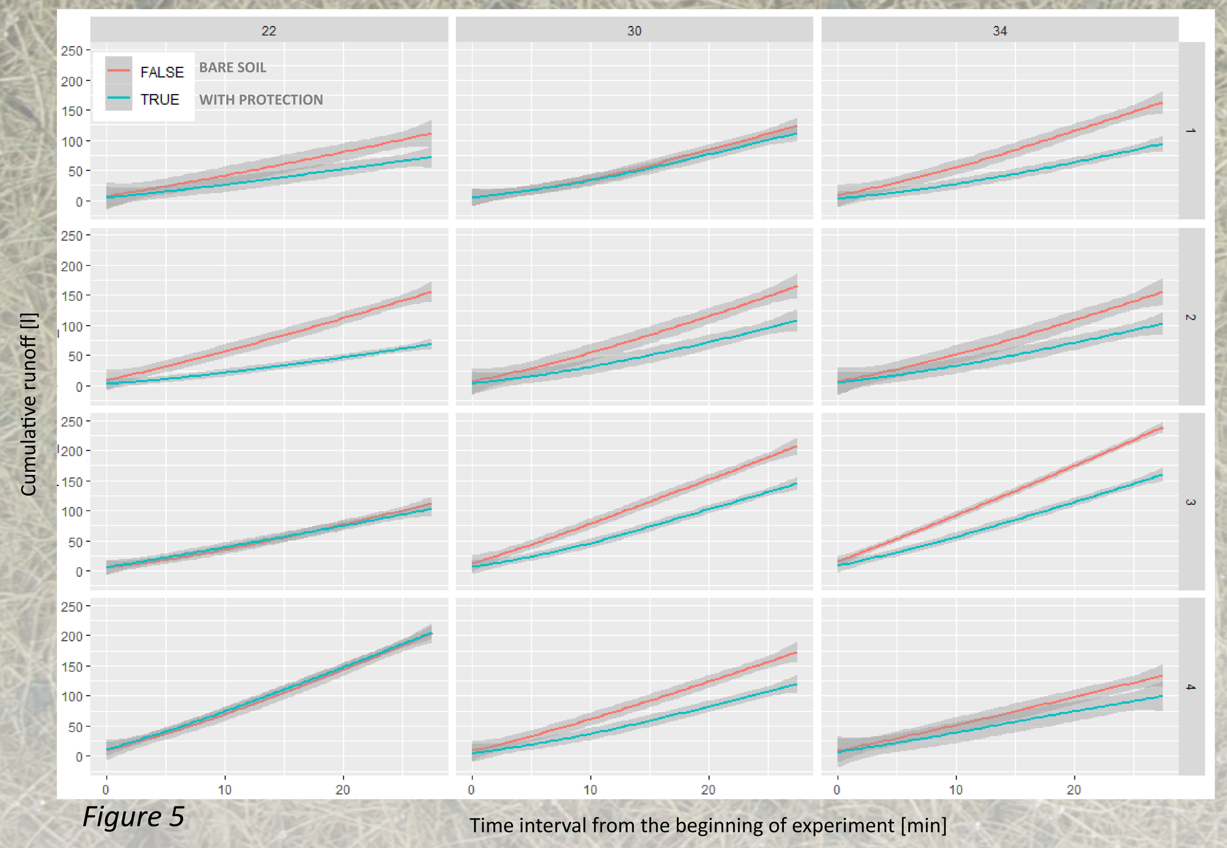

Figure 5

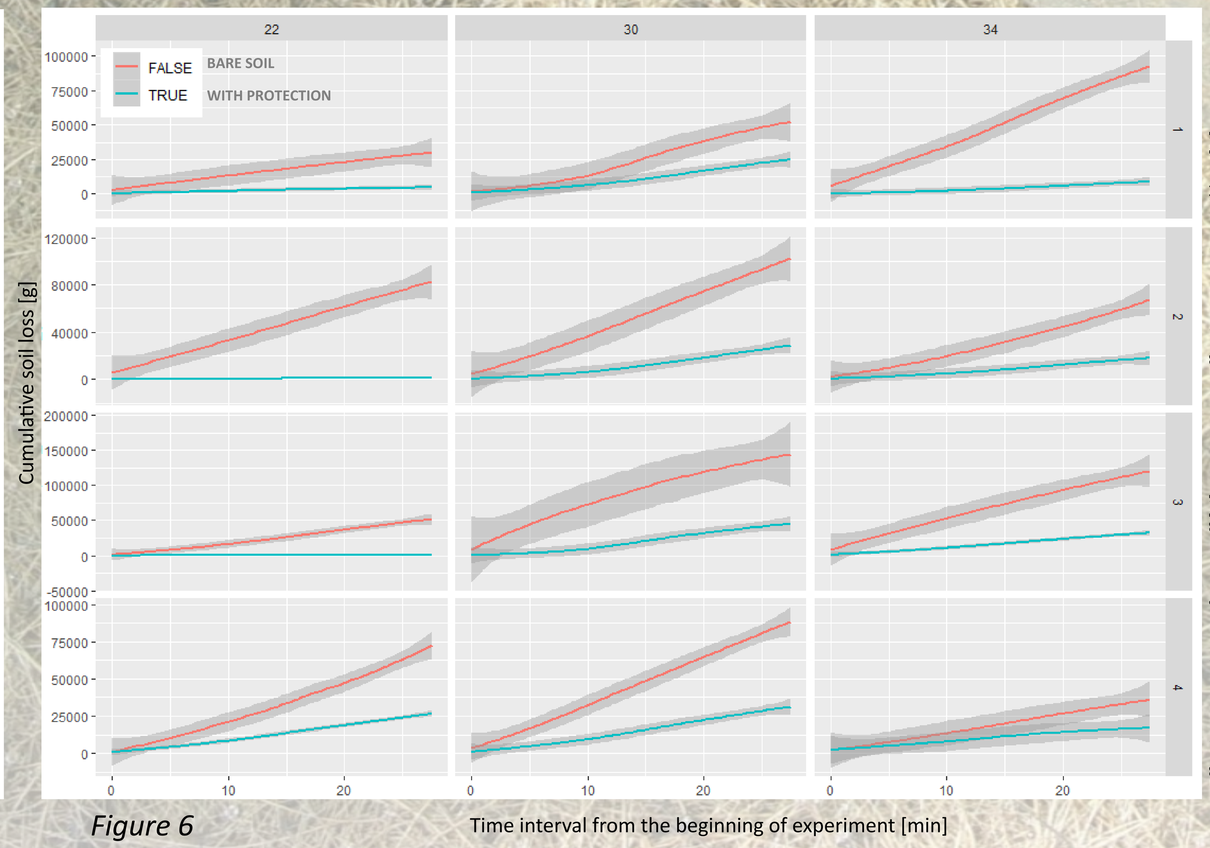

Figure 6

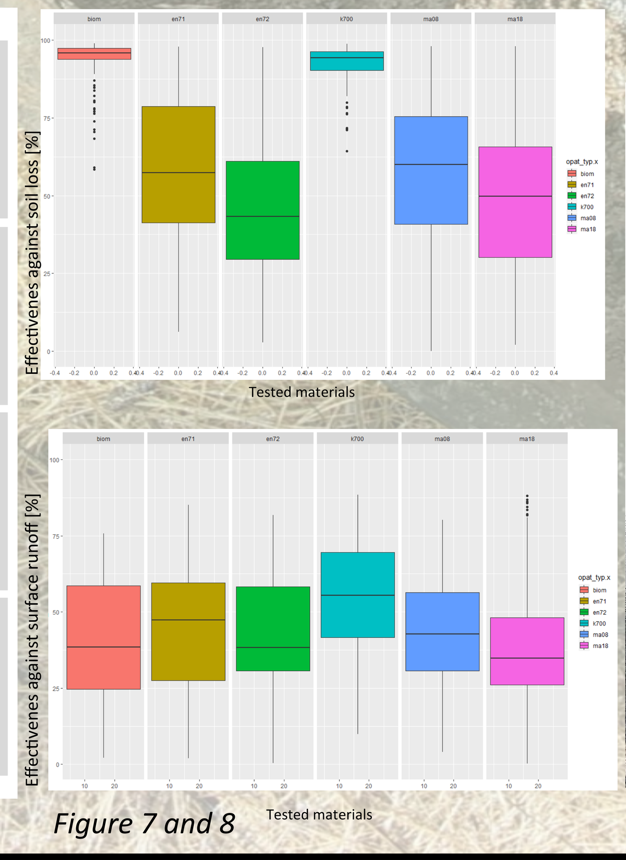

Figure 7 and 8

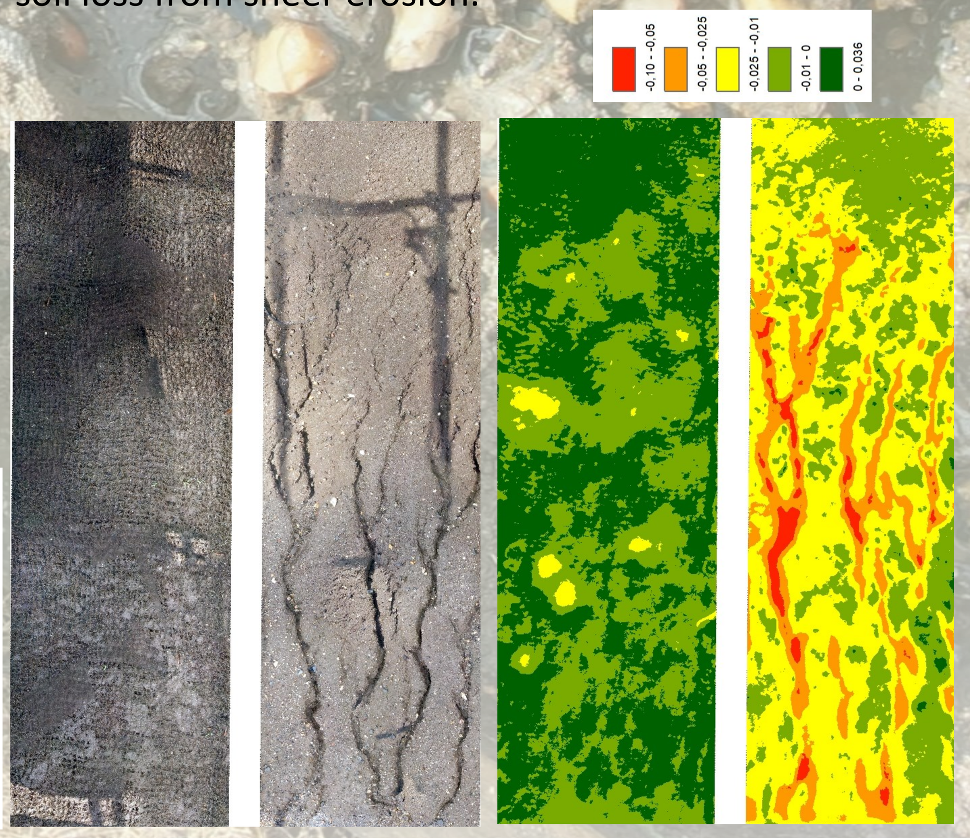

Figure 9 Orthophoto and DoD of experimental plots.

D. CONCLUSION

- Rainfall simulation is a useful technique for measuring the effect of artificial slopes protection measures
- High reduction of the net soil loss from the experimental plots due to the protection measures, as the rills do not develop on the covered plots.
- Development of the rills can be observed on the untreated plots (bare soil surface). The rills propagate especially during the repeated simulation under the wet initial conditions.

OUTLOOK

- Evaluation of the effect of the surface cover on soil water regime.
- Assessment of the impact and suitability of individual measures .
- Effect of the soil temperature on the rills development in laboratory conditions.

AKNOWLEDGEMENTS: Research has been supported by grant **TH02030428 - „Design of technical measures for slopes stabilization and soil erosion prevention“ and SGS17/173/OHK1 – „Experimental research of erosion and transport processes in agricultural landscapes“**.

CONTACT: tomas.laburda@fsv.cvut.cz, petr.kavka@fsv.cvut.cz

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